20th Cambridge Workshop: Cool Stars, Stellar Systems, and the Sun

July 29 - Aug 3, 2018
Boston / Cambridge, USA

Abstracts

Connecting to the Boston University Network

1. Select network ”BU Guest (unencrypted)”
2. Once connected, open a web browser and try to navigate to a website. You should be redirected to https://safeconnect.bu.edu:9443 for registration. If the page does not automatically redirect, go to bu.edu to be brought to the login page.
3. Enter the login information:
   Guest Username: **CoolStars20**
   Password: **CoolStars20**
   Click to accept the conditions then log in.

Foreword

Our story starts on January 31, 1980 when a small group of about 50 astronomers came together, organized by Andrea Dupree, to discuss the results from the new high-energy satellites *IUE* and *Einstein.* Called "Cool Stars, Stellar Systems, and the Sun," the meeting emphasized the solar stellar connection and focused discussion on "several topics … in which the similarity is manifest: the structures of chromospheres and coronae, stellar activity, and the phenomena of mass loss," according to the preface of the resulting, "Special Report of the Smithsonian Astrophysical Observatory." We could easily have chosen the same topics for this meeting.

Over the summer of 1980, the group met again in Bonas, France and then back in Cambridge in 1981. Nearly 40 years on, I am comfortable saying these workshops have evolved to be the premier conference series for cool star research. Cool Stars has been held largely biennially, alternating between North America and Europe. Over that time, the field of stellar astrophysics has been upended several times, first by results from Hubble, then *ROSAT*, then Keck and other large aperture ground-based adaptive optics telescopes. The discovery of the first brown dwarfs and planets were both announced at Cool Stars 9. Later, *Chandra*, *XMM-Newton* and *Spitzer* and more recently *Kepler* and the *Solar Dynamics Observatory* repeatedly made us re-write text books—no really, the missions and meetings directly led to new editions. This year, as *TESS* and *Parker Solar Probe* threaten to make us re-write the text books yet again, approximately 500 international experts in Low-Mass Stars, Solar Physics, and Exoplanets meet here, in Boston and Cambridge, to again exchange ideas in a cross-disciplinary and friendly environment. I would like to thank all of you for coming and bringing your ideas and your willingness to share. This meeting is a celebration of you and the work you do.

Four institutions in the Boston area (Boston University, Harvard-Smithsonian Center for Astrophysics (Harvard College Observatory / Smithsonian Astrophysical Observatory), MIT, and University of Massachusetts Lowell) jointly organized Cool Stars 20 at Boston University in Boston/Cambridge, MA from July 29 to August 4, 2018.

I would like to thank the Scientific Organizing Committee who developed the science program. For this meeting the Scientific topics are:

- Galactic Cartography in the Gaia Era,
- Solar/Stellar Environments,
- Fundamental Properties of Cool Stars,
- Solar/Stellar Magnetic Fields and Surface Structure,
- Very Low Mass (VLM) Objects.

The Science Organizing Committee chose the invited speakers, the hosts of the splinter sessions, and the contributed speakers for the plenary session. Overall, we accepted only 37 contributed talks out of 289 submissions to speak in the plenary session. This means a speaking opportunity in the plenary session was about as difficult to obtain as Hubble time. I would like to thank the international SOC for their efforts: Silvia Alencar, Fabienne Bastien, Sarbani Basu, Chas Beichman, Svetlana Berdyugina, Angela Bragaglia, Paul Charbonneau, Ofer Cohen, Charlie Conroy, Andrea Dupree, Catherine Espaillat, Gregory Feiden, Lindsey Glesener, Suzanne Hawley, Dave Huenemoerder, Gaitee Hussain, Moira Jardine, Adam Kowalski, Phil Muirhead, Jürgen Schmitt, John Stauffer, Gerard van Belle. They held up under the weight of so many difficult decisions. They have some more work to do choosing the best posters and the host for Cool Stars 21. Within the SOC, I especially want to thank Phil and Catherine for making the facilities at BU available to us. This meeting has grown to 10 times its original size and finding a large venue with enough room for all of us near the Center of the Universe (Cambridge, MA) is difficult. I would also like to thank Nancy Brickhouse and Ed DeLuca for helping me write the original proposal to help bring this meeting home and for graciously stepping aside from the SOC to allow more people to contribute.

The hardest work organizing this meeting falls to the local organizing committee. They are drawn from the host institutions and have been working almost since the day we left Uppsala. Their tasks range from writing the web-based software, to organizing the excursions, dealing with the AV equipment, badges, designing T-shirts, coffee mugs, and pilsner glasses, creating the abstract book and lining up the banquet. This is a bit more complicated than it was in 1980. Thanks go to Rana Ezzeddine, Moritz Günther (chair), Jenine Humber, Nishu Karna, Aurora Kesseli, David Principe, Sam Quinn, Benjamin Roulston, Carl Schmidt, Julie Skinner, Anastasiia V Uvarova, Mark Veyette, Jen Winters. Kristin Ann Divona created our logos. I especially want to thank Jenine our single administrator responsible for making sure every bill got paid, every visa question got answered and every invitation was sent. I also want to single out Moritz for thanks. He runs a very tight ship on the LOC, writes the really excellent software that drives the knowledge base of the meeting and he reminds me when I am falling behind schedule.

I would also be remiss not to thank our sponsors, Charles Alcock at the Harvard-Smithsonian Center for Astrophysics, Gloria Waters at Boston University, Chas Beichman at NExSci and Fabio Favata at ESA; all made significant contributions which helped us keep the overall cost of the meeting down and in many cases allowed us to waive registration entirely.

Finally, I would like to thank Andrea Dupree. Without her efforts in 1980 and throughout the 80's, 90's and 00's, none of us would be here now for CS 20. She has been a tremendous source of encouragement and inspiration to me.

Here is to seeing you all at Cool Stars 40 in 2058 or so.

Scott Wolk

Scott Wolk
Chair, Scientific Organizing Committee

Code of Conduct & Contact Information

Cool Stars 20 is dedicated to a harassment-free workshop experience for everyone regardless of gender, gender identity and expression, sexual orientation, disability, physical appearance, body size, race, age, or religion. We do not tolerate harassment of workshop participants in any form. A description of the full Code of Conduct can be found on the CS 20 website or at: **http://coolstars20.cfa.harvard.edu/docs/CS20_code_of_conduct.pdf**

Reporting

If someone makes you or anyone else feel unsafe or unwelcome, please report it as soon as possible. Conference staff can be identified by workshop t-shirts and colored name badges. Harassment and other code of conduct violations reduce the value of our event for everyone.

Anonymous Report

You can file an anonymous report using this form:
https://goo.gl/forms/UXtcpH5kwjskcvU52

While we cannot follow up an anonymous report with you directly, we will fully investigate the incident and take whatever action is necessary to prevent a recurrence.

Personal Report

You can make a personal report by calling or messaging this number: (+1 781-819-3233) which will be continuously monitored by one member of the LOC for the duration of the event. When taking a personal report, our staff will ensure you are safe and cannot be overheard. They may involve other event staff to ensure your report is managed properly. You won't be asked to confront anyone and we won't tell anyone who you are.

Contact Information

Email address for organizers: **coolstars20@cfa.harvard.edu**
Note: this address is private and accessible to a limited number of organizing members.
Phone number for conference security or organizers:
Boston University Police Department: +1 617-353-5362
LOC Conduct Representatives:
David Principe (principe@mit.edu) and
Julie Skinner (jskinner@bu.edu)
Local medical/police emergency number: 911
Local non-emergency medical (Beth Israel Deaconess Medical Center): +1 617-667-7000
Local law enforcement off-campus (Boston Police): +1 617-343-4500
Local sexual assault 24/7 hot line (Boston Area Rape Crisis Center): +1 800-841-8371

Maps

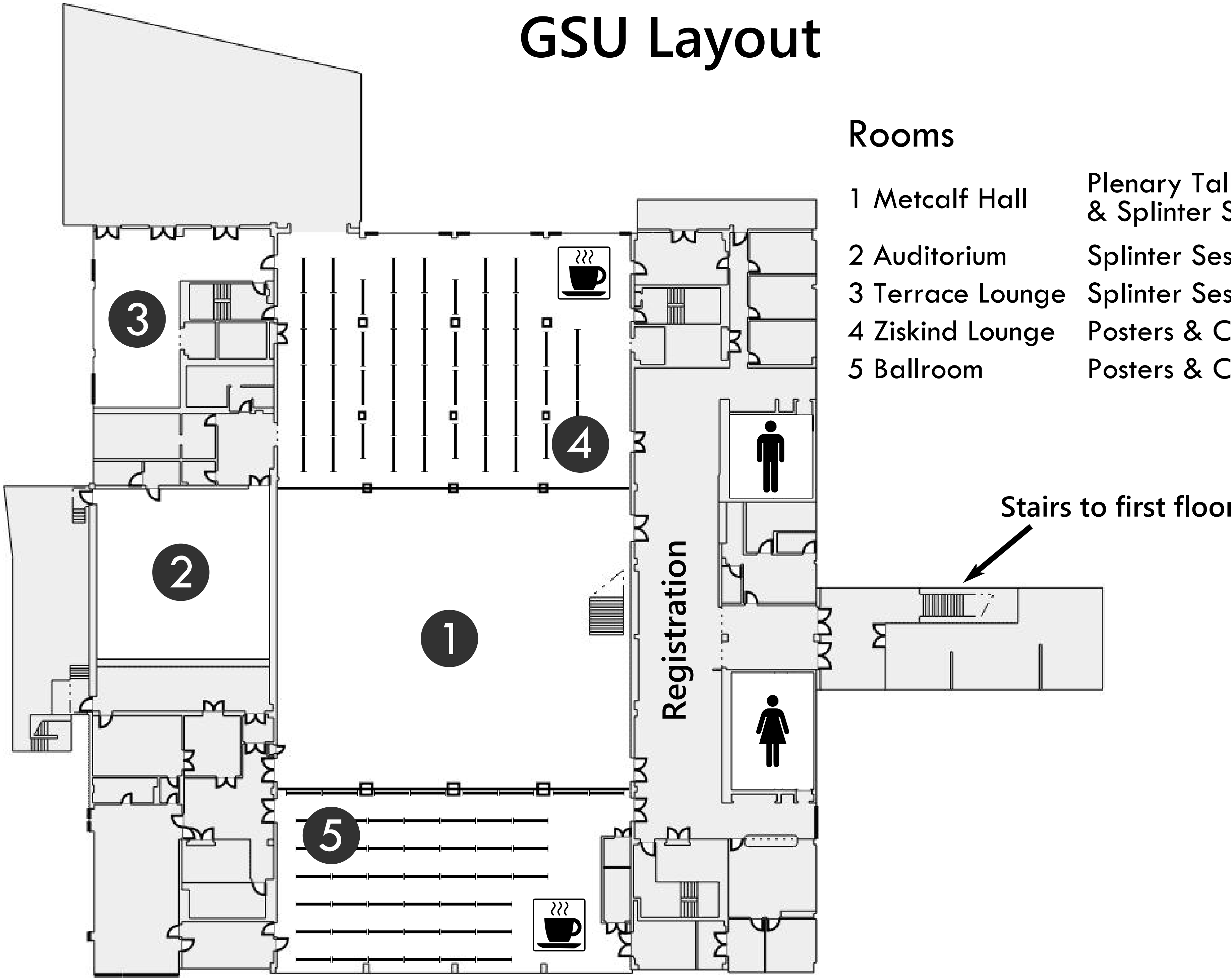
The maps on the following pages are meant to help you navigate the very local universe.

The first shows the layout of the Boston University George Sherman Union, where the conference is held.

The second shows the area immediately surrounding the George Sherman Union, and includes some local dining options and the locations of the BU Dorms, the Hyatt, and the Marriot. Please note the pedestrian detour to navigate the area west of the GSU while Commonwealth Avenue is under construction. Additional information (including interruptions for bikes, cars, and public transportation) about the Commonwealth Avenue Bridge Replacement can be found via MASSDOT:
http://www.massdot.state.ma.us/highway/HighlightedProjects.aspx.

If you have any other questions, please don't hesitate to ask at Registration.

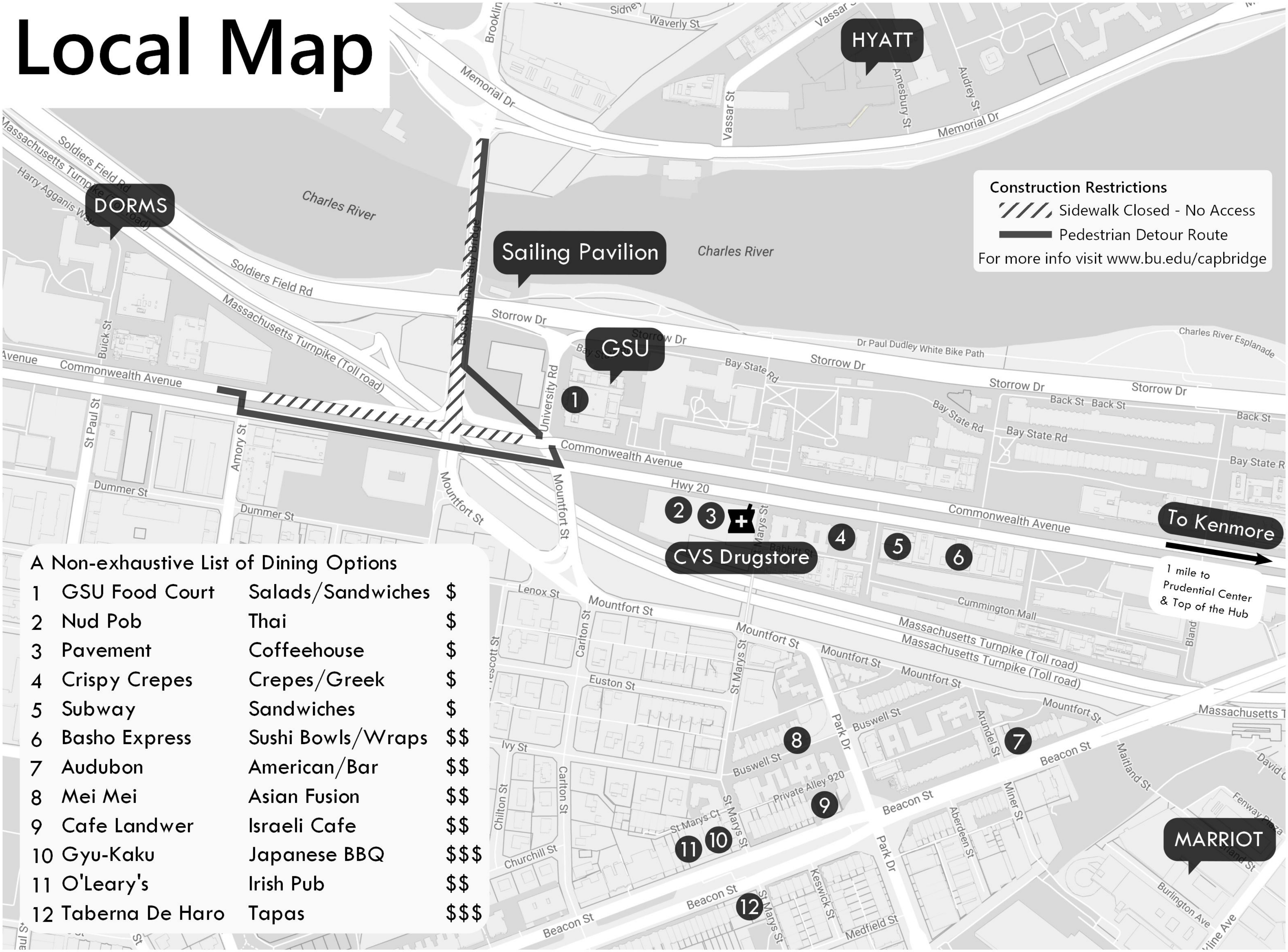
GSU Layout



Rooms

1 Metcalf Hall	Plenary Talks & Splinter Session A
2 Auditorium	Splinter Session B
3 Terrace Lounge	Splinter Session C
4 Ziskind Lounge	Posters & Coffee
5 Ballroom	Posters & Coffee

Local Map



A Non-exhaustive List of Dining Options

1	GSU Food Court	Salads/Sandwiches	$
2	Nud Pob	Thai	$
3	Pavement	Coffeehouse	$
4	Crispy Crepes	Crepes/Greek	$
5	Subway	Sandwiches	$
6	Basho Express	Sushi Bowls/Wraps	$$
7	Audubon	American/Bar	$$
8	Mei Mei	Asian Fusion	$$
9	Cafe Landwer	Israeli Cafe	$$
10	Gyu-Kaku	Japanese BBQ	$$$
11	O'Leary's	Irish Pub	$$
12	Taberna De Haro	Tapas	$$$

Conference Schedule

<table>
<tr><th>Time</th><th>Sunday</th><th>Monday</th><th>Tuesday</th><th>Wednesday</th><th>Thursday</th><th>Friday</th><th>Saturday</th></tr>
<tr><td></td><td>Jul 29</td><td>Jul 30</td><td>Jul 31</td><td>Aug 1</td><td>Aug 2</td><td>Aug 3</td><td>Aug 4</td></tr>
<tr><td></td><td></td><td>Galactic Cartography in the Gaia Era</td><td>Solar/Stellar Magnetic Fields and Surface Structure</td><td>Fundamental Properties of Cool Stars</td><td>Solar/Stellar Environments</td><td>Very Low Mass (VLM) Objects</td><td></td></tr>
<tr><td>08:30-10:05</td><td rowspan="7">CIAO workshop / ExoPAG 18</td><td>Plenary</td><td>Plenary</td><td>Plenary</td><td>Plenary</td><td>Plenary</td><td rowspan="7">Hack Day</td></tr>
<tr><td>10:05-10:50</td><td>Coffee + Posters</td><td>Coffee + Posters</td><td>Coffee + Posters</td><td>Coffee + Posters</td><td>Coffee + Posters</td></tr>
<tr><td>10:50-12:35</td><td>Plenary</td><td>Plenary</td><td rowspan="2">Plenary</td><td>Plenary</td><td>Plenary</td></tr>
<tr><td>12:35-13:05</td><td rowspan="2">Lunch</td><td rowspan="2">Lunch</td><td rowspan="2">Lunch</td><td rowspan="6">End of conference BBQ.
Place and time will be announced.</td></tr>
<tr><td>13:05-14:00</td><td>Lunch</td></tr>
<tr><td>14:00-15:30</td><td>Splinter Sessions</td><td>Splinter Sessions</td><td rowspan="4">Excursions

(exact time varies)</td><td>Splinter Sessions</td></tr>
<tr><td>15:30-16:00</td><td>Coffee + Posters</td><td>Coffee + Posters</td><td>Coffee + Posters</td></tr>
<tr><td>16:00-17:30</td><td></td><td>Splinter Sessions</td><td>Splinter Sessions</td><td>Splinter Sessions</td><td></td></tr>
<tr><td>17:30-18:30</td><td>Registration Opens
18:00-20:00 Opening Reception (including TESS talk)</td><td rowspan="2">Posters + Bar</td><td rowspan="2">Posters + Bar</td><td></td><td></td></tr>
<tr><td>18:30-19:00</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>19:00-20:30</td><td></td><td rowspan="2">Meet the CHARA Array</td><td>Academics to Industry</td><td></td><td rowspan="2">Banquet</td><td></td><td></td></tr>
<tr><td>20:30-22:00</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Splinter Sessions

The titles of the splinter sessions, their organizers, and descriptions of their scientific content can be found below. Each splinter session has its own website, on which you can find additional information about the scheduled speakers and their talks. Links to these websites are provided in the session titles and at http://coolstars20.cfa.harvard.edu/splinters.html.

Monday Splinter Sessions

Benchmarks, and How to Benchmark Them: Cutting-Edge Science and a Data Challenge for Eclipsing Binary Systems

Adam L. Kraus (UT-Austin), Leslie Hebb (Hobart & William Smith), Andrew Mann (Columbia, UNC-Chapel Hill), Keivan Stassun (Vanderbilt), Ben Tofflemire (Wisconsin, UT-Austin), Guillermo Torres (CfA)
CS20EB@gmail.com

The fundamental properties of stars constitute a bedrock upon which much of modern astrophysics is built. Eclipsing binary studies are now testing the detailed astrophysics of stellar evolutionary models, enabled by the ongoing revolution of wide-field time domain surveys like Kepler, K2, TESS, and Evryscope, and by the newest generations of ground-based spectrographs. Our splinter will provide a venue for many leading teams in EB studies to present their newest scientific results across all regimes of the HR diagram.

Analyses of eclipsing binary systems can routinely achieve precisions of 1–3% with robust analysis of high-quality datasets. However, it is growing increasingly evident that there are large systematic uncertainties in the accuracy of the analysis techniques used to measure those stellar properties for eclipsing binary systems. We therefore also will organize a data challenge (occurring before and during the meeting) wherein each participating team must analyze uniform, high-volume datasets that test our analysis methods and illustrate best practices for the field to adopt going forward.

We anticipate that the final product of this splinter will be a journal article summarizing the results of the data challenge and best practices for reducing analysis-driven variance in results. All teams participating in the challenge will be invited to join this article.

Brown Dwarfs, Low–Mass Stars, and Directly Imaged Exoplanets in the Era of Gaia

Jackie Faherty, American Museum of Natural History; John Bochansky, Rider University, Jonathan Gagne, Carnegie DTM
jfaherty17@gmail.com

The Importance of Gaia

Astrometric surveys of increasing precision are responsible for our understanding of the structure of the Milky Way. For instance, early studies by Kapteyn 1905 and Eggen 1965 identified large kinematically coherent associations of stars through ground based kinematic studies of common proper motion and parallax. Those associations were resolved into smaller age-coherent groups with the progression to milliarcsecond parallaxes and proper motions with the Tycho and Hipparcos surveys (Perryman et al. 1997, Hog et al. 2000).

We are now on the precipice of a new era in the kinematic understanding of the Milky Way as we are moving from milli- to microarcsecond astrometry with the Gaia data release catalogs. It is no understatement to say that Gaia will revolutionize our understanding of the kinematic structure of the Milky Way galaxy. Importantly it will drastically update our astrometric understanding of low-mass stars. For instance, Hipparcos only had parallaxes for 10% of stars within 30 pc, and 2% of all those within 100 pc. Gaia will give us parallaxes for all stars within 50 pc, down to the substellar boundary (0.072 $M_\odot$) and for all stars above 0.12 $M_\odot$ within 150 pc (through M5–the peak of the mass function). In April 2018 Gaia will make public the second data release, containing 1.5 billion parallaxes and six million radial velocities. This will be a 10,000 fold increase over what Hipparcos supplied and at a precision up to 100 times better. Leading up to Cool Stars 20 (as well as for many years to follow) we will see a giant leap forward in the membership lists as well as fine-detailed kinematic, velocity, and spatial resolutions of all clusters, star forming regions, and moving groups within a few hundred parsecs from the Sun. Moreover, we will see the identification and refinement of co-moving pairs as well as hierarchical systems (triples, quadruples, etc.) that will be the seed for understanding co-evolving structures in the Galaxy.

Gaia and Moving Groups, Clusters, and Star Forming Regions

Coeval associations of stars, such as those found in star forming regions, clusters, and kinematically coherent moving groups, are unique testbeds for stellar and Galactic investigations (Zuckerman & Song 2004; Torres et al. 2008). Within a few hundred parsecs of the Sun, there are numerous associations ranging in age from a few megayears (e.g. Rho Ophiuchus, 0.5–2 Myr, Wilking et al. 2008; Taurus, 1–2 Myr, Daemgen et al. 2015) through hundreds of megayears (e.g. Tucana Horologium, 45 Myr; AB Doradus, 150 Myr, Bell et al. 2015; Pleiades, 112 Myr, Dahm 2015; Hyades, 750 Myr, Brandt & Huang 2015). In depth studies of the closest associations to the Sun (< 200 pc) have revealed that they harbor large numbers of low-mass stars, brown dwarfs, and even objects whose mass falls below the deuterium burning boundary (so called free-floating planetary-mass objects; Gagne et al. 2015; Faherty et al. 2016). Moreover, given that moving groups harbor the closest young stars to the Sun, they are also the targeting ground for directly imaged exoplanets. Associations such as Tucana

Horologium, TW Hya, and AB Doradus contain isolated objects that range in mass from a few solar masses down to a few Jupiter masses (Gagne et al. 2017, Faherty in prep) as well as stars with planetary-mass companions. Observations of these associations enable investigations of the mass function, kinematics, and spatial distribution across the full range of objects generated through star formation processes in different isolated groups at young (1–2 Myr), medium (30–50 Myr), and early adult (100–700 Myr) ages.

Interestingly, the origin and evolution of many of the nearby associations remains a mystery. Nearby moving groups such as AB Doradus and Pictoris have overlapping kinematics and are widely distributed across the sky. Associations such as Tucana Horologium and TW Hya have bottom-heavy mass functions with a surprisingly large number of low-mass stars, brown dwarfs and free-floating planetary-mass objects (see e. g. Gagne et al. 2015, 2017; Faherty et al. 2016). Many associations do not trace back into a singular point which would be indicative of a singular moment for the collapse of a nascent cloud but rather appear to be filamentary in origin (e.g. Donaldson et al. 2016, Riedel et al. 2017).

In this splinter session we will highlight the work being done to refine cluster membership lists, determine mass functions, and ground the important relations for higher mass stars that might host giant exoplanets, low-mass stars, brown dwarfs, and free floating planetary-mass sources. We will also highlight the work ongoing to uncover co-moving, low-mass stars and brown dwarfs in Gaia and investigate telling parameters of co-evolution.

From light curves to rotation periods, and then ages via gyrochronology - where do we stand, and where do we go from here?

Sydney A. Barnes, Leibniz Institute for Astrophysics Potsdam (AIP), Germany; Silva Järvinen, Leibniz Institute for Astrophysics Potsdam (AIP), Germany; Søren Meibom, Harvard-Smithsonian Center for Astrophysics, USA; José Dias do Nascimento, Universidade Federal do Rio Grande do Norte, Brazil

Gyrochronology – the method by which ages of cool dwarf stars can be derived from their rotation periods – is now over a decade old, and has become a useful and accepted member of the family of age indicators. The technique has many demonstrated advantages, but challenges exist, and more work is needed to extend empirical age-rotation relations to cool stars of lower mass, higher age, and non-solar metallicities. Additional uncertainties include those of applicability to binary stars or exoplanet systems of certain architectures. This splinter session will focus on these challenges, the work currently being undertaken to overcome them, and clarify what help and solutions may result from future observational developments – like TESS and PLATO, but also including modern and long-term ground-based efforts.

Relevant themes/questions are:

A. What are the prospects for establishing age-rotation relations for M dwarfs?

B. Can age-rotation relations be extended to the age of the Sun and beyond?

C. Is binarity/exoplanet architecture a problem, and if so, under what circumstances?

D. Does metallicity affect the rotational evolution of a star?

E. Additional topics (Comparision with other age indicators, supporting data, etc.)

Context

The wave of progress ushered in by Kepler and K2 is continuing, together with steady improvements in ground-based time-series gathering. TESS will likely be launched before Cool Stars 20, and PLATO will eventually follow. M dwarfs and other low mass stars are highly sought-after targets for exoplanet searches, with the consequent desire to determine their ages. Solar-type stars in M67 have been measured, and additional efforts are underway. The literature is increasingly occupied with nonsolar-metallicity stars, and questions about the applicability of gyrochronology abound. Finally, Gaia DR2 (scheduled for Apr 2018) and following data releases will provide invaluable supporting information for both cluster and field stars. Real advantage could be taken of these events/opportunities with planning and coordination, such as that possible at this Splinter.

Tuesday Splinter Sessions

Advances in Computational Astrophysics and the Solar-Stellar-Planetary Connection

Mark Giampapa (National Solar Observatory); Mandhulika Guhathakurta (NASA HQ/Ames Research Center); Jay Bookbinder (NASA Ames Research Center); Derek Buzasi (Florida Gulf Coast University); Marc DeRosa (Lockheed Martin Solar and Astrophysics Lab)
giampapa@nso.edu, madhulika.guhathakurta@nasa.gov

Scientific Motivation

We have entered a new era in astrophysics characterized by the advent of transformative capabilities in space and on the ground. In parallel, we are entering the era of multi-petascale computing. Powerful new simulation software—coupled to the new generation of massively parallel computers—is transforming how modeling and simulations interact with observations. Going from the data to interpretative frameworks, combined with a feedback loop from the observations back to the models, has become an imperative. Concurrent with these new computational approaches, open source software, high-performance hardware, and cloud computing capabilities are much more widely available than in the past. A full scientific exploration of the themes of the 20th Cool Stars Workshop is dependent on this new computational universe.

This splinter session will highlight computational advances at the frontiers in the heliospheric/asterospheric hierarchy, extending from the generation of solar-stellar activity to its impact on the ambient conditions of planetary systems. Efforts in petascale computing and associated visualizations, as applied to the solar-stellar-planet connection, will enable advances in both modeling and simulation and data analysis/reduction software, which promise to continue the transformation of observation and modeling interactions. Models with visualizations and simulations, together with observations, empower us to originate and explore new theories and to develop physical intuition about complex systems in ways never before attained.

Program Format

The speakers will highlight recent research and future directions in computational astrophysics that seek to advance our understanding of the nature and origin of solar-stellar activity, including impacts on asterospheres and planetary systems, as an integrated system. An equally important goal is to provide an impetus and a context for building a hierarchy of community-based modeling codes that interface seamlessly, in which data can be assimilated smoothly from space-based observatories and ground-based facilities. Both observers and modelers could provide synergistic feedback to produce model-driven code applications and new, model-driven observations along with data-driven models.

Panel discussion participants will engage the audience in a variety of topics that, among other salient issues, address:

- What are the primary computational platforms now, and what is needed in the future?
- What is the status of community/open source modeling efforts (e.g., MESA)?
- What will a community user need in background and data in order to provide useful input to obtain informative results from these codes?
- What does the theorist/modeler need in terms of observational parameters?

Know Thy Starspot, Know Thy Star

Garrett Somers (Vanderbilt University), Rachael Roettenbacher (Stockholm University), James Davenport (Western Washington University, University of Washington), Michael Gully-Santiago (NASA Ames)
knowthystarspot@gmail.com

The regions of intense magnetic activity and suppressed convection known as starspots are a ubiquitous feature on the surface of cool stars. Sometimes maligned as a contaminating nuisance for spectral typing and planet finding, starspots are instead an important and fascinating physical phenomenon deserving of intensive study in their own right. They represent a fundamental component of the surface layers of magnetically-active and rapidly-rotating stars, which cannot be neglected.

Ample historical literature exists on the detection and characterization of starspots using diverse techniques such as Doppler imaging, spectroscopy of Zeeman-broadened absorption lines, and molecular band flux measurements. Piggy-backing on this legacy, the last few years have witnessed a slew of new spot detection methods come to maturation, which harness different observational techniques such as interferometry, two-temperature spectral modeling, exoplanet transits, and high cadence space-based photometry. These recent advances have brought fresh insights into the nature of spot temperatures, sizes, and distributions, and we are only beginning to scratch the surface.

Concurrent with this spot characterization renaissance has been the growing recognition that starspots, and magnetic activity more generally, play a major role in shaping the structure and evolution of active stars. Numerous astrophysical puzzles, including the enigmatic radius inflation phenomenon, spreads in age and lithium abundance during the pre- and zero-age main sequences, and the mysterious existence of sub-sub-giants, have been credibly suggested as bi-products of spot-induced perturbations to stellar structure. Fully unraveling the mystery of starspots thus promises important implications across the full sweep of cool star astrophysics.

Given these recent advances, the time is ripe for the community to coalesce and discuss what we have learned about the detection, characterization, and broader implications of starspots. We are planning a wide-ranging conversation centered on two major topics, summarized in the title of the splinter:

Know Thy Starspot: New research on the detection, characterization, and properties of spots themselves the dozen or so starspot measurement techniques currently in use by the community. These including surface distributions, dependence on age and evolutionary state, and spot lifetimes.

...Know Thy Star: Stellar astrophysical results pertaining to starspots. These include the direct influence of spots on stellar structure and evolution, the influence on inferred stellar properties, and more.

Meter- to Millimeter Emission from Cool Stellar Systems: Latest Results, Synergies Across the Spectrum, and Outlook for the Next Decade

Jan Forbrich (Hertfordshire), Peter Williams (CfA) Edo Berger (CfA), Manuel Güdel (Vienna), Rachel Osten (STScI)
j.forbrich@herts.ac.uk, pwilliams@cfa.harvard.edu

In this splinter session, participants will take stock of the present state of stellar radio astronomy and chart a course for the field's future, emphasizing:

- **Latest results:** what are the cutting-edge astrophysical insights created by radio observations performed with powerful new facilities like the upgraded VLA and ALMA?
- **Synergies across the spectrum:** what unique astrophysics can be achieved through the combination of observations at radio and other wavelengths? This question is particularly timely given the number of revolutionary observatories coming online (at both radio and shorter wavelengths) in the next few years.
- **Outlook for the next decade:** how will studies of stellar magnetism and high-energy stellar processes be transformed by the next generation of radio facilities and complementary observatories? Special attention will be paid to SKA, the ngVLA, and the upcoming US Decadal Survey of astronomy and astrophysics.

Nonthermal radio emission, in the context of cool star radio astronomy, has traditionally encompassed mainly (gyro)synchrotron radiation and centimeter and millimeter wavelengths, i.e., emission from (mildly) relativistic electrons in magnetic fields. But recent years have shown a variety of other ways in which radio observations can deliver astrophysical insight. The discovery of brown dwarf radio emission has rekindled interest in electron cyclotron maser (ECM) emission as just one of several intriguing physical mechanisms in this regime, many of which are stepping stones toward studies of low-frequency exoplanetary radio emission. VLBI observations of stellar radio emission can be used to obtain precision astrometry—and hence precise measurements of fundamental parameters—of ultracool dwarfs or young stellar objects that are not accessible even to Gaia. Broadband, high-time-resolution studies of flares reveal the detailed plasma processes operating in the coronae of other stars.

The world's best present-day radio observatories—chiefly the VLA and ALMA—launched the stellar radio astronomy renaissance. This is particularly true for constraints on nonthermal emission, which are particularly dependent on continuum sensitivity. Spectral indices, polarization, and variability all require high S/N detections to derive meaningful constraints. The upgraded VLA and VLBA as well as Arecibo now provide such information in the cm wavelength range, ALMA is doing so in the mm wavelength range, and LOFAR, MWA, LWA, HERA, and GMRT are making new forays into the low-frequency range. As a result of these newly feasible measurements, we are obtaining unique information on the role of magnetic fields on various scales and a new and complementary perspective on high-energy processes. These scales now even include outflows/jets from protostars and T Tauri stars, providing initial evidence for magnetic fields in young stellar environments.

The new generation of low-frequency radio observatories promises to figure especially prominently in the upcoming decade of stellar radio astronomy. These observatories can monitor the whole sky nearly continuously, surveying for stellar flares, coronal mass ejections, and other heliospheric phenomena. They are also expected to be the only facilities that will be able to directly probe the magnetic fields of extrasolar planets, through auroral radio bursts, providing unique insight into an essential facet of exoplanetary habitability.

There are important synergies of nonthermal radio emission with other wavelength ranges, and these will also be featured in this splinter session. These are mainly due to the beginning of radio time domain astronomy with the advent of sensitive continuum receivers, as seen for instance in the nearly-complete MeerKAT telescope. It is now possible to systematically study high-energy processes in both the X-ray and the radio time domain, and capabilities for doing so will increase dramatically when eROSITA commences operations. Understanding the correlations between optical and radio variability will be essential in the era of first TESS, then LSST.

While we expect most of the presenters to be astronomers with radio observing experience, our goal is to facilitate a splinter session that is highly relevant to a broad swathe of the Cool Stars community. For radio and non-radio astronomers in the audience alike, it will provide a forum to share the latest developments in areas such as stellar magnetism and stellar plasma physics. Motivated by the timeline of the US Decadal Survey and the suite of new instruments becoming operational in just the next few years, participants will pool their expertise to envision how they can leverage the current and upcoming generation of radio facilities to make the next round of discoveries.

Thursday Splinter Sessions

Stellar Brightness Variations: building on the solar knowledge

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The unprecedented precision of stellar brightness measurements achieved by the planet-hunting space telescopes initiated a new era in stellar photometric variability investigations. Understanding stellar brightness variations is of great interest to the solar, stellar, and exoplanetary communities, for the following reasons: Stellar brightness variations can provide constraints on the historical solar variability and solar role in climate change, as well as they allow to determine stellar magnetic cycles' properties. Moreover, stellar brightness variations are a limiting factor for detection and characterisation of the exoplanets via transit photometry. Recently, a plethora of observational data have pushed ahead theoretical studies aiming at developing methods for extracting information about stars and their planets from the available records of brightness variations. These studies can greatly profit from knowledge acquired by studying the Sun. Thus the way forward is to focus on the solar-stellar comparison and examining how the solar paradigm can help us to explain variability of other stars and develop criteria for distinguishing between typical photometric signatures of intrinsic stellar variations and exoplanet transits.

Key Topics

1. Observing stellar photometric variability
2. Advances in modelling stellar photometric variability
3. Exoplanet detection and limiting factors
4. State-of-the-art in solar irradiance modeling

Solar Physics with the DKIST

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The Daniel K. Inouye Solar Telescope (DKIST) will be the largest and most data-intensive solar telescope ever built.

When complete, the DKIST will observe the Sun, our nearest cool star, at extremely high temporal and spatial resolution with new adaptive optics technology and a suite of five instruments covering the solar spectrum from 380 nm – 4.7 microns. The DKIST will reveal the nature of the Sun's magnetic fields from the photosphere through the corona, it will resolve the turbulent motions predicted in the Sun's photosphere, and it will provide new diagnostics for the solar eruptive events that produce our space weather.

At Cool Stars 20, we will convene a splinter session to bring the wider stellar and solar astrophysics communities up to speed on the current major problems in solar physics and how these problems will be addressed with the DKIST. In particular, we will summarize several major science areas that are being discussed within a series of Critical Science Plan Workshops, an undergoing effort led by NSO to involve the community and prepare for the wide variety of science areas that will be transformed in the era of the DKIST.

Formation and evolution of star clusters in the Gaia Era

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Introduction

Most of the stars do not form in isolation but in clusters and associations composed of a few tens to a few millions of members. During the first 10–100 Myrs star clusters undergo a rapid evolution, which most times leads to their dispersion (e.g. Lada & Lada, 2003). The physical properties (e.g., mass and density) of young star clusters affect the evolution of both stars and planetary systems. In fact, in very dense environments close encounters and feedback from massive stars can alter the orbital properties of multiple systems, destroy or truncate protoplanetary discs, or trigger the ejection or the migration of newborn planets (e.g. Parker & Goodwin 2009; Adams 2010). Furthermore, studying the mechanisms driving the dynamical evolution of young star clusters and their early dispersion is critical to understand differences between stellar populations in open clusters and in the Galactic field as well as the evolution of the Milky Way.

Despite the large number of observations dedicated to young clusters (age < 100 Myr), several issues on their formation and evolution are still debated. Some authors suggest that almost all stars form in high density environments and low density associations are just the result of dynamical evolution (e.g., Kroupa 2001; Baumgardt & Kroupa 2007). However, recent results challenge this view suggesting that stars form in a hierarchically structured environment spanning a large range of densities (e.g. Bressert et al. 2010; Wright et al. 2016; Vicente et al. 2016; Costado et al. 2017; Gonzalez & Alfaro 2017; Ward & Kruijssen 2018; Wright & Mamajeck 2018). The cluster dispersion could be driven by the stellar feedback (e.g., Goodwin & Bastian 2006), or according to recent simulations, by two-body stellar interactions (e.g., Kruijssen et al. 2012; Parker & Dale 2013).

The Gaia Revolution: opportunities and challenges

This field of research has been recently boosted by the Gaia space mission (Gaia Collaboration 2016) and its associated spectroscopic survey APOGEE (Majewski et al. 2017) and Gaia-ESO (Gilmore et al. 2012; Randich & Gilmore 2013). Spectroscopic observations of young clusters revealed a complex kinematic structure, the presence of multiple populations (Jeffries et al. 2014; Sacco et al. 2017) and a discrepancy between velocity dispersion in stars and protostellar cores (Foster et al. 2015; Rigliaco et al. 2016; Stutz & Gould 2016; Sacco et al. 2017). Studies based on the first Gaia data release confirmed the complex structure and star formation history of massive star forming regions (Zari et al. 2017) and found evidence that not all the stars form in dense clusters (Ward & Kruijssen 2018; Wright & Mamajeck 2018).

The second Gaia data release—scheduled for the 25th of April—will provide astrometric parallaxes (precision 0.04–0.7 mas), proper motions (precision 0.06–1.2 mas/yr), and three bands photometry for more than one billion sources with a limiting magnitude of $G{\sim}21$ as well as radial velocities (precision 0.2–1.2 km/s) for six million of late type stars with $G < 12$. This new dataset will provide several opportunities, but also open some challenges. New dedicated tools that take into account of potential biases and use modern statistical techniques need to be developed and complex numerical simulations are required for going from the observables to meaningful physical quantities.

Goals of the Splinter Session

The aim of this splinter session is to put together scientists, which are actively working in this field both on the analysis of data and on the development of theoretical models to:

- Summarize the recent progresses in the field and outline the remaining open issues;
- Present the earliest results obtained from the analysis of the data of the second Gaia release;
- Foster new collaborations to improve analysis tools;
- Enhance the synergies between observers and theorists

Instructions for the Conference Proceedings

Proceedings for Cool Stars 20 will be entirely electronic. Submission will be handled using Zenodo, an EU funded data and project repository, and then indexed on the ADS. All submissions are assigned a Digital Object Identifier (DOI) number through Zenodo, making contributions citeable, before indexing to ADS to make contributions discoverable. Submission to the arXiv in parallel with submission to the conference proceedings is encouraged. Contributions are accepted from invited plenary session reviews, contributed plenary session talks and splinter session talks, and contributed posters. In addition, collective contributions from (parallel) splinter sessions and contributions from the CS20 hack day are welcome. If you would like to submit a typical conference proceeding, there are no formal page limits. However for some guidance, we recommend you limit yourself to 4–8 pages for contributed talks and 10–15 pages for invited talks. Those wishing to submit a written conference proceeding are encouraged to format the document using the Cool Stars 20 LaTeX document class. All such submissions should be made as PDFs and will be reviewed for content by the SOC and we may suggest edits.

Submission of presentation slides from speakers and full posters are also encouraged. PDF versions of these documents are the preferred format for Zenodo contributions to permit the documents to be previewed in a web browser. For maximum impact, you can submit both, a written contribution and your presentation slides and/or a poster to provide greater context. Contributions will be checked for the proper metadata.

Briefly, to submit, go to https://zenodo.org/communities/cs20/ and click on the green ”New upload” button. We will provide more detailed instructions in the next few weeks. Please visit the Cool Stars 20 website for the most current and detailed instructions.

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Talks

Sunday, 29 July

Early Results from the Transiting Exoplanet Survey Satellite (TESS)

Sun
19:30
Invited Talk

George Ricker for the TESS Science Team
MIT

The Transiting Exoplanet Survey Satellite (TESS) will discover thousands of exoplanets in orbit around the brightest stars in the sky. In a two-year survey, TESS will monitor 200,000 pre-selected bright stars for planetary transits in the solar neighborhood at a 2-minute cadence. The survey will identify planets ranging from Earth-sized to gas giants, around a wide range of stellar types and orbital distances. TESS will also provide full frame images (FFI) at a cadence of 30 minutes or less. These FFI will provide precise photometric information for every object within the 2300 square degree instantaneous field of view of the TESS cameras. In total, more than 30 million stars and galaxies brighter than magnitude I=16 will be precisely photometered during the two-year prime mission. In principle, the lunar-resonant TESS orbit will provide opportunities for an extended mission lasting more than a decade, with data rates of 100 Mbits/s.

An extended survey by TESS of regions surrounding the North and South Ecliptic Poles will provide prime exoplanet targets for characterization with the James Webb Space Telescope, as well as other large ground-based and space-based telescopes of the future. The TESS legacy will be a catalog of the nearest and brightest main-sequence stars hosting transiting exoplanets, which should long endure as the most favorable targets for detailed future investigations.

The launch as a NASA Astrophysics Explorer is to take place in April 2018 from Cape Canaveral on a SpaceX Falcon 9 rocket. First light results from the TESS mission will be presented.

Monday, 30 July: Galactic Cartography in the Gaia Era

Mon
8:45
Invited Talk

Status of the Gaia Mission and the Gaia DR2 Results

F. Thévenin

Université de la Côte d'Azur, Observatoire de la Côte d'Azur, CNRS

The Gaia mission is in its forth year of work, and is a key space mission devoted to astrometric measurements of stars. More than astrometric data will be delivered in the Gaia DR2, 3, 4 and the mission is now foreseen to be extend. For the Gaia DR2 one of the most important result is the parallaxes of 1.3 billion sources with accurate determinations. The use of them deserve some attention and carreful read of the companion papers that explain in details how to use the catalogue and what are the limits. On the 25 April the catalog will be on line for all the community of astronomers to produce stellar astrophysics from young to very old stars, isolated or in clusters. The return on the physics of stars is vast and for sure will be a central part of the workshop. Inputs on the parallaxes and PM or first estimates of Teff and reddening of stars or radial velocities and more outputs will be presented and discussed.

Mon
9:20

The Chemical Homogeneity of Sun-like Stars in the Solar Neighborhood

Megan Bedell

Center for Computational Astrophysics, Flatiron Institute

The compositions of stars are a critical diagnostic tool for many topics in astronomy such as the evolution of our Galaxy, the formation of planets, and the uniqueness of the Sun. Previous spectroscopic measurements indicate a large intrinsic variation in the elemental abundance patterns of stars with similar overall metal content. However, systematic errors arising from inaccuracies in stellar models are known to be a limiting factor in such studies, and thus it is uncertain to what extent the observed diversity of stellar abundance patterns is real. We have performed an analysis of 79 Sun-like stars within 100 parsecs and achieve abundance measurements of 30 elements with precisions of 2 percent. Systematic errors are minimized in this study by focusing on solar twin stars and performing a line-by-line differential analysis using high-resolution, high-signal-to-noise spectra. We resolve [X/Fe] abundance trends in galactic chemical evolution at precisions of 10^{-3} dex Gyr^{-1} and reveal that stars with similar ages and metallicities have nearly identical abundance patterns. These results imply that exoplanets may exhibit much less compositional diversity than previously thought. We also discuss new insights from this data set on the

dimensionality of chemical abundance space and prospects for chemical tagging studies.

3D mapping of the Solar Neighbourhood with Gaia DR2

Mon 9:35

Eleonora Zari; Anthony Brown

Leiden Observatory

Because of their relatively short lifetimes, O and B type stars are good tracers of recent star formation events in the Milky Way and in other galaxies. Bouy & Alves (2015) analysed the spatial density of OB stars within 500 pc from the Sun using the Hipparcos catalogue and reported the discovery of large scale stream-like structures.

We plan to use Gaia DR2 to expand Bouy & Alves study, aiming at: 1) tracing the spatial distribution of early-type stars in the Solar Neighbourhood, making use of Gaia DR2 precise astrometry; 2) producing an age map of the Solar Neighbourhood using Gaia photometry to determine stellar ages; 3) tracing the kinematics of the Solar Neighbourhood using Gaia proper motions and radial velocities. The interpretation of the global age map in conjunction with the 3D spatial and kinematic map will allow to draw a picture of the star formation history of the Solar Neighbourhood.

A few months after Gaia DR2, we will present our results from an initial exploration of Gaia DR2 data and show how this incredibly large amount of information will revolutionise our understanding of large-scale star formation processes.

Rotating Stars from Kepler Observed with Gaia DR2

Mon 9:50

James R. A. Davenport[1,2]; Ruth Angus[3]; Kevin R. Covey[2]; David Kipping[3]; Marcel Agüeros[3]

University of Washington; Western Washington University; Columbia University

The Kepler mission produced rotation period measurements for more than 30,000 stars, enabling for the first time statistical studies of the age distribution of field stars using ”gyrochronolgy”. Intriguingly, McQuillan et al. (2013, 2014) also discovered a bimodal distribution of rotation periods for nearby M and K dwarfs, suggesting a dearth of stars with ages of 600 Myr. Using Gaia DR1, Davenport (2017) found this bimodality extended to the G dwarfs within 300 pc as well, having previously been obscured due to subgiant contamination. Using parallaxes from Gaia DR2, we are now able to explore the bimodal

rotation period distribution for all main sequence Kepler stars as a function of their distance. This new sample allows us to constrain the volumetric extent of this period bimodality, and thus explore the recent star formation history of the Milky Way disk in 3D.

Mon
10:55
Invited Talk

Status and Results for the Spectroscopic follow up of Gaia

Antonella Vallenari
INAF

TBD

Mon
11:30

The Dynamics of OB Associations

Nicholas J. Wright
Keele University, UK

The formation and evolution of young star clusters and OB associations is fundamental to our understanding of the star formation process, the conditions faced by young binary and planetary systems, and the formation of long-lived open and globular clusters. Despite this our understanding of the physical processes that drive this evolution has been limited by the static nature of most observations. This is all changing thanks to a revolution in kinematic data quality from large-scale radial velocity surveys and new astrometric facilities such as Gaia. I will present new kinematic data for multiple OB associations from Gaia and ground-based astrometric surveys that show they have considerable kinematic substructure and no evidence for the radial expansion pattern predicted by theories such as residual gas expulsion. This means that, contrary to the standard view of OB associations as expanded star clusters, these systems could never have been dense star clusters in the past and were most likely born as extended and highly substructured groups of stars. This places strong constraints on the primordial clustering of young stars and the conditions faced by young planetary systems.

Towards the six-dimensional view of the Orion Complex

Mon 11:45

Marina Kounkel[1]; Kevin Covey[1]; Genaro Suarez[2]; Carlos Román-Zúñiga[2]; Jesus Hernandez[2]; APOGEE collaboration

Department of Physics and Astronomy, Western Washington University, 516 High Street, Bellingham, WA 98225, USA; Instituto de Astronomía, Universidad Nacional Autónoma de México, A.P. 70-264, 04510, Mexico, D.F., México

We present the analysis of spectrosopic and astrometric data from APOGEE-2 and Gaia (DR1 and later DR2) that trace the structure as well as the star forming history within the Orion Complex. Applying a hierarchical clustering algorithm to the 6-dimensional data, we identify spatially and kinematically distinct groups of young stellar objects with ages ranging from 1 to 12 Myr. We find substructure in the massive clusters such as NGC 2024 and λ Ori. We also reconstruct the population of the currently dissipated Orion C molecular cloud which formed σ Ori, and is independent from Ori OB1ab region. With the current data, these structures are most distinct in the radial velocity space; with Gaia DR2 it will be be possible to achieve a comparable resolution in the proper motions and parallax space, which will further improve on both the ability to identify subclusters and derive ages. These observations provide an unprecedented portrait of the structure and dynamics of the Orion Complex, a region that provides a critical case study for cluster assembly within a molecular cloud and the subsequent cluster dispersal.

Physical properties of evolved Open Clusters in the Gaia era

Mon 12:00

L. Casamiquela[1]; C. Soubiran[1]; H. Bouy[1]; U. Heiter[2]; P. Jofré[3]; S. Blanco-Cuaresma[4]

Laboratoire d'Astrophysique de Bordeaux -CNRS; Uppsala Universitet; Universidad Diego Portales; Harvard-Smithsonian Center for Astrophysics

Evolved Open Clusters (OCs) are excellent tracers of the formation and evolution of the galaxy, as well as an ideal laboratory to test theories of star formation and evolution. In particular, nearby OCs are commonly used as benchmark objects to assess the determination of physical properties of field stars. We have designed a project to perform an in-depth study of the physical properties of a sample of nearby clusters: 13 OCs at 500 pc around the Sun. We determine shape, radii, extinction, galactic velocity, age and chemical composition, using recent data from Gaia DR2, asteroseismic information from K2, ground-based spectroscopic surveys and other complementary high resolution spectroscopic data. This project has many applications, including validation of stellar evolution

theories and calibration of parametrization methods. Also it has the potential to answer questions: how do the structural properties correlate with the age of the OC and with the environment?, what is the formation mecanism of tidal tails?, what is the influence of density, age and galactic environment in the disruption process of OCs? We will present the first results of this project short after the release of Gaia DR2.

Mon
12:15

Metal-poor stars observed by Gaia-ESO and other large stellar spectroscopic surveys

Rodolfo Smiljanic

Nicolaus Copernicus Astronomical Center, Poland

I will present an overview of the properties of about 1300 metal-poor stars (defined here as those with [Fe/H] $<$ -0.8 dex) observed by the Gaia-ESO Spectroscopic Survey so far (internal data release 5). Stars observed both with the UVES and Giraffe spectrographs are included in the sample. When possible, Gaia parallaxes and proper motions will be used to compute their kinematics and orbits. I will report on an analysis using machine learning techniques with the aim of disentangling the various stellar populations at the low metallicity regime, including the thick disk, the metal-weak thick disk, and the different halo components. Further, I will report on similar analyses using samples of metal-poor stars taken from public releases of other large spectroscopic surveys (e.g., RAVE and APOGEE). Finally, I will also highlight the need to improve the analysis of metal-poor stars in these surveys. For example, a comparison between observations and model isochrones in the $T_{\rm eff}$ vs. $\log\ g$ plane shows that spectroscopic values of temperature and gravity tend to have important accuracy issues.

Tuesday, 31 July: Solar/Stellar Magnetic Fields and Surface Structure

Stellar magnetism: origins, effects, and enigmas

Tue 8:30 **Invited Talk**

Matthew Browning[1]; Laura Currie[1]; Lucia Duarte[1]; Lewis Ireland[1]; Felix Sainsbury-Martinez[1]; Maria Weber[2,3]

University of Exeter; University of Chicago; Adler Planetarium

All main-sequence stars transport some energy by convection, whether within a central core (as in massive stars), a convective envelope (as in the Sun), or throughout the interior (as in lower-mass stars). In many cases this convection, coupled to rotation and occurring in regions of high electrical conductivity, likely acts to build magnetic fields through dynamo action. The resulting magnetism leads to a host of observable effects, with the high-energy emission from a star, its rotational evolution, and perhaps even its overall structure all influenced (in certain cases) by the magnetic fields. I will review how the fields probably arise, and what they do, drawing partly on the results of large-scale numerical simulations that have sought (together with 1-D models and basic theory) to model stellar interiors with reasonable fidelity. I will argue that the theoretical models can provide some insight into how strong the fields can get, what spatial and temporal structure they might have, and how these things depend on parameters like the overall rotation rate or stellar mass – but will also highlight some enduring puzzles that have yet to be solved.

Simulations of Flux Emergence in Cool Stars: What's Convection, Rotation, and Stellar Structure got to do with it?

Tue 9:05

Maria Weber[1,2]

University of Chicago; Adler Planetarium

Establishing the details of magnetic flux emergence plays a key role in deciphering stellar dynamos and starspot properties. Motivated by the fibril nature of solar surface magnetism, insight into the flux emergence process has been obtained by assuming the bundles of magnetic field giving rise to starspots consists partly of idealized, buoyantly rising thin flux tubes (TFTs). Here we present multiple sets of TFT simulations in rotating spherical shells of convection representative of cool stars. Our solar simulations reproduce sunspot observables such as low-latitude emergence, tilting action toward the equator following the Joy's Law trend, and a phenomenon akin to active longitudes. We comment

on the effect of rotation and convective flows (both local and mean) on the subsequent evolution of rising flux tubes in Suns rotating at three and five times the solar rate. Typically, rapid rotation deflects the flux tubes poleward, while strong radial flows distort the flux tube and differential rotation supplies it with added torque. Such TFT simulations share similarities, and a few differences, with buoyant magnetic structures that have recently been realized self-consistently in a unique set of convective dynamo simulations. Finally, we compare our TFT models in partially convective stars to those of fully convective M dwarfs. In these simulations computed at the solar rotation rate, the expected starspot latitudes deviate from the solar trend, favoring significantly poleward latitudes unless the differential rotation is sufficiently prograde or the magnetic field is strongly super-equipartition. This work is a step toward linking magnetic flux emergence, convection, and dynamo action along the lower end of the main sequence.

Tue
9:20

Exploring the Role of a Tachocline in M-Type Stars' Magnetism

Connor Bice[1,3]; Juri Toomre[1,3]; Benjamin Brown[2,3]

JILA; LASP; Department of Astrophysical and Planetary Sciences, University of Colorado, Boulder

M-type stars are quickly stepping into the forefront as some of the best candidates in searches for habitable Earth-like exoplanets, and yet many M-stars exhibit extraordinary flaring events which would bombard otherwise habitable planets with ionizing radiation. Stars' propensity for such flaring appears to be intimately tied to their rotation rates in a rotation-activity relation, with fast rotators (Ro $\leq$ 0.1) reaching a plateau in observational proxies for magnetic activity such as X-ray luminosity. Observers also find that the fraction of M-type stars which are magnetically active rapid-rotators transitions swiftly from roughly 10$\%$ for main-sequence stars earlier (more massive) than spectral type M3.5 (0.35 $M_\odot$), to nearly 90$\%$ for stars later (less massive) than M3.5. Suggestively, stars below 0.35 $M_\odot$ become fully convective and may no longer contain a tachocline, a shear layer revealed by helioseismology to lie at the base of the solar convection zone, and which is traditionally thought to be fundamental in organizing the solar dynamo. Using the spherical MHD code Rayleigh, we have compared the peak field strengths, topologies, and time-dependencies of the dynamos generated within slowly (Ro $\sim$ 0.4) and quickly (Ro $\sim$ 0.05) rotating stars of masses 0.3 $M_\odot$ and 0.375 $M_\odot$, finding some evidence for distinctive differences in the magnetism of stars containing tachoclines relative to their fully convective counterparts.

Probing the surfaces of Sun-like stars using transiting planets and 3D magneto-hydrodynamical simulations

Tue 9:35

H. M. Cegla

University of Geneva

Our ability to spatially resolve and visually inspect the solar surface makes the Sun the best studied star to date. Even so, the intricacies of many surface phenomena are poorly understood, especially once we move beyond the Sun. Not only will this prevent us from confirming Earth-like planets, but it also limits many areas of stellar physics, such as dynamo theories. In this talk, I will present a new technique to use transiting planets as probes to spatially resolve stellar spectra. With this, we can inspect centre-to-limb variations in the local absorption line profiles shape and net velocity. In turn, this allows us to search for signatures of magnetic activity (e.g. magneto-convection, spots, faculae) and surface differential rotation (as well as determine the star-planet alignment). It also means that, for the first time, we can make detailed comparisons with 3D magnetohydrodynamical simulations of main-sequence stars other than the Sun. We have successfully applied this technique to a G, K, and M dwarf (WASP-8, HD189733, GJ436); for our brightest target, HD189733, we can detect significant differential rotation and confirm good agreement with MHD simulations. For the Sun, we can make more precise centre-to-limb comparisons, and examine the impact of the magnetic field on convective variations. I will also demonstrate how we can use the simulations to predict the relationship between convection-induced line profile shape variations and radial velocities.

Identifying the spectroscopic signatures of magnetic features on the surfaces of the Sun and Sun-like stars

Tue 9:50

Raphaëlle D. Haywood; the HARPS-N Solar Telescope Team

Harvard College Observatory

Magnetic activity features, such as faculae, spots, granulation, and flares leave an imprint in the optical spectrum of a star. Their spectroscopic signatures inform our knowledge of stellar magnetic fields, velocity flows and convection processes; they are also the main obstacle to detecting and characterising small planets orbiting Sun-like stars. The Sun is the only star whose surface can be imaged directly and at high spatial resolution, allowing us to identify the spectroscopic signatures of individual features directly. We use full-disk images from the Helioseismic and Magnetic Imager onboard the Solar Dynamics Observatory (SDO/HMI) to reconstruct the disk-integrated radial-velocity of the Sun. We compare our reconstructed radial velocities to spectroscopic observations of sunlight reflected from the asteroid Vesta, and of the Sun seen as a distant, point-like star through the HARPS-N Solar Telescope. We find that the intrinsic radial-velocity variations of the Sun arise predominantly from suppression of convective blueshift by faculae, rather than spots. This is in agreement with our analysis of simultaneous spectroscopic and photometric observations of the Sun-like star CoRoT-7. We are now reconstructing the shape of the Fe I line at 6173A observed by SDO/HMI, which displays distortions induced by magnetic features, particularly faculae. Comparing these line-profile distortions with the cross-correlation functions of the HARPS-N spectra, we will identify a proxy for faculae, which will enable us to see faculae in observations of Sun-like stars.

Tue
10:55
Invited Talk

The devil is in the details: spicules, jets and the fine structure of the solar atmosphere

Gianna Cauzzi[1,2]

National Solar Observatory, USA; INAF-Arcetri, Italy

The proximity of our Sun allows us to observe the atmosphere of a star in exquisite details, with current facilities routinely reaching resolutions of few 100 km at the solar surface. These observations of the outer solar atmosphere reveal a plethora of magnetically driven, highly dynamic features such as spicules, jets or flare-related transients (just to name a few), many occurring at scales we can’t yet fully resolve. While most of these features seem to interact with the coronal plasma, their actual role in providing mass and energy to the corona and the solar wind remains uncertain - a debate fueled by the difficulty in properly deriving their physical characteristics.

In this talk I will focus on state-of-the-art, high-resolution observations of the dynamic solar atmosphere, in particular the chromosphere and transition region, and on current efforts in interpreting and modelling the polarimetric data in terms of the underlying magnetic and thermodynamic structure. I will discuss the prospects for making significant progress in resolving some of these questions using the four-meter aperture Daniel K. Inouye Solar Telescope (DKIST), with first light expected in 2020.

The Rarity of Sun-like Activity Cycles and their Dependence on the Rossby Number

Tue 11:30

Ricky Egeland[1]; Willie Soon[2]; Sallie Baliunas; Jeffrey C. Hall[3]

High Altitude Observatory at NCAR; Harvard-Smithsonian Center for Astrophysics; Lowell Observatory

The magnetic activity of a few dozen solar-analog stars have been observed using the Ca II HK proxy for about 50 years. In this small sample, we find that smooth, regular Sun-like cycles are exceedingly rare. Returning to the larger FGK-type sample of Baliunas et al. 1995, we have combed the literature for rotation period measurements and used these to compute the Noyes et al. 1984 semi-empirical Rossby number. Analyzing the statistics of this larger sample, we find that most of the known high-quality Sun-like cycles are from K-type stars, and of the G-type stars only the Sun and the subgiant HD 81809A demonstrate Sun-like cycles. What these sets of stars have in common is a relatively large Rossby number, which we hypothesize is necessary to have a smooth, approximately mono-periodic variability like the Sun. Finally, we will review the importance and problematic derivation of the stellar Rossby number, how it may evolve in evolved stars like HD 81809A, and how recent global convective MHD simulations stand with respect to these observational results.

Imaging Active Stellar Surfaces with Photometric, Spectroscopic, and Interferometric Observations

Tue 11:45

Rachael Roettenbacher

Stockholm University

In the outer layers of cool stars, stellar magnetism stifles convection creating localized, dark starspots. Recently, studies have shown that the presence of starspots can lead to inaccurate estimates of stellar parameters and can obscure the signal of planets. In order to begin disentangling the signatures of stellar magnetism, we image active stellar surfaces with a three state-of-the-art techniques, including ground-breaking aperture synthesis imaging. We obtain interferometric data with sub-milliarcsecond resolution from the Michigan InfraRed Combiner (MIRC) at Georgia State University's Center for High Angular Resolution Astronomy (CHARA) Array. We characterize active RS CVn binary systems and compare the interferometric images with contemporaneous Doppler images from high-resolution spectra and light-curve inversion images. We observe wide-spread regions of suppressed convection on active RS CVn primary stars that would affect stellar

parameter estimates and cannot be easily explained by dynamo theories. We extend this study by surveying spotted stars to understand how stellar magnetism changes across evolutionary states, impacts the evidence of companions and their characterization, and differs from the Sun for stars with large convective envelopes.

Tue
12:00

The Activity Cycle of HAT-P-11

Brett M. Morris[1]; Leslie Hebb[2]; Suzanne Hawley[1]; James R. A. Davenport[1, 3]; Eric Agol[1]

University of Washington; Hobart and William Smith Colleges; Western Washington University

HAT-P-11 is an active K4 dwarf in the Kepler field. We have studied its starspots with Kepler short-cadence photometry, and its chromospheric emission with echelle spectroscopy from the ground. We take advantage of starspot occultations by its highly-misaligned planet to compare the spot size and latitude distributions to those of sunspots. We find that the spots of HAT-P-11 are distributed in latitude much like sunspots near solar activity maximum, with mean spot latitude of 16 ± 1^o. The majority of starspots of HAT-P-11 have physical sizes that closely resemble the sizes of sunspots at solar maximum, with occasional spots larger than the largest sunspots. We measure the mean spotted area coverage on HAT-P-11 is 3 per cent, roughly two orders of magnitude greater than the Sun's. The similarities in spot distribution and radii are interesting given the star's similar rotation period (29 d) but smaller mass ($0.8 M_\odot$) than the Sun. The chromospheric emission of HAT-P-11 is consistent with an ~ 10 year activity cycle, which plateaued near maximum during the Kepler mission. In the cycle that we observed, the star seemed to spend more time near active maximum than minimum. We compare the log R'_{HK} normalized chromospheric emission index of HAT-P-11 with other stars. HAT-P-11 has unusually strong chromospheric emission compared to planet-hosting stars of similar effective temperature and rotation period, perhaps due to tides raised by its planet.

Enhanced stellar activity for slow antisolar differential rotation?

Tue
12:15

Axel Brandenburg[1,2]; Mark S. Giampapa[3]

University of Colorado; Nordita; National Solar Observatory

High precision photometry of solar-like members of the open cluster M67 with Kepler/K2 data has recently revealed enhanced activity for stars with a large Rossby number, which is the ratio of rotation period to the convective turnover time. Contrary to the well established behavior for shorter rotation periods and smaller Rossby numbers, the chromospheric activity of the more slowly rotating stars of M67 was found to increase with increasing Rossby number. Such behavior has never been reported before, although it was theoretically predicted to emerge as a consequence of antisolar differential rotation (DR) for stars with Rossby numbers larger than that of the Sun, because in those models the absolute value of the DR was found to exceed that for solar-like DR. Using gyrochronological relations and an approximate age of 4 Gyr for the members of M67, we compare with computed rotation rates using just the B-V color. The resulting rotation-activity relation is found to be compatible with that obtained by employing the measured rotation rate. This provides additional support for the unconventional enhancement of activity at comparatively low rotation rates and the possible presence of antisolar differential rotation.

Wednesday, 1 August: Fundamental Properties of Cool Stars

Wed
8:30
Invited Talk

Stellar Ages and Galactic evolution: what have we learned from Asteroseismology

S. Hekker

Max Planck Institute for Solar system research; Stellar Astrophysics Centre

With the advent of space telescopes MOST, CoRoT and Kepler/K2 asteroseismology has undergone a revolution. In this talk I will discuss what we have learned from asteroseismology of cool main-sequence stars, subgiants and red giants in terms of Stellar Ages and Galactic Evolution. I will also address future prospects of asteroseismology with the launch of TESS and Plato.

Wed
9:05

Kepler/K2: mission update & overview of its cool star legacy dataset

J. Dotson[1]; G. Barentsen[2]; A. M. Cody[2]; M. Gully-Santiago[2]; C. Hedges[2]

Kepler / K2 Project Scientist, NASA Ames Research Center; Kepler Guest Observer Office / NASA Ames Research Center

The K2 survey has expanded the Kepler legacy by using the repurposed spacecraft to observe a selection of fields along the ecliptic plane. The K2 dataset includes high-precision 30-minute cadence of over 60,000 stars cooler than 4000K. K2 observations of cool stars are providing an unprecedented look at activity, flares, and rotation of cool stars. In addition, K2 has observed open and globular clusters at all ages, including very young (1-10 Myr, e.g. Taurus, Upper Sco, NGC 6530), moderately young (0.1-1 Gyr, e.g. M35, M44, Pleiades, Hyades), middle-aged (e.g. M67, Ruprecht 147, NGC 2158), and old globular clusters (e.g. M9, M19, Terzan 5). K2 observations of stellar clusters are exploring the rotation period-mass relationship to significantly lower masses than was previously possible, shedding light on the angular momentum budget and its dependence on mass and circumstellar disk properties, and illuminating the role of multiplicity in stellar angular momentum. I will review the cool stars and star clusters sampled by K2 across 18 fields so far, highlighting several characteristics, caveats, and unexplored uses of the public data set along the way. With fuel running out in 2018, I will discuss the closing Campaigns, as well as the data archive and TESS-compatible software tools the K2 mission intends to leave behind for posterity.

Fixing UV Continuous Opacities and Model Spectra for Cool Stars

Wed
9:20

Jeff A. Valenti[1]; Nikolai Piskunov[2]

STScI; Uppsala University

Opacity is a fundamental physical property and an essential ingredient in stellar models. Over the decades, observations of cool stars and the Sun have revealed a variety of opacity sources that were neglected in models. HST/STIS spectra of cool stars with accurately measured angular diameters reveal that model spectra in the near ultraviolet are too bright by as much as a factor of two over the entire wavelength range. At high spectral resolution it is clear that the model errors are in the ”continuum” between strong lines, rather than the line cores. We infer that one or more continuous opacity sources are missing from some commonly used models. The dominant opacity source in the NUV turns out to be molecular dissociation of CH, NH, and OH. New photoionization cross sections for neutral metals also increase opacity. Predicted UV fluxes are now substantially better, but discrepancies remain. UV continuum fluxes impact atmospheric structure, abundance determinations for rare elements, stellar population synthesis, and photochemistry in exoplanet atmospheres.

Non-LTE stellar parameters and abundances of metal-poor stars in the Galaxy

Wed
9:35

Rana Ezzeddine[1,2]; Tatyana Sitnova[3]; Lyudmilla Mashonkina[3]; Anna Frebel[1]

Massachusetts Institute of Technology; Joint Institute for Nuclear Astrophysics - Center of the Evolution of the Elements [JINA-CEE];Institute of Astronomy, Russian Academy of Sciences

The chemical compositions of metal-poor stars provide important observational clues to the astrophysical objects that enriched the primordial gas with elements heavier than H and He. Accurate atmospheric parameters are a prerequisite to any precise abundance determination. Spectroscopically derived stellar parameters, however, can be inaccurate when assuming Local Thermodynamic Equilibrium (LTE) methods, especially for metal-poor stars. This can have important consequent effects on the derived abundances and interpretations. In this talk, I will present Non-LTE atmospheric stellar parameters of a sample of metal-poor stars in our Galaxy. I will show that departures from LTE in stellar parameters can grow up to 1 dex in [Fe/H], 200 K in Teff and 0.6 dex in logg toward the lowest metallicities. I will reflect upon the effects that these differences can have on stellar population studies, especially in the era of large-scale surveys such as Gaia, APOGEE, RAVE and GALAH.

Wed
9:50

Optical high-resolution spectroscopy of 14 young α-rich stars

T. Matsuno[1,2]; D. Yong[3]; W. Aoki[1,2]; M. N. Ishigaki[4]

Sokendai; National Astronomical Observatory of Japan; Australian National University; University of Tokyo

Combination of asteroseismology and a large spectroscopic survey has revealed the existence of a peculiar stellar population: they look young from their mass but look old from their α-element abundances (so-called young α-rich stars). We obtained high quality optical spectra for 14 of them to confirm their reported abundances and to constrain their origin from unexplored elements. We first confirm that their α-element abundances are consistent with belonging to the α-rich population in the Galactic disk. Newly obtained abundances of neutron-capture elements are also similar to those of typical stars in the α-rich population. Although one object has been shown to have high Li abundance, the other 13 objects do not show significant abundance anomalies and we conclude that they have the typical abundance pattern of old stars over all the measured elements. Together with the high frequency of radial velocity variation, we suggest they are results of stellar merger or mass transfer from red giants.

Wed
10:55
Invited Talk

APOGEE: The Apache Point Observatory Galactic Evolution Experiment

Ricardo Schiavon for the APOGEE team

Liverpool John Moores University

The SDSS-III-IV/APOGEE survey is a dual hemisphere, high-resolution, near-infrared spectroscopic survey of the stellar populations of all components of the Galaxy, as well as some of its Local Group neighbours. By obtaining precision chemistry and multi-epoch kinematics for hundreds of thousands of stars, APOGEE is making fundamental contributions in many areas of Astrophysics, including the structure of the Milky Way Galaxy and its history of formation, globular cluster formation, multiple stellar systems, and stellar physics. In this talk I will describe the main observational aspects of the survey and present some of its science highlights.

Are open clusters chemically homogeneous?

Wed
11:30

F. Liu[1]; M. Asplund[2]; D. Yong[2]; S. Feltzing[1]; J. Melendez[3]; I. Ramirez[4]

Lund University; Australian National University; University of Sao Paulo; Tacoma Community College

The common wisdom is that all stars in an open cluster are expected to share the same chemical abundance pattern. This is a fundamental assumption of the concept of chemical tagging: the ability to identify which stars were born together even the stars are now dispersed throughout the Milky Way. However, recently we have found that this may in fact not be the case, which would have far-reaching implications. Our team has developed a differential analysis technique that has led the field of stellar chemical abundances to unprecedented precision, about 2 percent, a five-fold improvement over traditional analyses. Our study on the Hyades revealed that this open cluster is chemically inhomogeneous at the 0.02 dex level, which could be due to pollution of gas before complete mixing of the proto-cluster cloud. Our recent study on the M67 showed a clear signature of atomic diffusing to be about 0.1 dex through the evolution stage in this benchmark open cluster. Our results thus provide significant new constraints on the chemical composition of open clusters and a challenge to the current view of Galactic archeology. A window of opportunity is open to conduct high-precision chemical abundance studies of a large number of open clusters in near future, in order to investigate the intrinsic chemical inhomogeneity level as well as 'cluster-to-cluster' abundance differences.

The evolution of cool dwarf spin rates: Data, models, and tensions

Wed
11:45

Marcel Agüeros[1]; Kevin Covey[2]; Jason Curtis[1]; Stephanie Douglas[3]; Sean Matt[4]

Columbia University; Western Washington University; Harvard-Smithsonian Center for Astrophysics; University of Exeter

Stellar ages are notoriously difficult to measure accurately for low-mass stars, severely limiting our ability to address questions ranging from the evolutionary state of exoplanets to the chemical history of the Galaxy. Gyrochronology, which uses stellar rotation as a proxy for age, is a promising solution to this quandary. Unfortunately, however, theoretical calibrations of the age-rotation relation have historically been hampered by the lack of rotational measurements for large numbers of low-mass stars with a wide range of well-known ages. We are still far from being able to describe fully the evolution of rotation for low-mass stars, or from being able to use rotation measurements to estimate accurately the ages of isolated field stars. I will first summarize recent ground-based and space-based work to characterize the rotational behavior of G, K, and M dwarfs in open clusters ranging in age from 125 Myr (the Pleiades) to 3 Gyr (Ruprecht 147), and then compare these data to each other and to models for stellar spin-down in order to appraise our current understanding of the age-rotation relation.

Wed
12:00
Invited Talk

Recent developments on the formation and evolution of young, low-mass stars

R.D. Jeffries

Keele University

In this contribution I will review some of the exciting developments that have occurred in the last few years regarding the formation of low-mass stars and of understanding pre-main sequence and early stellar evolution. I will focus primarily on what has been learned by observing young open clusters in a number of large spectroscopic and photometric surveys from the ground and from space. Among the topics to be addressed will be the age-scale and dynamics of young clusters and the timescales of star formation; tests of stellar evolution models at early ages; the evolution of rotation, and the influence of magnetic fields and stellar activity on young stellar structure. I will conclude by briefly outlining some areas of progress that might be expected as a result of new surveys, particularly Gaia DR2.

Wed
12:35

The Sun as a star: the evolution of stellar activity during the main sequence

Diego Lorenzo-Oliveira[1]; Fabrício C. Freitas[1]; Jorge Meléndez[1]; Megan Bedell[2,7]; Iván Ramírez[3]; Jacob L. Bean[2]; Martin Asplund[4]; Lorenzo Spina[1,8]; Stefan Dreizler[5]; Alan Alves-Brito[6]; Luca Casagrande[4]

Universidade de São Paulo, Departamento de Astronomia do IAG/USP, Brazil; University of Chicago, Department of Astronomy and Astrophysics, USA; Tacoma Community College, USA; The Australian National University, Research School of Astronomy and Astrophysics, Australia; Institut für Astrophysik, Universität Göttingen, Germany; Instituto de Fisica, Universidade Federal do Rio Grande do Sul, Brazil; Center for Computational Astrophysics, Flatiron Institute, USA; Monash Centre for Astrophysics, School of Physics and Astronomy, Monash University, Australia

The magnetic activity of solar type stars decreases with age, but it is widely debated in the literature whether there is a smooth decline or if there is an early sharp drop until 1-2 Gyr followed by a relatively inactive constant phase. We revisited the activity-age relation using time-series observations of a large sample of 82 solar twins whose precise isochronal ages and other important physical parameters have been determined. We measured the Ca II H and K activity indices using 9000 HARPS spectra, to assess the relation between chromospheric activity and stellar age. The age-activity relation is statistically significant up to ages around 6−7 Gyr. We found evidence that, for the most homogenous set of old stars, the chromospheric activity indices seem to continue decreasing after the solar age towards the end of the main-sequence. Our results indicate that a significant part of the scatter observed in the age-activity relation of solar twins can be attributed to stellar cycle modulations effects. The Sun seems to have a normal activity level and variability for its age, being thus a normal Sun-like star.

Modelling Brightness Variability of Sun-Like Stars

Wed
15:50

V. Witzke[1]; A. I. Shapiro[1]; S. K. Solanki[1, 2]; N. A. Krivova[1]

Max-Planck-Institut für Sonnensystemforschung, Justus-von-Liebig-Weg 3, 37077, Göttingen, Germany; School of Space Research, Kyung Hee University, Yongin, Gyeonggi, 446-701, Republic of Korea

Observations of Sun-like stars revealed stellar brightness variability on multiple time-scales, where variations on the time-scales of rotational periods and of magnetic activity cycles are induced by stellar magnetic features. The interest in understanding such variations is many-fold, for example to determine stellar properties, and because they are a limiting factor in exoplanet detection. Similar brightness changes occur on our Sun, where they can be observed in detail and have been extensively studied. Thus, models for solar brightness variations have been developed for decades and provide accurate agreement with the solar observations. Since stellar variability is based on the same concepts that were used in solar irradiance models, those can be extended to investigate Sun-like stars. In our approach we focus on stars with different fundamental stellar parameters, e.g. metallicities and effective temperatures. In order to obtain realistic contrasts for magnetic features on different stars we calculate emergent spectra with the ATLAS9 code by using three dimensional (3D) cubes of near-surface magneto convection, which are obtained with the MURaM code. In particular, we show that the solar metallicity value corresponds to a local minimum for the brightness variations, which allows to explain a long-standing puzzle: The observation of the anomalously low solar variability on the magnetic activity cycle time-scale in comparison to stellar brightness variability of Sun-like stars with the same magnetic activity as the Sun.

Thursday, 2 August: Solar/Stellar Environments

The Space Weather Environment that Stars Create

Thu
8:30
Invited Talk

Rachel A. Osten

Space Telescope Science Institute, Johns Hopkins University

One of the central tenets of stellar astrophysics (and indeed, one of the rationales for the Cool Stars, Stellar Systems, and the Sun conference series) is the reciprocal utility in studying both the Sun and stars. That is, we can use the detailed knowledge gleaned about physical processes on the Sun and apply those findings to other stars. Conversely, the diversity of stars and their reach of parameter space broadens the conclusions based on a single stellar evolutionary path. The Sun's radiation, particles, and mass loss have long been known to impact the inner solar neighborhood, leading to detailed space weather studies in our solar system. The discovery of thousands of exoplanets broadens this study to consider the space weather environment that is experienced in other solar systems. The solar-stellar connection is absolutely necessary here. Recent stellar observations shed light on key differences with the middle-aged Sun. I will talk about recent results regarding extreme stellar flares and what this tells us about the scaling between solar and stellar flares and the underlying physics. I will motivate the need for a better understanding of unsteady and steady stellar mass loss, and highlight some recent results questioning the applicability of solar flare-coronal mass ejection scalings into the stellar regime. An improved understanding of how differences in stellar magnetospheric properties impact the environment around them is a necessary ingredient to put the Sun in context, and is especially important in considering the impact of a star's space weather environment.

Thu
9:05

First X-ray detection of plasma motions in a stellar flare and in the associated CME

C. Argiroffi[1,2]; F. Reale[1,2]; J. J. Drake[3]; A. Ciaravella[2]; P. Testa[3]; R. Bonito[2]; M. Miceli[1,2]; S. Orlando[2]; G. Peres[1,2]

DiFC, Università degli Studi di Palermo, Italy; INAF - Osservatorio Astronomico di Palermo, Italy; Smithsonian Astrophysical Observatory, Cambridge, MA, US

The solar corona has always been the starting point to understand all the magnetically-related phenomena occurring in stellar atmosphere. Stars however show activity levels up to 10^4 higher than the Sun. Therefore, direct observations of the different magnetic phenomena in active stars are crucial to understand how they scale with the activity level. While global coronal properties are well studied, many other phenomena, among which flaring plasma motions and coronal mass ejections (CME), remain observationally unexplored in active stars. By performing time-resolved X-ray spectroscopy of a strong stellar flare, observed with Chandra/HETGS, we present here the direct and unambiguous evidence of Doppler shifts due to upward and downward motions of plasma within the flaring loop, and, unexpectedly, also of the subsequent CME expulsion. The observed motions within the flaring loop neatly agree with HD model predictions, indicating that the standard flare model holds also for flares 10^4 more energetic than the most intense solar ones. Moreover, this first direct and clear observation of a stellar CME allows us to infer its physical properties, including mass ($\sim 10^{20}$ g) and kinetic energy ($\sim 10^{34}$ erg). These values provide fundamental constraints to extrapolate the properties of solar CME to that of active stars, and eventually to understand the potential effects of CME on exoplanetary systems.

Irradiance Coronal Dimming and its Connection to CME Kinetics

Thu
9:20

James Paul Mason[1]; Nick Arge[1]; Barbara J. Thompson[1]; David F. Webb[2]; Thomas N. Woods[3]

NASA Goddard Space Flight Center; Boston College Institute for Scientific Research; University of Colorado at Boulder Laboratory for Atmospheric and Space Research

When coronal mass ejections (CMEs) depart the corona, they leave behind a transient void. Such a region evacuated of plasma is known as coronal dimming and it contains information about the kinetics of the CME that produced it. The dimming can be so great that it reduces the overall energy output of the star in particular emission lines, i.e., dimming is observable in spectral irradiance. This should be generally true for magnetically active stars.

We use the Solar Dynamics Observatory (SDO) EUV Variability Experiment (EVE) data to search for and parameterize dimming. We search these light curves for dimming around >8,500 $\geq$C1 solar flares. In prior work, we have found that it is important to remove the gradual flare phase from dimming light curves in order to obtain slopes and magnitudes that are consistent with what can be obtained by spatially isolating flaring loops in spectral image data. Applying that method, we come to a total of 13 million light curves in which to search for dimming. We parameterize each light curve in terms of magnitude, slope, and duration and correlate these with independently-derived CME speed and mass. Thus, we obtain a robust relationship between irradiance coronal dimming and CME kinetics.

Here, we briefly describe the feature detection and characterization algorithms developed and applied to the irradiance light curves. Machine learning techniques have been used for both this backend processing pipeline and to analyze the results. All of the code is open source python available on GitHub (github.com/jmason86/James-s-EVE-Dimming-Index-JEDI). We then discuss results on the comparison between our new catalog and the established Coordinated Data Analysis Workshops' CME Catalog.

This method may be capable of not only detecting CMEs from other stars, but estimating their kinetic energy and frequency of occurrence; information needed for assessing exoplanet habitability.

Thu
9:35

Prominence formation and ejection in Cool Stars

Carolina Villarreal D'Angelo[1]; Moira Jardine[1]; Victor See[2]

SUPA, School of Physics and Astronomy, University of St Andrews; Departament of Physics and Astronomy, University of Exeter

Slingshot prominences are cool, mainly neutral clouds that are trapped in the coronae of magnetically active stars. They have been observed in single and binary G and K type stars for many years now, but they have only recently been detected in M dwarfs (Vida et al. 2016). They carry away both mass and angular momentum when they are ejected and the impact of this mass on any orbiting planets may be important for the evolution of exoplanetary atmospheres. We have recently modelled both the masses and ejection frequencies of such prominences and determined the contribution their ejection makes to the rate of loss of mass and angular momentum of the star. We have also studied the evolution of these type of prominences for a star with a mass equal to our Sun, employing a rotational evolution code (Jonhstone et al. 2015, Tu et al. 2015).

In this talk I will present our results and compare it with observed prominence masses and lifetimes for a range of stars. I will discuss the implication of the ejection of these prominences on exoplanets, and the influence that they may have had in our solar system.

Thu
9:50

Space Weather Beyond the Solar System

J. D. Alvarado-Gómez[1]; J. J. Drake[1]; G. A. J. Hussain[2]; O. Cohen[3]; J. Sanz-Forcada[4]; B. Stelzer[5]; J. F. Donati[6]; E. M. Amazo-Gómez[7]; C. Garraffo[1]; S. P. Moschou[1]

Harvard-Smithsonian Center for Astrophysics; European Southern Observatory; University of Massachusetts at Lowell; Centro de Astrobiología CSIC-INTA; Eberhard Karls Universität; CNRS-IRAP; Max-Planck-Institut für Sonnensystemforschung

Stellar magnetic fields completely dominate the environment around late-type stars. They are responsible for driving the coronal high-energy radiation (EUV/X-rays), transient events such as flares and Coronal Mass Ejections (CMEs), and the development of stellar winds and astrospheres. The study of these phenomena is nowadays possible combining Zeeman-Doppler Imaging observations of stellar magnetic fields, with sophisticated 3D magneto-hydrodynamics models of the corona and wind structure of stars. I will briefly review some generalities of this data-driven methodology and discuss two specific applications in the context of cool main sequence stars: a) The suppression of CMEs in active stars by

an overlying magnetic field, and b) The evolution of the space weather and habitability conditions through the magnetic cycle of a young Sun.

How planets affect cool stars

Thu
10:55
Invited Talk

Katja Poppenhaeger

Queen's University Belfast

All cool stars display magnetic phenomena including flares, spots, and coronal high-energy emission, collectively called magnetic activity. Cool stars also spin down over time by shedding a magnetized wind which couples to the stellar magnetic field; these magnetic effects therefore fade over timescales of gigayears. Cool stars with exoplanets in close orbits may be a fundamental exception from the age-activity-rotation relationships which govern other cool stars. In analogy to close stellar binaries, a planet and its star are thought to interact tidally and magnetically. If the planetary orbit is shorter than the stellar rotation period, angular momentum transfer from the orbit to the stellar spin can take place. This can lead to a spin-up (or inhibited spin-down) of the host stars and a shrinking planetary orbit. In addition to this long-term evolution, planets have also been speculated to trigger stellar flares or other changes in the stellar atmosphere through magnetic interaction or accretion of evaporating exoplanetary material. Observational searches for such enhanced rotation or activity of Hot-Jupiter host stars are not straightforward due to the presence of selection effects and the stochastic nature of stellar activity itself; however, there has been progress over the past years which I will report on. I will also highlight the influence these effects can have on exoplanets themselves.

Thu
11:30

Detection of a Millimeter Flare from Proxima Centauri

Meredith MacGregor[1]; Alycia Weinberger[1]; David Wilner[2]; Adam Kowalski[3]; Steven Cranmer[3]

Carnegie DTM; Harvard-Smithsonian Center for Astrophysics; University of Colorado Boulder

We present new analyses of ALMA 12-m and ACA observations at 233 GHz (1.3 mm) of the Proxima Centauri system with sensitivities of 9.5 and 47 μJy beam^{-1}, respectively, taken from 2017 January 21 through 2017 April 25. These analyses reveal that the star underwent a significant flaring event during one of the ACA observations on 2017 March 24. The complete event lasted for approximately 1 minute and reached a peak flux density of 100 ± 4 mJy, nearly a factor of $1000\times$ brighter than the star's quiescent emission. At the flare peak, the continuum emission is characterized by a steeply falling spectral index with frequency, $F_\nu \propto \nu^\alpha$ with $\alpha = -1.77 \pm 0.45$, and a lower limit on the fractional linear polarization of $|Q/I| = 0.19 \pm 0.02$. Since the ACA observations do not show any quiescent excess emission, we conclude that there is no need to invoke the presence of a dust belt at $1-4$ AU. We also posit that the slight excess flux density of 101 ± 9 μJy observed in the 12-m observations compared to the photospheric flux density of 74 ± 4 μJy extrapolated from infrared wavelengths may be due to coronal heating from continual smaller flares, as is seen for AU Mic, another nearby, well-studied, M dwarf flare star. If this is true, then the need for warm dust at ~ 0.4 AU is also removed.

Thu
11:45

Radio activity reloaded: Young Stellar Objects as seen by VLA, VLBA, and ALMA

Jan Forbrich

University of Hertfordshire

In recent years, high-energy processes in young stellar objects have largely been studied using X-ray observations. While it has been known for some time that radio observations provide complementary information on coronal activity, high-energy irradiation of both protoplanetary disks and planets, mass accretion, and jet formation, it is only now, with unprecedented observational capabilities, that we can systematically obtain this information. To highlight these capabilities, I will present results of radio surveys targeting the Orion Nebula Cluster (ONC), using the upgraded VLA and VLBA as well as ALMA, partly with simultaneous Chandra observations. Our deep VLA and Chandra observations have enlarged the sample of known radio sources in the ONC by a factor of more than 7,

enabling detailed comparisons of X-ray and radio YSO populations while providing the first systematic set of simultaneous YSO radio and X-ray lightcurves. With these data, we can look into the detailed correlation of X-ray and radio flares from YSOs, including radio spectral index information. Improved VLBA capabilities now allow us to follow up hundreds of sources in an astrometric monitoring program that is producing both a definitive census of nonthermal emission and precision astrometry of embedded YSOs that remain out of reach for Gaia, thus complementing the Gaia mission by producing a proper motion survey of embedded YSOs and a rare cross-check of absolute astrometric measurements. Last but not least, we have now used ALMA to extend our scope of high-energy phenomena from gyrosynchrotron radiation in the centimeter wavelength regime to synchrotron radiation by obtaining a first systematic set of millimeter-wavelength lightcurves of Orion YSOs. Overall, these results highlight a new perspective on high-energy processes in YSOs while serving as a stepping stone for future surveys with the SKA and ngVLA.

Full Sun Spectrally Resolved Soft X-ray Measurements from the Miniature X-ray Solar Spectrometer (MinXSS) CubeSats

Thu
12:00

Christopher S. Moore

Harvard-Smithsonian Center for Astrophysics

Detection of soft X-rays from the atmosphere of low mass stars like the Sun, provide direct information on coronal plasma at temperatures in excess of ~ 1 MK and is commonly used as a proxy for surface magnetic activity. There have been relatively few solar spectrally resolved measurements from $0.5-10.$ keV. The Miniature X-ray Solar Spectrometer (MinXSS) CubeSat is the first solar science oriented CubeSat mission flown for the NASA Science Mission Directorate, and has provided full Sun measurements from $0.8-12$ keV, with resolving power ~ 40 at 5.9 keV, at a nominal ~ 10 second time cadence. MinXSS measurements span over four orders of magnitude in photon flux and can be used to extract the spectral components of the quiet Sun, active regions and solar flares. Furthermore, elemental abundance variations among the various solar conditions yield information on plasma transport and heating processes in the corona. Finally, MinXSS solar measurements can insight in determining how complex spatial features map to full Sun integrated signatures, which is vital to understanding properties of other low mass stars.

Thu
12:15

Accretion Dynamics in Pre-Main Sequence Binary Systems

B. Tofflemire[1]; R. Mathieu[1]; G. Herczeg[2]; C. Johns-Krull[3]; R. Akeson[4]; D. Ciardi[4]; D. Ardila[5]

University of Wisconsin-Madison; Kavli Institute for Astronomy & Astrophysics, Peking University; Rice University; IPAC; JPL

Over the past thirty years, a detailed picture of star formation has emerged that highlights the significance of the interaction between a pre-main sequence star and its protoplanetary disk. This star-disk interaction has been extensively characterized in the case of single stars, revealing implications for pre-main sequence stellar evolution and planet formation. Many stars, however, form in binary or higher-order systems where orbital dynamics fundamentally alter this star-disk interaction. In short-period binaries, orbital resonances are predicted to carve out the center of the protoplanetary disk, leading to periodic accretion streams that bridge the gap between a circumbinary disk and the central stars. To test these predictions, we have conducted an intensive observational campaign combining multi-color photometry and high-resolution spectroscopy in time-series. Within these data we search for periodic trends in the accretion rate and in the velocity structures of accretion-tracing emission lines. I will present results highlighting the detection of periodic enhanced accretion events in two eccentric binaries (DQ Tau and TWA 3A) and evidence for preferential mass accretion onto the TWA 3A primary. Both results are presented in the context of recent hydrodynamic simulations of binary accretion.

Friday, 3 August: Very Low Mass (VLM) Objects

Brown Dwarfs: Cooling Into the Future

Fri
8:30
Invited Talk

Adam Burgasser
UC San Diego

The story of substellar brown dwarfs has been written in the Cool Stars conference series, from the first speculations of brown dwarfs as wide stellar companions (Cool Stars 5); to the discovery of Gliese 229B (Cool Stars 9) and brown dwarfs in young clusters (Cool Stars 9 & 10); to the definitions of the L dwarf, T dwarf (Cool Stars 12) and Y dwarf (Cool Stars 17) spectral classes. In this review talk, I highlight some of the key advancements made in this field, as conveyed by the research scientists who made them. I also reflect on the future (and future needs) of brown dwarf research with upcoming ground and space facilities, monitoring surveys, advanced computing, and citizen science initiatives.

Measuring the radius and mass of the smallest stars

Fri
9:05

Avi Shporer
MIT

Compared to the large number of planets and Sun-like stars with measured radius and mass, there are only a handful of small stars, from $\approx$0.2 $M_\odot$ down to brown dwarf mass, with these measured properties. This gap prevents testing theoretical radius-mass relations for the smallest stars. Furthermore, these stars are interesting also as transiting planet hosts, where an improved understanding of their radius and mass will lead to an improved measurement of the radius and mass of transiting planets such stars host. We are working to increase the sample size of the smallest stars with measured radius and mass. These objects are detected first as transiting planet candidates, where radial velocity follow-up identifies their true nature. This work has so far resulted in the discovery of three objects (Shporer et al. 2017, ApJL, 847, 18) and we are currently working on completing the orbit of several others.

Fri
9:20

Young brown dwarfs and the planetary spin-mass relation: new insights from K2

Aleks Scholz
University of St Andrews

While brown dwarfs show great similarities with during their early evolution, their spin evolution is much more akin to that of giant planets. We have used high precision lightcurves from the K2 mission to measure new rotation periods for brown dwarfs in star forming regions, ranging from 1 to 10Myr in age and from 0.02 to 0.08 Msol in mass (published in Scholz et al. 2015, ApJ, and Scholz et al. 2018, ApJ, submitted). Based on these robust period samples, we detect a weak link between slow rotation and the presence of disks in brown dwarfs, for the first time with mid-infrared data. The analysis of periods vs. age shows, however, that disk braking is inefficient or short-lived. By and large, young brown dwarfs retain their angular momentum through the first Myr of their evolution, in stark contrast to low-mass stars. For the first time, we demonstrate that the rotation rates of young brown dwarfs, calculated forward to the age of the solar system, fit the spin-mass relation of planets, a trend that holds over at least six orders of magnitude in object mass, including those formed by core accretion, disk fragmentation, and core collapse. We argue that studies of rotation in young brown dwarfs and planetary-mass objects have potential to shed light on the change in formation scenario as a function of mass.

Fri
9:35

High-Energy Radiation at the Substellar Boundary

K. Punzi[1]; J. Kastner[1]; D. Principe[2]; B. Stelzer[3]; U. Gorti[4]; I. Pascucci[5]; C. Argiroffi[6]
Rochester Institute of Technology; MIT Kavli Institute; Eberhard Charles University; SETI Institute; Lunar and Planetary Laboratory, The University of Arizona; INAF-Osservatorio Astronomico di Palermo

We have conducted a Cycle 18 Chandra Large Program survey of very cool members of the $\sim$8 Myr-old TW Hydra Association (TWA) to extend our preliminary study of the potential connections between M star disks and X-rays (Kastner et al. 2016, AJ, 152, 3) to the extreme low-mass end of the stellar initial mass function. Thus, we can further investigate the potential connection between the intense X-ray emission from young, low-mass stars and the lifetimes of their circumstellar planet-forming discs, as well as better constrain the age at which coronal activity declines for stellar masses approaching the H-burning limit of $\sim$0.08 $M_{\odot}$. This extended survey supports the conclusions found in

the initial survey: there exists a trend of decreasing X-ray luminosity relative to bolometric luminosity (L_X/L_{bol}) with decreasing effective temperature (T_{eff}) for TWA M stars. The earliest-type (M0–M2) stars appear overluminous, having log(L_X/L_{bol}) $\approx$ -3.0, but for spectral types M4 and later log(L_X/L_{bol}) decreases and its distribution broadens, with these mid- to late-M TWA stars appearing underluminous in X-rays compared to very young pre-main sequence stars of similar spectral type and luminosity. Additionally, the fraction of TWA stars that display evidence for residual primordial disk material sharply increases in this same (mid-M) spectral type regime. Thus, our data suggests that disk survival times may be longer for ultra-low-mass stars and brown dwarfs than for higher-mass M stars. These types of observations can provide key information about the X-ray radiation fields of M stars to constrain circumstellar disk and exoplanet formation and evolution models, allowing us to explore the realistic effects of M star X-rays on the survival of atmospheres of terrestrial planets.

Understanding planets hotter than cool stars: the MMT Exoplanet Atmosphere SURvEy (MEASURE)

Fri 9:50

J. L. Birkby
University of Amsterdam

High-resolution spectroscopy is a robust and powerful tool in substellar companion characterization. It uses changes in the Doppler shift of the faint companion to disentangle its spectrum from the glare of its host star. The technique is sensitive to the depth, shape, and position of the object's spectral lines, and thus reveals information about its composition, atmospheric structure, mass, global wind patterns, and rotation. I will present the first results from MEASURE: the MMT Exoplanet Atmosphere SURvEy. This 40 night survey of 11 exoplanet atmospheres at R 30,000 is the largest homogenous high-resolution survey to date. Many of the planets in the survey have temperatures hotter than brown dwarfs, and some are even hotter than M-dwarfs. I will focus on how the survey will provide an accurate measurement of the temperature at which atmospheres transition into having thermal inversion layers. At high spectral resolution, these features are clearly detected via multiple strong emission lines from e.g. CO, and preliminary results indicate this occurs at hotter temperatures than previously expected. I will discuss the chemical species and processes responsible for this in exoplanet atmospheres and contrast this to processes occurring in the atmospheres of brown dwarfs and M-dwarfs. MEASURE not only provides a homogenous dataset to perform comparative exoplanetology, but provides complementary high-resolution spectra for substellar objects already observed

with HST and Spitzer, allowing the next step in the detailed characterization of exoplanet atmospheres and their more massive substellar cousins.

Fri
10:55
Invited Talk

A New Generation of Substellar Atmosphere & Evolution Models

M. Marley[1]; D.Saumon[2]

NASA Ames Research Center; Los Alamos National Laboratory

We present a new generation of substellar atmosphere and evolution models. These models, spanning 200 to 2400 K and masses from about 1 to 80 Jupiter masses for a range of metallicities and C/O ratios, are appropriate for interpreting spectra and photometry of brown dwarfs and directly imaged extrasolar giant planets. Notable improvements from past such models include updated opacities and cloud models. We find that the edge of the main sequence has moved down, compared to our previous models, from 0.075 to $0.072\,\mathrm{M}_{\odot}$. In addition to comparing the new models to various datasets, we will discuss how data retrieval methods and forward models working together can validate assumptions and lead to greater understanding than either approach alone.

Fri
11:30

Cloud Formation on Brown Dwarfs and Hot Jupiters

Diana Powell[1]; Xi Zhang[1]; Peter Gao[2]; Jonathan Fortney[1]; Mark Marley[3]; Vivien Parmentier[4]

UC Santa Cruz; UC Berkeley; NASA Ames; Le LAM, Laboratoire d'Astrophysique de Marseille

Clouds on brown dwarfs and extrasolar worlds are seemingly abundant and interfere with observations; however, little is known about their properties. In this talk I will present the first application of a bin-scheme microphysical and vertical transport model to determine the size distribution of cloud particles in the atmospheres of very low gravity brown dwarfs as well as hot Jupiters. We predict particle size distributions from first principles and investigate how observed cloud properties depend on the atmospheric thermal structure and vertical mixing. In particular, we investigate whether these objects' interesting observational properties can be explained by clouds. For hot Jupiters, I will show that the predicted realistic size distributions are frequently bimodal and irregular in shape and that the cloud opacities are roughly constant across a broad wavelength range with the exception of features in the mid-infrared. I will also suggest that cloud opacities in emission may serve as sensitive tracers of the thermal state of a planet's deep interior through the existence or lack of a cold trap in the deep atmosphere.

Weather Patterns on Exoplanet Analogues

Fri 11:45

Johanna Vos

University of Edinburgh

Photometric variability monitoring is sensitive to atmospheric features as they rotate in and out of view, allowing us to probe the presence of surface inhomogeneities caused by patchy clouds, hot spots and temperature fluctuations. Periodic variability has been detected in L and T brown dwarfs, and more recently in a small sample of free-floating, planetary-mass objects. These young, low-gravity objects share a striking resemblance with the directly-imaged planets and can be studied in far greater detail in the absence of a bright host star. The large amplitudes observed in this small sample of low-gravity objects suggests that variability may be enhanced for the exoplanet analogues. We have recently carried out the first large survey for weather patterns on exoplanet analogues. I will present the results of this survey and discuss what we have learned about the role of surface gravity in variability properties.

Student Poster Prize Talk

Fri 12:00

T. B. Determined, E. T. Alia

We will hear a talk from the winner of the student poster contest. The talk will be 10 minutes plus 5 minutes for questions.

Postdoc Poster Prize Talk

Fri 12:15

T. B. Determined, E. T. Alia

We will hear a talk from the winner of the postdoc poster contest. The talk will be 10 minutes plus 5 minutes for questions.

Posters

Properties of correlated solar flares and CMEs, revisited: more data, more questions

Poster 1

Alicia Aarnio
University of Colorado Boulder

Outstanding problems in young stellar systems revolve around mass loss, angular momentum evolution, and the effects of energetic events on the surrounding environs. Likewise, the latter of these drives much research into our own system's space weather and the development of predictive algorithms for geomagnetic storms. So dually motivated, we have leveraged a big-data approach to combine two decades of GOES and LASCO data to identify a large sample of spatially and temporally correlated flares and CMEs. In this talk, I will present results of our previous efforts for solar cycle 23 and an updated catalog inclusive of part of cycle 24 having now doubled the sample. We present changes across the solar cycles, find correlated physical properties in spatially and temporally coincident pairs of events, and have taken further measures to identify sets of related events. Lastly, we present a cautionary note regarding changes in observational cadence that need to be accounted for when aggregating this large data set.

Ultra-short-period planets around low-mass stars

Poster 2

E. R. Adams[1]; B. Jackson[2]; M. Endl[3]
Planetary Science Institute; Boise State University; McDonald Observatory, The University of Texas at Austin

Planets with orbital periods less than a day, ultra-short-period planets (USPs), are unique laboratories for observation and planet formation and evolution theories, but the planets' origins remain unclear. Competing origins theories make different, testable predictions: for instance, USPs may be the remnants of tidally disrupted hot Jupiters, or they may have been brought in from farther out by orbital decay driven by tides raised on their host stars. If USPs were brought in by tidal decay and interactions with other planets, that would mean USP systems would often (perhaps always) host additional planets. The characteristics of the ultra-short-period planet population can therefore be used to directly test the predictions of competing planet formation theories. Over 60 candidate or confirmed USPs have been identified around stars with less than 0.7 solar masses (about a quarter of all known USPs). M dwarfs also account for a similar fraction (25 percent) of stars with at least one identified companion planet, and every USP system with 3 or more planets orbits a star less massive

than the sun. We will report on the efforts of the Short Period Planet Group (SuPerPiG) to identify USPs and the implications of USP population characteristics for planet formation theories.

Poster 3

Brown Dwarfs Beyond the Era of GAIA: Measuring the Galactic Distribution of late-M, L, T Dwarfs with HST-WFC3 Parallel Fields, JWST & Euclid

Christian Aganze[1]; Adam Burgasser[1]; Matthew Malkan[2];Benne Holwerda[3]; Eduardo Martin[4]

UCSD; UCLA; University of Louisville; Centro de Astrobiologia

The lowest-mass stars and brown dwarfs, or ultracool dwarfs (UCDs, M $<$ 0.1 Msun, Teff $<$ 3000 K) constitute a significant and long-lived population in the Milky Way Galaxy. The spectra of these sources are distinct from stellar blackbodies and extragalactic sources, and shaped by strong molecular features that are highly sensitive to temperature, surface gravity and metallicity. Wide-field optical and infrared surveys (e.g., 2MASS, SDSS, WISE) and their follow-up have uncovered thousands of UCDs, enabling measurement of their density and luminosity function in a relatively shallow (d leq50-100 parsecs) local volume. As such, constraints on the scale height and radial distributions of UCDs, particularly metal-poor ultracool halo subdwarfs, are poor. We have searched the near-infrared grism spectra contained in the WFC3 Infrared Spectroscopic Parallel Survey (WISPS) and 3D-HST Survey data to spectroscopically identify over 150 UCDs classified M6 and later to maximum distances of 3 kpc; this includes a dozen L dwarfs out to 1 kpc and ten T dwarfs out to 500 pc. We compare the spectrophotometric distance distribution of these sources to Galactic thin disk, thick disk and halo models accounting for substellar cooling, variations in the Galactic formation history, and kinematic evolution. We use these results to predict the expected yields of UCDs in future grism surveys by Euclid and the James Webb Space Telescope (JWST).

Poster 4

A new approach to the problem of lithium-rich giants

C. Aguilera-Gómez[1,2]; J. Chanamé[3,2]; M. Pinsonneault[4]; J. Carlberg[5]

Universidad Andrés Bello, Chile; Millenium Institute of Astrophysics, Chile; Pontificia Universidad Católica de Chile; The Ohio State University, USA; Space Telescope Science Institute

Lithium is very sensitive to environmental conditions, and as such, it is commonly used as a proxy for complex stellar processes affecting stars. Lithium is destroyed in stellar interiors during the main sequence phase, and in consequence, the existence of lithium enriched giants challenges our current understanding of post-main sequence stellar evolution. Possible explanations for these atypical objects invoke either internal extra-mixing or planet engulfment by the star. Through the use of models of canonical stellar evolution and planet engulfment, we show that the current definition of what is a lithium-rich giant is misleading. We show that mass, exact evolutionary stage, and metallicity are fundamental in understanding the lithium depletion pattern in giants, and in the classification of the unusual stars. In doing

so, we propose a new approach to solve this long-standing problem. Moreover, we calculate a maximum lithium abundance that could be found in giants that have engulfed substellar mass companions, limiting lithium-rich giants formed by this mechanism. Also, based on the fundamental stellar properties obtained by surveys such as Gaia, APOGEE, and K2 we have selected different interesting samples, where we can identify the enriched giants, study the non-canonical mechanisms, and select candidates of planetary accretion.

Metallicity and rotational evolution of low-mass stars

Poster 5

L. Amard[1]; C. Charbonnel[2]; A. Palacios[3]

University of Exeter; University of Geneva; Université de Montpellier

A lot of efforts have been made recently in understanding the rotational evolution of low-mass stars. However, modelling stars of different clusters at different ages suggests at least slightly different chemical composition. These become even bigger if one aim at studying the whole Kepler field. We investigate here the effects of a variation of metallicity ($-1 < [Fe/H] < +0.3$) on the rotation period evolution of low-mass stars (0.2 - 1.5 $M_\odot$).

From the Sun to other CoolStars: Accurate rotational periods by the GPS method

Poster 6

Eliana m. Amazo-Gomez[1,2]; Alexander I. Shapiro[1]; Sami K. Solanki[1,3]; Natalie A. Krivova[1]; Greg Kopp[4]; Timo Reinhold[1]; Mahmoudreza Oshagh[2]; Ansgar Reiners[2]

Max-Planck-Institut für Sonnensystemforschung, Justus-von-Liebig-Weg 3, 37077 Göttingen, Germany; Georg-August Universität Göttingen, Institut für Astrophysik, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany; School of Space Research, Kyung Hee University, Yongin, Gyeonggi 446-701, Republic of Korea; Laboratory for Atmospheric and Space Physics, 1234 Innovation Dr, Boulder, CO 80303, USA

Understanding the physics behind magnetic activity of cool stars is a challenging task, even when such stars are analogs to the most analysed star, our Sun. There are many variables and degeneracies working simultaneously. However, there is a key parameter for characterising the action of the stellar dynamo, which is also needed to determine, magnetic fields, inclinations, age, precise chemical abundances, etc. This parameter is the rotational period. Taking advantage of the connection between photometric variations and the rotational period, we developed a new method to retrieve accurate stellar periods. We derive the rotation periods based on the Gradient of the Power Spectra (GPS) of brightness time-series. To test and calibrate our method, we use high-stability and high-sensitivity measurements of the total solar irradiance (TSI) by the SORCE/TIM and the SoHO/VIRGO instruments, detailed models of solar brightness variations and, high-quality photometric data acquired by the Kepler mission. We validate the GPS method for the exemplary case of the Sun and stars with known rotational periods. We then selected a sample of Kepler solar analogs and determined their heretofore-unknown rotation periods.

Poster 7

The ages of exoplanet hosts

Ruth Angus
Columbia University

Thanks in large part to Kepler, it is now possible to infer the occurrence rate of exoplanets as a function of their radii and orbital periods. The influence of host stars on planet occurrence rate is also being explored: host star mass and metallicity, for example, appear to influence the radii and orbital periods of the planets that form around them. The ages of young planet hosts even provide tentative observational evidence of shrinking planet radii due to cooling and photoevaporation. Searching for evidence of time-dependent trends in the exoplanet population is challenging however, in part because stellar ages are difficult to measure and in part due to inconsistent planet detection efficiency over stellar age (it is more difficult to detect planets orbiting young stars as they are typically more active). I will highlight new advances in the accuracy and precision of stellar age-dating methods applicable to Kepler exoplanet hosts, with particular emphasis on light curve-based dating methods, and present preliminary results from an exoplanet population study that searches for trends in the planet population as a function of host star age.

Poster 8

The low-mass population of Vela OB2 with Gaia

Joseph Armstrong; Nick Wright; Rob Jeffries
Keele University

The first Gaia data release gives us an opportunity to better characterise and investigate the low-mass population of OB associations, which in turn can inform us about the formation and evolution of associations and clusters and the origins of field stars and planetary systems.

This study aims to demonstrate how Gaia photometry may be used to identify low-mass members of nearby associations, using the Vela OB2 association as a test case.

We select objects with both Gaia and 2MASS photometry located around the Vela OB2 association and filter these objects through selection tests based on the known positions of low-mass, pre-main sequence stars from GES (Jeffries et al. 2014) in the G-K vs G colour-magnitude diagram and J-H vs H-K colour-colour diagram. From this we have mapped out the spatial distribution of low-mass association members, which can be compared with the known OB star population from De Zeeuw et al. (1999).

Our method picks out known clusters such as Gamma Velorum and NGC 2547, as well as other over-densities that may represent previously-unknown clusters. Of particular interest is a lack of correlation between over-densities in the distribution of low- and high-mass stars, suggesting that the structure and dynamics of these two populations can evolve separately in OB associations.

A HST Catalog of UV Activity Levels in Planet-Hosting and Non-Planet Hosting Stars

Poster 9

Nicole Arulanantham; Kevin France

University of Colorado Boulder; Laboratory for Atmospheric and Space Physics [LASP]

We present an analysis of FUV emission line activity in a sample of 65 stars with planets, as identified with The Extrasolar Planet Encyclopedia, and 48 stars with no known planets. Our full data set was assembled from new and archival observations with the Cosmic Origins Spectrograph (COS) and Space Telescope Imaging Spectrograph (STIS) onboard the Hubble Space Telescope. A comparison of the two stellar populations shows that the planet-hosting systems have systematically lower relative fluxes (F_{ion}/F_{bol}) from N V, C II, Si III, and Si IV emission. This effect can be attributed to observational biases, which allow planets to be more readily detected around older, less active, and more slowly rotating stars. We also find a direct correlation between the FUV transition region emission line strengths and the total EUV flux between 90 and 360 Å for a subset of 11 stars in our sample with archival data from the Extreme-Ultraviolet Explorer. The resulting linear relationships allow us to estimate the EUV flux from the N V and Si IV FUV emission to within a factor of two. Finally, we conduct a principal component analysis (PCA) to examine the relationship between FUV emission line fluxes, stellar properties, and a star-planet interaction (SPI) parameter in the sample of planet-hosting stars. We find that the inclusion of the SPI parameter does not result in a significantly better best-fit model, suggesting that the stellar parameters alone dominate the UV activity on late-type stars.

A Flexible Model for Investigating Properties of Starspots: Comparison of Models to Observed Data

Poster 10

Amanda Ash; Jessica Hamilton; Gregory Feiden

University of North Georgia

Cool, late-type stars have proven problematic when determining accurate age estimates for young open clusters due to inaccuracies in stellar evolution models. Starspots have been suggested as an explanation for discrepancies between stellar model predictions and observed properties of cool stars. By applying a flexible starspot model to stellar evolution isochrones and comparing to photometric data from the Pleiades, Praesepe, NGC 2516, the Hyades, and M67, we determine which starspot properties are required to bring stellar evolution isochrones into agreement with the observed data. The starspot model allows us to estimate starspot surface coverages, temperature contrasts, and possible formation mechanisms. Preliminary results suggest that starspots form in deeper, more opaque layers and not in stars' superadiabatic layers. We find two families of starspot models are consistent with the photometric data. Models in which the star restructures to redistribute flux as compensation for the spot have provided the best fit for the cluster data, but are inconsistent with expected temperature contrast values between starspots and the ambient stellar photosphere. By contrast, models assuming that spots exist for a small duration of time, causing only a brief decrease in luminosity, provide more consistent temperature contrast values, but require stars to have questionably high spot surface coverages. Although we cannot yet

discriminate between these two families of models, efforts to do so will provide an important clue as to how starspots form and how they affect stellar structure and evolution.

Poster 11

Ecliptic-poles Stellar Survey (EclipSS)

Thomas Ayres
University of Colorado [CASA]

Ecliptic-poles Stellar Survey (EclipSS) is collecting far-UV spectra (115-143 nm), using HST's ultra-sensitive Cosmic Origins Spectrograph (COS), of a sample of 49 F2-K2 dwarf stars in the North and South ecliptic polar regions, to further advance studies of magnetic activity among cool Main sequence stars similar to the Sun. The ecliptic poles are favored places for several current and up-coming astronomical survey satellites, including Gaia (astrometry), TESS (exoplanets and asteroseismology), and eROSITA (coronal X-rays). These instruments scan along lines of ecliptic longitude, and thus accumulate their deepest exposures close to the ecliptic poles. The EclipSS targets were selected to be single, isolated, bright enough for eROSITA, not too bright for TESS, and just right for COS. The combined photometric (starspots), asteroseismic, FUV, and X-ray measurements will provide rotation periods, sizes, masses, metallicities, ages, activity levels, and coronal properties to inform community-wide efforts to explore the underlying magnetic engine, the Dynamo.

Poster 12

The TESS Yield for M Dwarf Planets: Multiplicity and Dynamics

Sarah Ballard
MIT

NASA's TESS mission will furnish many of the most promising planets for detailed atmospheric study in the next decade, and nearly all of these planets will orbit M dwarf stars. M dwarfs often host densely packed systems of multiple planets, and the shorter stares of NASA's TESS mission will favor detection of such systems. Previous study to predict the yield of planets from TESS have not included these "compact multiples", nor folded in the dynamical information we have in hand for M dwarf planets from Kepler and radial velocity efforts. We revisit the likely TESS yield, both in raw number of M dwarf planets likely from TESS and their system architectures. We report four main findings: first, that TESS will likely detect more planets orbiting M dwarfs that previously predicted. Secondly, TESS will find two or more transiting planets around 20

Rotation period determinations for certain open cluster and field stars, and implications for gyrochronology

Poster 13

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Our group in Potsdam has been involved in deriving rotation periods for cool stars in certain key open clusters, both using space-based data, and also ground-based assets, particularly our own STELLA robotic observatory in Tenerife. We will present some highlights from this work, especially with a view towards the implications for deriving ages using gyrochronology, and (in)consistencies between gyro- and other ages.

WEIRD: Wide-orbit Exoplanet search with InfraRed Direct imaging

Poster 14

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We report results from the Wide-orbit Exoplanet search with InfraRed Direct imaging (WEIRD), a survey designed to search for Jupiter-like companions on very wide orbits (1000 to 5000 AU) around young stars (< 120 Myr) that are known members of moving groups in the solar neighborhood (< 70 pc). Sharing the same age, distance, and metallicity as their host while being on large enough orbits to be studied as ”isolated” objects make such companions prime targets for spectroscopic observations and valuable benchmark objects for exoplanet atmosphere models. The search strategy is based on deep imaging in multiple bands across the near-infrared domain. For all 177 objects of our sample,z' , J , [3.6] and [4.5] images were obtained with CFHT/MegaCam, GEMINI/GMOS, CFHT/WIRCam, GEMINI/Flamingos-2, and Spitzer /IRAC. Using this set of 4 images per target, we searched for sources with red $z' - J$ and [3.6] - [4.5] colors, typically reaching sensitivity to 1 MJup companions at separations of 1000 - 5000 AU. The search yielded 4 candidate companions with the expected colors, but they were all rejected through follow-up proper motion observations. Our results constrain the occurrence of 1-13 MJup planetary-mass companions on orbits with a semi-major axis between 1000 and 5000 AU to be less than 0.02, with a 95

Poster 15

What is Kepler really telling us about Starspots?

Gibor Basri

UC Berkeley

The signature of starspots in Kepler data is obvious and pervasive. There have been many papers discussing aspects of these lightcurves, including rotation period detection, dependence of amplitude on rotation, differential rotation signatures, and activity cycles. There are some subtleties of interpretation, however, that have received much less attention (but are relevant to these analyses). 1) as the lightcurves change, how much of that is due to differential rotation (spots changing phase with respect to each other) and how much is due to spot evolution (spots growing and decaying in various locations)? 2) given that Kepler only provides differential photometry, how can we properly convert light deficits to actual spot areas (what does the unspotted star look like)? 3) how much information is actually in the light curves, given that there are generally only one or two dips in intensity per rotation?

I discuss progress on these questions, utilizing a large search of parameter space with spot models. I also present a new rotation-activity relation: there is a strong correlation between a) the ratio of of the time spent by a lightcurve in single dip mode to that spent in double dip mode, and b) the rotation period of that star. I give a tentative interpretation of this new result.

Poster 16

Seismic Probing of the first dredge-up event and tidal interactions in red-giant binaries

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Binaries in spectroscopic systems provide a homogeneous set of stars. Differences between parameters, such as age or initial conditions, which otherwise would have strong impact on the stellar evolution and blur the comparison on a star-to-stars basis, can be neglected.

In this poster, we present the comprehensive analysis of KIC9163796, constituted of two red giants of $\sim$1.4$\pm$0.1$M_\odot$. The masses of the two components differ only by 1.5$\pm$0.5%. We show that both stars are located in the short-lived phase of the first dredge up on the red-giant branch, when the convective envelope reaches the deepest penetration into the star. While asteroseismology allows to characterise the primary component well, the large difference in lithium abundance between the two otherwise very similar components is used to test stellar evolutionary models. From a study of tidal interactions in the ensemble of red-giant binary systems, we conclude that the close resemblance of the surface rotation and orbital period is a coincidence and does not correspond to a sign of spin synchronisation. The comparison of the rotation period inferred from asteroseismology and surface rotation indicates that the convective envelope is rotating rigidly.

Evidence for the detection of the power excess of the secondary component in the composite power spectrum is presented. Therefore, KIC9163796 is one of the prototypes of binary systems with two oscillating red-giant components. Such seismic systems, which offer many constraints, can be employed as benchmark object to be use to calibrate evolutionary models and stellar ages.

Model-independent measurements of internal structure in solar-like stars with asteroseismology: a new test-bed for stellar physics

Poster 17

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Asteroseismology provides the opportunity to learn about the properties of stars through their global modes of oscillation. This is often achieved by fitting evolutionary models to the observations of the star. However, even after applying corrections, the best stellar models fail to match the oscillations of the stars. This implies that the internal structures of the models are not exactly right.

Through an inverse analysis of the oscillations, it is possible to obtain model-independent measurements of internal stellar structure. In this work, we use asteroseismology to make the first measurements of core structure in solar-like stars observed by Kepler. We compare the results against stellar models constructed using a number of different physics inputs, and report the ingredients that best reproduce the inner structures of the stars.

Calibrating asteroseismology for red giants with eclipsing binaries

Poster 18

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Given the potential of ensemble asteroseismology for understanding fundamental properties of large numbers of stars, it is critical to determine the accuracy of the scaling relations on which these measurements are based. Eclipsing binary systems hosting at least one star with detectable solar-like oscillations constitute ideal test objects. By combining radial velocity measurements and photometric time series of eclipses, it is possible to determine the masses and radii of each component of a double-lined spectroscopic binary. Gaulme et al. (2016, ApJ 832, 121) analyzed radial velocity measurements of a sample of 10 red giants that were observed by the Kepler space telescope, for which oscillations have been detected. They showed that asteroseismic scalings systematically overestimate red-giants masses and radii, by about 15 and 5 percent in average, respectively. Overestimating masses lead to underestimating stellar ages, which can have important implications for ensemble asteroseismology used for galactic studies. In this work, we present radial velocity measurements of new systems including an oscillating red giant and we compare our results to those of Gaulme et al., and the recent results from Brogaard et al. (2018, MNRAS). We confirm that asteroseismology significantly overestimates masses of red giants and we test all of the methods that have been proposed to correct possible inaccuracies of the asteroseismic scaling relations.

Poster 19

An Accurate Mass of the 31 Cygni Red Supergiant

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Red supergiants are massive, evolved stars that are among the brightest stars in the near infrared. But the uncertain physics of mass loss limits the ability of evolutionary models to accurately represent these stars in detail. Lacking a fundamental, predictive theory of mass loss, this process is normally incorporated into stellar models using simple parametric formulas such as Reimer's Law. In this situation, it is important to constrain theoretical models evolved using such mass loss parametrizations by observation.

A key stellar parameter is mass. In combination with a star's position in the H-R diagram, a well-determined mass provides a strong constraint on stellar evolution models. Unfortunately, there are very few red supergiants with masses known to even 5% accuracy. In response, the objective of Hubble Space Telescope GO program 14070 (PI: Bennett) was to determine the mass of the red supergiant K star in the long-period eclipsing binary 31 Cygni (K4 Ib + B3 V) accurate to 1%. To obtain this accuracy requires the incorporation of new optical radial velocity observations of the supergiant; that work is in progress. But the observational program of GO-14070 is now complete, and these new HST/STIS observations of the 31 Cyg binary in the ultraviolet have provided an immediate determination of the secondary orbit radial velocity amplitude, K_2, accurate to 1%. This result suffices to determine the masses of both 31 Cyg stars to an accuracy of about 2%, and provides a useful constraint on the evolution of the intermediate-mass red supergiant in this well-separated binary system.

Exoplanet Terra Incognita

Poster 20

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Seeing oceans, continents, weather, and surface features on exoplanets may allow us to detect and characterize life outside the solar system. However, even the largest planned telescopes will not be able to resolve surface features directly, even on the nearest exoplanet Proxima b. Here, we demonstrate an inversion technique to image indirectly exoplanet surfaces using observed unresolved reflected light variations over the course of the exoplanets orbital and axial rotation: ExoPlanet Surface Imaging (EPSI). We show that the reflected light curve contains enough information to resolve both longitudinal and latitudinal structures and to map exoplanet surface features. We demonstrate this using examples of Solar system planets and moons as well as simulated planets with Earth-like life and artificial megastructures. Such albedo maps obtained in different wavelength passbands can provide "photographic" views of distant exoplanets. We estimate the signal-to-noise ratio necessary for successful inversions and discuss telescope and detector requirements necessary for the first surface images of Proxima b and other nearby exoplanets.

Precise Properties of *Kepler* Stars and Planets in the *Gaia* Era

Poster 21

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A critical bottleneck for stellar astrophysics and exoplanet science using data from the *Kepler* mission has been the lack of precise radii and evolutionary states of the observed target stars. Here, we present revised stellar properties (radii, log g, masses, luminosities, and ages) of $\sim$190,000 *Kepler* stars derived by combining parallaxes from *Gaia* Data Release 2 with the DR25 *Kepler* Stellar Properties Catalog. The median radius precision is $\sim$8 percent, a factor 4-5 improvement over previous estimates for typical *Kepler* stars. We find that $\sim$65 percent of all *Kepler* targets are main-sequence stars, $\sim$23 percent are subgiants, and $\sim$12 percent are red giants, demonstrating that subgiant contamination is less severe than previously thought and that the *Kepler* parent population mostly consists of unevolved main-sequence stars. We also identify a secondary main sequence for K and M dwarfs, which likely consists of a number of equal mass binaries. Using the revised stellar radii, we recalculate the radii for $>$ 4000 confirmed/candidate exoplanets. Our results confirm the presence of a gap in the radius distribution of small, close-in planets, but yield evidence that the gap may be located closer to 2 Earth radii. We furthermore find several confirmed exoplanets which occupy the "hot super-Earth desert," detect direct evidence for a correlation of gas-giant planet inflation with increasing incident flux, and establish a bona-fide sample of planets with $<$ 2 Earth radii in the habitable zone. The results presented here demonstrate the enormous potential for the precise characterization of stellar and exoplanet populations using the transformational dataset provided by *Gaia*.

Poster 22

A Volume-Limited Sample of L and T Dwarfs Defined by Parallaxes

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Parallaxes are the most direct measures of distance and are therefore essential for defining the high-confidence volume-limited samples needed for precise stellar population studies. We are using UKIRT/WFCAM to conduct the largest near-infrared program to date measuring parallaxes of L and T dwarfs. For the past 4 years we have monitored over 350 targets, most of which are too faint to be observed by Gaia. Our program has more than doubled the number of known L and T dwarf parallaxes, defining a volume-limited sample of $\approx$400 L0-T6 dwarfs out to 25 parsecs, the first L and T dwarf sample of this size and depth based entirely on parallaxes. Our sample combines with the stellar census from Gaia DR2 parallaxes, as well as late-T and Y dwarf parallaxes from Spitzer, CFHT, and other infrared telescopes, to form a continuous volume-limited sequence of nearby stars and brown dwarfs. Our volume-limited sample presents a comprehensive portrait of the local substellar population, including a precise estimate of the space density and a refined description of how brown dwarfs cool through the L/T transition.

Poster 23

Orbital misalignment of GJ 436b with the spin of its cool host star: Kozai migration scenario and subsequent constraints.

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Kozai-Lidov mechanism is a major source of dynamical evolution in multiple stellar systems and in young planetary systems with large mutual inclinations. It drives orbital eccentricities to very high values while keeping semi-major axes constant, thus reducing periastron distances. Furthermore, tidal friction at periastron acts at shrinking orbits and generating misaligned close-in planets and tight pairs in triple stellar systems.

GJ 436b is a short period transiting Neptune-mass exoplanet orbiting an M dwarf on a surprisingly eccentric orbit. Tides should have already circularized its orbit. In an earlier study (Beust et al. 2012, A&A 545, A88), we showed that Kozai migration combined with tides could have delayed the circularization of this planet and explain the residual eccentricity. This model implies the presence of another yet unknown body at larger distance in this system. It also predicts that GJ 436b's orbital plane should be tilted with respect to the stellar equator.

We report here the recent detection of this spin-orbit misalignment, derived by mapping the spectrum of the stellar protosphere along the chord transited by the planet. GJ 436b orbits nearly perpendicularly to the stellar equator (Bourrier et al. 2018, Nature 553, 477). This result reinforces the 2012 hypothesis, and allows us to derive additional constraints on the dynamical model, in particular concerning the mass and the distance of the hypothetical perturber. The inward migration of GJ 436b could have triggered the atmospheric escape that now sustains its giant exosphere.

This mechanism is generic and likely at work in other systems. The GJ 504 system also harbours a distant companion that is presumably misaligned with the stellar equator. This rotation of this star also suggests that it could have recently engulfed an exoplanet. This configuration could also be due to a similar mechanism. Contrary to GJ 436, we would see here the perturbing body instead of the planet it applied to.

Multi-wavelength and Spectroscopic Variability Monitoring as a probe of Planetary Mass Object Atmospheres

Poster 24

Beth Biller[1]; Johanna Vos[1]; Esther Buenzli[2]; Katelyn Allers[3]; Mickaël Bonnefoy[4]; Benjamin Charnay[5]; Bruno Bézard[5]; France Allard[6]; Derek Homeier[7]; Mariangela Bonavita[1]; Wolfgang Brandner[8]; Ian Crossfield[9]; Trent Dupuy[10]; Thomas Henning[8]; Taisiya Kopytova[11]; Michael Liu[12]; Elena Manjavacas[13]; Joshua Schlieder[14]

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Quasiperiodic variability has been observed in L and T type field brown dwarfs at near-IR and mid-IR wavelengths, likely driven by top-of-atmosphere inhomogeneities due to e.g. patchy clouds, hot spots, or composition variations. Variability at similar or higher amplitudes has recently been observed in young planetary mass objects, which share similar T_{eff} as field brown dwarfs, but have considerably lower surface gravities. Variability studies of these objects relative to old field objects is then a direct probe of the effects of surface gravity on atmospheric structure. Multi-wavelength and especially spectroscopic variability characterization studies yield valuable insights into the rotation and atmospheric structure of these objects. As an example, we present results from simultaneous HST WFC3+Spitzer IRAC variability monitoring for the variable young ($\sim$20 Myr) planetary-mass object PSO J318.5-22. We find a period of 8.6$\pm$0.1 hr and an inclination of 56.2$\pm$8.1°. We measure peak-to-trough variability amplitudes of 3.4$\pm$0.1% at 4.5 μm and 4.4-5.8% in the near-IR (1.07-1.67 μm) –the mid-IR variability amplitude for PSO J318.5-22 is one of the highest variability amplitudes measured in the mid-IR for any brown dwarf or planetary-mass object. Additionally, we detect phase offsets ranging from 200° to 210° between synthesized near-IR light curves and the Spitzer mid-IR light curve, indicating depth-dependent longitudinal atmospheric structure in this atmosphere. The detection of similar variability amplitudes in wide spectral bands relative to absorption features suggests that the driver of the variability may be inhomogeneous clouds (perhaps a patchy haze layer over thick clouds), as opposed to hot spots or compositional inhomogeneities. I will also discuss how such studies can be extended to fainter free-floating planetary mass objects as well as bound exoplanet companions in the era of JWST.

Poster 25

Rotation of M Dwarfs Observed with APOGEE

Cullen Blake; Steven H. Gilhool

University of Pennsylvania

We present an analysis of projected rotational velocity in more than 1,000 M Dwarf stars observed with the Sloan Digital Sky Survey APOGEE spectrograph. We describe a novel, data-driven technique for measuring projected rotational velocities and compare our results to previous studies using spectroscopic or photometric techniques to measure stellar rotation. We find that the overall rotational properties of the stars in our sample are broadly consistent with previous studies, exhibiting a sharp increase in the fraction of stars with measurable rotation at spectral types M4 and later. We find consistent spectroscopic and photometric rotation estimates for the small number of objects in our sample with both types of measurements. However, overall we find very few slow rotators in our sample at these late spectral types, a result inconsistent with some photometric studies that have shown a significant population of slow rotators.

Poster 26

Precise Ages of Low-Mass Stars in the Field

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The age of a star is one of the most difficult fundamental parameters to precisely estimate. Using proper motions and distances from TGAS (GAIA DR1), Oh et al. identified thousands of stars in co-moving associations. These co-moving stars are assumed to be co-eval, allowing them to serve as calibrators of period-age relations for a wide variety of ages and metallicities. We have selected groups of three or more co-moving stars to serve as "mini-clusters", containing at least one solar-type star, and one or more K and M dwarf. We are studying these systems in order to derive a comprehensive age-period relation for low-mass stars, and report on our efforts to date. The ages of these groups can be estimated from their primary stars, employing isochrones, asteroseismology, or rotation periods. Rotation periods will be measured from existing light-curves from existing large surveys. The result period-age relation, when applied to future TESS and LSST observations will permit the age mapping of low-mass stars across the Galaxy, and for the first time produce precise age estimates for billions of field stars.

The Transiting Dust of Boyajian's Star

Poster 27

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First observed with the Kepler mission, KIC 8462852 undergoes unexplained dimming events, "dips," on the timescale of days which were again observed from the ground from May to December 2017. Monitored with multi-band photometry by the Los Cumbres Observatory, all four dips of the "Elsie dip family" display clear wavelength dependence. We measure how the wavelength dependence changes over the whole dimming event, including the secular dimming occurring with the dips. We find that a single wavelength dependence does not fit the entire light curve and the secular dimming appears to be non-gray and varying in time. Because of the non-gray secular dimming, we measure the wavelength dependence of the dips separately and without the extra depth from the secular dimming. Such measurements yield a different estimate of the wavelength dependence of the dips but remains consistent with the previous measurement except for Elsie (the first dip), which is surrounded by dimming with strong wavelength dependence. We find that the range of the wavelength dependence variation of the entire 2017 light curve is consistent with optically-thin dust with an average grain radius of $r<1$ micron and the dust causing just the dips being $r<0.5$ micron. Since the dependence is time-dependent, the dust occulting the star must be heterogeneous in size, composition, or both and the distributions of these properties along the line of sight must change over time.

The GJ 504 system revisited: combining high contrast imaging, interferometry, and radial velocity data

Poster 28

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Institut de Planétologie et d'Astrophysique de Grenoble

The G-type star GJ504 is known to host a substellar companion whose temperature (Teff 400-600K), mass (3-35 MJup), and projected separation (44 au) all contribute to make it a unique benchmark for the planet formation theories and for testing the atmospheric models of giant planets and brown dwarfs at the so-called Y/T transition.

We present new VLT/SPHERE deep imaging data on the system. Our 1.0-2.3 m photometry allows to test the latest generation of atmospheric models and to infer new temperature, surface gravity, and metallicity estimates for the companion. We also present a new characterization of the host star using CHARA/VEGA interferometric measurements which enable to derive a new age estimates for the system and the inclination of the host star. We combine the SPHERE multi-epoch detection limits to the long-term (21 years of Lick and SOPHIE data) radial velocity monitoring of the star to set unprecedented contraints on the system architecture. We discuss the system properties and the implications for the planet formation and evolution models.

Poster 29

Stellar coronae and chromospheres in the era of asteroseismology: A new age-activity relationship for old main-sequence stars

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Stellar magnetic activity is an important parameter to study as it can give insights into stellar activity cycles and even how the stellar dynamo operates. However, over time cool stars spin down due to magnetic braking and the magnetic activity becomes less pronounced. This has led to many studies concerning the evolution of stellar rotation and stellar activity with age. The majority of these studies construct a relationship that is only reliable for ages younger than a gigayear due to the difficulty of determining ages for older stars. However, recent observational advancements have made it possible to study ages for a larger sample of stars through asteroseismology; opening up the possibility of stellar age investigations for stars older than a gigayear.

I will present work that has combined ages of stars from asteroseismology and X-ray observations to construct an improved age-activity relationship for cool stars older than a gigayear. When this work is compared to previous studies, it reveals an interesting change in the age-activity relationship. Additionally, I will present results from recent work concerning the age-activity relationship using emission from the Calcium II H and K lines.

Poster 30

Observations of the solar chromosphere with ALMA and comparison with theoretical models

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The aim of this work is to utilize solar observations with the ALMA radio telescope. The main advantage of solar observations with ALMA is mapping of the solar chromosphere with an unprecedented spatial, temporal, and spectral resolution in the wavelength range between 0.3 mm and 8.6 mm. It can also be used as an approximately linear thermometer - the measured brightness temperature is directly proportional to the gas temperature of the observed structure or the continuum-forming layer in the solar atmosphere. Formation height of the continuum radiation increases with increasing observing wavelength which enables very accurate measurements of solar chromosphere's temperature as a function of height. The topic is important for solar physics, but it is important for stellar physics too, since the Sun is representative for the whole class of solar-like stars (solar-stellar connection). The study has

an observational and a modelling part. Within the observational part, data reduction is performed on CSV data taken in previous years and made publicly available in 2017. Models of various observed solar structures were developed and compared with actual ALMA observations. Radiation models are based on various VAL and FAL atmosphere models with thermal bremsstrahlung as the dominant mechanism responsible for the emission at ALMA wavelengths. A comparison of observations and models provides precise constraints on plasma properties in the solar atmosphere. The modelling part of the work is performed within the SSALMON international scientific network. Fast-scan single dish maps are used to characterise the Sun's millimetre radiation in comparison with the chromospheric and coronal emission seen at optical and EUV wavelengths. A high degree of correlation was found for many structures and millimetre counterparts of coronal bright points were identified. These results are analyzed in more detail using the interferometric measurements of small portions of the solar disc.

Signatures of Planet Migration in Cluster Chemistry

Poster 31

John M. Brewer

Yale University; Columbia University

Stellar formation models assume stars form in chemically well mixed clouds leading to readily observable consequences for binary stars and clusters. All of the dwarf stars in a cluster should be chemically homogeneous, as should binaries that formed together. Planet migration should occasionally result in planets being pushed into their stellar host, and evidence of this pollution has been clearly seen in white dwarfs, their normally smooth spectra temporarily sprinkled with metal lines. The thin atmospheres of main sequence F and G dwarfs can retain a record of planet engulfment in their observed chemical abundance patterns. Using MESA stellar evolutionary models, we explored the magnitude of these signatures for a selection of stars. We have also obtained high resolution spectra of both the Hyades and Praesepe to derive abundances and place constraints on the frequency of migration that results in planet engulfment.

Arcus: The Soft X-ray Grating Explorer

Poster 32

Nancy Brickhouse for the Arcus Collaboration

Smithsonian Astrophysical Observatory

The Arcus mission is now in Phase A of the NASA Medium-Class Explorer competition. We present an overview of the mission, which will study the formation and evolution of clusters, galaxies, and stars, with a particular focus on the Arcus science case for stellar astrophysics. With spectral resolving power of at least 2500 and effective area greater than 300 cm^2, Arcus will measure new diagnostic lines, e.g. for H- and He-like ions of oxygen and other elements. Weak dielectronic recombination lines will provide sensitive measurements of temperature to test stellar coronal heating models. Arcus will also resolve the coronal and accretion line components in young accreting stars, allowing detailed studies of accretion shocks and their post-shock behavior. Arcus can resolve line shapes and variability in hot star winds to study

inhomogeneities and dynamics of wind structure. Such profiles will provide an independent measure of mass loss rates, for which theoretical and observational discrepancies can reach an order of magnitude. Arcus will also study exoplanet atmospheres through X-ray absorption, determining their extent and composition.

Poster 33

UV and Optical Variability of the Young Star T Cha Produced by Inner Disk Obscuration

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CASA/U. of Colorado; LASP/U. of Colorado; Stony Brook University; Hamburg University; LCGTN; SAO

The young (7 Myr) 1.5 $M_\odot$ T Tauri star T Cha shows dramatic variability. The optical extinction varies by at least 3 magnitudes on few hour time-scales with no obvious periodicity. The obscuration is produced by material at the inner edge of the circumstellar disk and therefore characterizing the absorbing material can reveal important clues regarding the transport of gas and dust within such disks. The inner disk of T Cha is particularly interesting, because T Cha has a transitional disk with a large gap at 0.2- 15 AU in the dust disk and allows study of the gas and dust structure in the terrestrial planet formation zone during this important rapid phase of protoplanetary disk evolution. For this reason we have conducted a comprehensive, multi-spectral- region, observing campaign to study the UV/X-ray/optical variability of T Cha. During 2018 February/March we monitored the optical photometric and spectral variability using LCOGT and the SMARTS telescopes. These optical data provide a broad context within which to interpret our shorter UV and X-ray observations. We observed T Cha during 3 coordinated observations (each 5 HST orbits + 25 ksec XMM; on 2018 Feb 22, Feb 26, Mar 2) using HST COS/STIS to measure the UV-optical spectra and XMM-Newton to measure the X-ray energy distribution. The observed spectral changes are well correlated and demonstrate the influence of the same absorbing material in the different spectral regions. In this poster we examine which spectral features in the different spectral regions (FUV/NUV/optical/X-ray) change and by how much, and thereby determine the location of different emitting regions within the complex stellar/inner disk system relative to the absorbers along the line-of-sight to the stellar photosphere. Understanding these contributions is vital for estimating the properties of the absorbing gas and dust. (This work is supported by grant HST-GO-15128 and time awarded by HST, XMM-Newton, LCOGT, and SMARTS.)

The Remarkable Spectroscopic and Photometric Variability of T Cha

Poster 34

F.M. Walter[1]; A. Brown[2]; K. France[3]; P.C. Schneider[4]; T. Brown[5]; S. Andrews[6]; D. Wilner[6]

Stony Brook University; CASA/Colorado; LASP/Colorado; Hamburg; LCGTN; SAO

The Classical T Tauri stars exhibit a vast amount of variability, of almost all foreseeable and some unforeseeable types. In February/March 2018 we undertook a week-long coordinated multiwavelength observing campaign on the violently variable pre-main sequence star T Cha, a 1.5 solar mass member of the ϵ Cha association. The T Cha system is viewed nearly edge-on; much of the variability is likely caused by obscuration by the inner disk. The overarching goal of the campaign is to study the structure of the gas and dust in the inner protoplanetary disk.

The campaign was built around three visits from XMM and HST (STIS+COS), which are reported elsewhere. In support of this campaign we used the SMARTS Chiron fiber-fed spectrograph on the CTIO 1.5m telescope to obtain high resolution (R=28,000) optical (4080 - 8900A) spectra. We got 29 spectra at 10-30 minute time resolution on the 8 nights of the campaign, including a 7 hour continuous sequence simultaneous with the third HST/XMM visit. To place the variability into context, we obtained spectra on 12 other nights from August 2017 through May 2018.

We shall discuss the remarkable variability of the Hα line. There is always at least one strong redshifted absorption component (<velocity> $\approx$ 100 km/s), and at most epochs a possible P Cygni absorption component. The equivalent width varies from -9.8Å (net emission) to +2.2Å (net absorption). We will discuss a search for correlations of the line profile with the photometric flux and its variability. The persistent O I λ6300Å line may arise in a disk wind. We will discuss other aspects of the spectra, including the radial velocity jitter and signs of variable gas absorption in the Na D lines.

The solar convective conundrum and implications for solar and stellar dynamos

Poster 35

Benjamin Brown

Department of Astrophysical and Planetary Sciences, University of Colorado, Boulder

Magnetic fields in stars like the Sun are generated by dynamo action, driven by convection in their subphotospheric convective envelopes and the differential rotation which that convection builds. In the Sun, a serious convective conundrum has emerged. The largest scales of convection seem to exist at much, much lower amplitudes than are predicted by either numerical simulations or theory. This conundrum is seen both observationally from helioseismology, where global modes of motion are very weak, and in numerical simulations, where the solar differential rotation profile has been difficult to retain as simulations achieve more realistic levels of turbulence. These two issues are linked and appear to have a common resolution. Here I review the observational and theoretical evidence for the solar convective conundrum, modern attempts at reconciling observations and simulations, and implications of the convective conundrum for the solar dynamo and stellar dynamos more generally.

Poster 36

NRES: The Network of Robotic Echelle Spectrographs

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Las Cumbres Observatory; University of Colorado

The Network of Robotic Echelle Spectrographs (NRES) consists of four identical high-resolution fiber-fed spectrographs, each attached to one or two of the robotic 1m telescopes operated by Las Cumbres Observatory. Optimized for moderate-precision radial velocity work, these spectrographs are now being commissioned for exoplanet studies, notably followup spectroscopy for the TESS Mission, and applications involving time-varying line shapes. We describe here the design and realized performance of the network, and show results from commissioning and from early science programs. We also discuss prospects for future expansion of the network.

Poster 37

Connecting the Past to the Future: Age-Rotation-Activity Studies from Kepler to TESS

D. Buzasi

Florida Gulf Coast University

Kepler has revolutionized the study of stellar rotational evolution by providing well-sampled, long-duration, high-quality photometric light curves for a wide range of stellar types. The K2 follow-on mission has provided similar data for a stellar sample comparable in size to that observed with Kepler, and drawn from new stellar populations, but for shorter sample periods – typically about 80 days. TESS data from full-frame images will further extend the population of stars with such light curves by perhaps two orders of magnitude, but for time periods as short as 27 days.

In this work, we resample Kepler light curves using the K2 and TESS observing windows and apply a variety of algorithms to extract rotational signals and estimate the envelope of photometric variability. From that we study what can be learned from high-precision light curves of short duration, and how to compare those results to what we have learned from Kepler. Specifically, we consider how to best compare results between different missions, and begin to address what is the ”best” approach to estimating photometric variability and rotational periods from these high-precision light curves. Results are particularly relevant to future studies of the age-rotation-activity relation on the lower main sequence.

The low-mass population of Upper Scorpius with Gaia DR2

Poster 38

V. J. S. Bjar[1,2]; A. Prez-Garrido[3]; P. Chinchilla[1,2]; N. Lodieu[1,2]; R. Rebolo[1,2]; M. R. Zapatero Osorio[4]; B. Gauza[5]; K. Y. Peña-Ramírez[6]

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Using 2MASS and Denis catalogs, we perfomred a search for very low-mass stars and brown dwarf candidates covering an area of 168 deg^2 in the Upper Scorpius association ($\sim$ 10 Myr, $\sim$ 145 pc). From $I, I-J$ and $I, I-Ks$ color-magnitude diagrams, we selected 1257 candidates in the magnitude range I=13-18.5 mag, which follow the photometric sequence of previously known members. Using the position on the sky, parallaxes and proper motions from the Gaia DR2 data, we determined bona fide members, searched for companions, and investigated the distance, spatial structure and the kinematic of the association.

Chemical connections between stars and planets building blocks investigated by stellar population synthesis

Poster 39

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Connecting star and planet properties in a single model is not straightforward. Currently, observations show that the presence of planetary companions is closely linked to the metallicity and the chemical abundances of the host stars (e.g. Adibekyan et al. 2015). Moreover, the different stellar populations in our Galaxy are characterized by different metallicities and alpha abundances (Haywood et al. 2013). Stellar population synthesis model are key to explore combined statistical constraints from stars and planets observations. The Besançon stellar population synthesis model (e.g. Robin et al. 2003, Lagarde et al. 2017) includes now the stellar evolutionary tracks computed with the stellar evolution code STAREVOL (e.g. Lagarde et al. 2012, Amard et al. 2016). It provides the global (M, R, Teff, etc) and chemical properties of stars for 54 chemical species. It enables to study the different galactic populations of the Milky Way (the halo, the bulge, the thin and thick disc) and a specific observational survey. Here, we study the expected planet properties from the host star abundances. In particular, we determine the composition of the planet building blocks (PBB) using a simple stoichiometric model (Santos et al. 2017). We investigate the trends and correlations of the expected chemical abundances of PBB in the different stellar populations of the Milky Way (Cabral et al. 2018, in prep.).

Poster 40

The discrepancy between dynamical and theoretical masses for low-mass multiple systems

P. Calissendorff

Stockholm University

Multiple systems prove to be excellent benchmarks for testing evolutionary models. By monitoring the motions of the components in the system we can derive orbital solutions that yield robust dynamical masses to test the theory against. However, the models and the dynamical masses are not alway in agreement, which is especially apparent for low-mass systems. Because not many multiple systems in the low-mass regime with short enough periods to obtain orbital solutions in reasonable time-frames have been observed, systems with constrained orbits become important calibrators for the models. In this talk I will present results from the AstraLux multiple system monitoring program, explaining how we can take advantage of the Lucky Imaging technique to observe otherwise unresolved systems to find faint companions, which have short enough orbits that orbital fits start to provide constrained results. I will in detail discuss the triplet-system 2MASS J10354483+1521394, which shows a 30 percent higher dynamical mass for the individual components compared to mass-values obtained from theoretical models.

Poster 41

Beryllium Abundances in Li-rich Red Giants

Joleen K. Carlberg[1]; Katia Cunha[2,3]; Verne V. Smith[4]; José D. do Nascimento Jr.[5,6]

Space Telescope Science Institute; Observatório Nacional; Steward Observatory; NOAO; Harvard-Smithsonian CfA

We present measurements of beryllium abundances in a sample of Li-rich red giant stars selected to discriminate between Li replenishment scenarios. One subset of the red giants have characteristics consistent with Li synthesis and extra-mixing (e.g., very low ^{12}C/^{13}C), while the other subset has characteristics more suggestive of planet engulfment (e.g., enhanced rotation or ”normal” ^{12}C/^{13}C ratios). These two Li-replenishment scenarios should result in either very low or enhanced Be abundances, respectively. We find that the two subgroups of stars do show differences in their Be abundances, but we do not find Be enhancements as large as predicted. We compare our results to a large sample of Be measurements in Li normal red giants in an effort to better interpret these findings.

Assessing M-Giant Mass-Loss Rates and Wind Parameters from UV Emission Line Profiles

Poster 42

K. G. Carpenter[1]; G. Rau[2]; K. E. Nielsen[3]

NASA-GSFC; CUA@NASA-GSFC; CUA

The photon-scattering winds of M giants produce absorption features in their strong chromospheric emission lines. These provide us with an opportunity to assess important parameters of the wind, including flow and turbulent velocities, the optical depth of the wind above the region of photon creation, and the star's mass-loss rate. We have used the Sobolev with Exact Integration (SEI) radiative transfer code, along with simple models of the outer atmospheric structure and wind, to determine the wind characteristics of the two M-giant stars, Gamma Cru (M3.4) and Mu Gem (M3IIIab). We use the SEI code because it has the advantage of being computationally fast and thus allows a great number of possible wind models to be examined. The analysis procedure involves specifying wind parameters and then using the program to calculate line profiles for the Mg II (UV1) lines and a range of unblended Fe II lines. These lines represent a wide range of wind opacities and thus different heights in the atmosphere. The assumed wind properties are iterated until the predicted profiles match the observations (in this case HST/GHRS UV spectra) over as many lines as possible. We present estimates of the wind parameters derived in this fashion for these stars and offer a comparison to wind properties previously-determined for low-gravity K stars using the same technique and similar data. Further details will be presented in Rau, Carpenter, and Nielsen (2018, ApJ, in prep).

The Shared Evolution of Stars and their Planetary Systems

Poster 43

B. Carter; B. Nicholson; D. Evensberget; S. Marsden

USQ

USQ's new Centre for Astrophysics combines the fields of stellar astrophysics and planetary science to study the shared evolution of stars and their planetary systems. Our complementary studies of exoplanets and host star magnetic fields include exoplanet detection and characterization, stellar magnetic field mapping and wind modeling, and the dynamical modeling of solar system bodies and exoplanetary systems. Our research uses existing and new facilities, including USQ's Mt Kent Observatory, its new MINERVA-Australis telescope array for NASA TESS follow-up and a forthcoming adjacent SONG asteroseismology node, and the new Veloce precision radial velocity spectrograph on the 3.9m Anglo-Australian Telescope at Siding Spring.

Poster 44

Discovery of M-dwarf Flares from SkyMapper Southern Survey

Seo-Won Chang; Christian Wolf; Christopher A. Onken

The Australian National University ANU; ARC Centre of Excellence for All-sky Astrophysics CAASTRO

M-dwarf flares are common candidates of high-amplitude, fast optical transients serendipitously discovered by many time-domain surveys. We present the results of our search to constrain the rate of these galactic transients in the Southern sky using a volume-limited sample (d $<$ 25pc) of 1359 M dwarfs and flux-limited sample (complete to 18 mag in all $uvgriz$ bands) from the SkyMapper Shallow Survey. By covering a large sky area homogeneously with a six-colour sequence, it allows us to assemble bona-fide flares on timescales of less than five minutes for each pointing. We apply either correlation-based or scatter-based outlier searches to identify flaring epochs in the light curves of M dwarfs. To provide meaningful constraints, in this talk, we will investigate in detail how the observed flare rate is sensitive to spectral type, survey depth, cadence or quality of the data.

Poster 45

VLMS in Eclipsing Binary systems with PARAS

Priyanka Chaturvedi[1]; Abhijit Chakraborty[2]; B.G. Anandarao[2]; Rishikesh Sharma[2]; Prasad J.S.S.V. Neelam[2]

Thuringer Landessterwarte Tautenburg TLS, Germany; Physical Research Laboratory PRL, India

Eclipsing binaries (EBs) with one of the companions as very low-mass stars (VLMS or M dwarfs) are testbeds to substantiate stellar models and evolutionary theories. Stars having masses $\geq 1 M_{\odot}$ observationally match well with the theoretical models of convective interiors and radiative atmospheres. However, there have been discrepancies reported for the observed and model-derived stellar radii of very low mass stars (VLMS) of masses $\leq 0.6 M_{\odot}$ (Torres 2010). With the motivation to study these VLMS, which are poorly modelled due to limited observational data, we shortlisted a collection of potential EB candidates from the photometric catalogues of Kepler, *STEREO*, and *SuperWasp* for the EB programme initiated at Physical Research Laboratory (PRL). The aim of the study is to look for single-lined EB systems (for which spectra of only the primary can be recorded), where VLMS occur as companions to F, G, K type primaries, for precise characterization of masses and radii at better accuracies. Radial velocity (RV) data of these sources were obtained using the high-resolution spectrograph, Physical Research Laboratory Advanced Radial velocity Abu-sky Search (PARAS) (Chakraborty 2014) coupled with the 1.2 m telescope at Gurushikhar Observatory, Mount Abu, India. Wideband differential photometry with the help of a 10 inch telescope located at PRL's Mount Abu Observatory has also been performed to complement the spectroscopy. In addition, for a few sources, the archival photometry data have been analysed and included in our study. We hereby present the results on few EBs studied through RV and photometry as a part of the EB program conducted at PRL. A brief comparison of the results of the current work is made with the M dwarfs already studied in the literature. Missions like TESS and PLATO will be able to fulfill this observational gap in near future.

Evolving Models of Stellar Surface and Coronal Magnetic Fields

Poster 46

M. C. M. Cheung[1,2]; M. L. DeRosa[1]

Lockheed Martin Solar and Astrophysics Laboratory; Stanford University

We present an ongoing effort to model the evolving photospheric and coronal magnetic fields of cool stars. In this project, we run a series of surface flux transport (SFT) models of starspot evolution. SFT models are used as lower boundary conditions to drive evolving models of stellar coronal magnetic fields. The coronal magnetic fields are modeled by magnetofriction (MF), which allows us to construct force-free coronal fields evolving in response to starspot evolution. The combined SFT/MF simulations are used to synthesize dynamic Stokes spectra to serve as inputs for Zeeman Doppler Imaging (ZDI) inversions. Photometric light curves modulated by starspot evolution and stellar rotation are also synthesized. We show inversion results for cases with various degrees of complexity, from isolated, stationary starspots with potential fields to emerging active regions consisting of multiple magnetic polarities with interlocking coronal fields. This project is part the Solar-Stellar Connection Focus Science Team funded by NASA's Living With A Star program.

Spin-Orbit Alignment of Planetary Systems (SOAPS): The Case of 63 Kepler planets and planet candidates

Poster 47

Y. Gómez Maqueo Chew[1]; E. F. Canul[1]; F. Faedi[2,3]; L. Fossati[4]; L. Hebb[5]; A. McQuillan; M. Goad[6]; D. Pollacco[2]

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The obliquity is the physical property that can be used to probe the history of formation and evolution of planetary systems describing their current orbital configuration. We study the exoplanetary architectures based on obliquity measurements in the line of sight for 34 stars observed by Kepler. These stars harbour a total of 63 transiting planets and planet candidates, with orbital periods ranging from 0.8 to 290 d, and planetary radii ranging from 0.3 to 12.5 $R_\oplus$, as measured from their Kepler transit light curves. We measured the obliquity in the line of sight through the implementation of an MCMC algorithm to find the most probable stellar inclination angle. To do so, we measured $v \sin i$ employing Subaru HDS spectra (R$\sim$160 000) combined with robust stellar rotational periods and stellar radii from the literature. As a result, we identify a dependence between planetary multiplicity and coplanarity, and high alignment of the orbits. We did not find evidence that candidate stellar companions modify the observed distribution of the obliquity in the line of sight. Our results do not support that alignment occurs preferably around relative cool stars through tidal interactions over hotter stars. Finally we explore the possible evolutionary pathways for the planetary systems in our sample to constrain mechanisms and scenarios that could explain the observed obliquities of our sample.

Poster 48

Ultra-cool subdwarfs in the Subaru HSC survey

Poshih Chiang[1]; Chien-Hsiu Lee[2]; Eugene Magnier[3]; Wen-Ping Chen[1];

National Central University; NAOJ; IfA, U of Hawaii

Ultra-cool subdwarfs (UCSD) are metal-poor low-mass stars and brown dwarfs with spectral types of M, L, T, and Y. Their old ages and long lives make them effective tracers to study the history of star formation and chemical enrichment in Milky Way. Only a handful of confirmed subdwarf brown dwarfs (L type and later) are known. Their faint optical photometry, required to identify them reliably in surveys, makes it very challenging to detect these important probes of early star formation. We are using the ongoing Hyper Suprime-Cam Subaru Strategic Program (HSC-SSP) survey to search for fainter ultracool subdwarfs. HSC-SSP allows us to push the depth of the optical photometry in a wide area matched with UKIDSS near infrared photometry. We have identified 7 strong candidate L subdwarfs on the basis of optical & near IR photometry combined with proper motions. One has been confirmed a sdL5 subdwarf in the spectroscopic followups this March.

Poster 49

Search for common proper motion wide substellar companions to young nearby stars with Vista Hemisphere Survey.

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We have performed a search for substellar objects as common proper motion companions to young nearby stars (including Young Moving Groups such as TW Hya, Tuc-Hor, Beta Pic, and associations such as Upper Scorpius) up to separations of 50,000 AU, using the VISTA VHS survey and 2MASS astrometric and photometric data. We have found tens of candidates with spectral types from M to L, and estimated masses from low-mass stars to the deuterium-burning limit. For some of these candidates, we have also obtained optical and/or near-infrared spectroscopy confirming them as true companions. We will present the preliminary results of our searches and discuss the most outstanding cases. Our results show that the frequency of young companions is higher than the field.

The POKÉMON Speckle Survey of Nearby M-Dwarfs

Poster 50

Catherine A. Clark[1,2]; Gerard T. van Belle[1]; Elliott Horch[3]; Kaspar von Braun[1]
Lowell Observatory; Northern Arizona University; Southern Connecticut State University

The POKÉMON (Pervasive Overview of Kompanions of Every M-dwarf in Our Neighborhood) survey of nearby M-Dwarfs intends to inspect, at diffraction-limited resolution, every low-mass star out to 15pc, along with selected additional objects to 25pc. The primary emphasis of the survey is detection of low-mass companions to these M-dwarfs for refinement of the low-mass star multiplicity rate. Given the priority these targets will have for upcoming exoplanet studies of TESS and JWST - and the degree to which initially undetected multiplicity has affected Kepler results - a comprehensive survey of our nearby low-mass neighbors will produce a homogenous, complete catalog of fundamental utility. Prior knowledge of those secondary objects - or robust non-detections, as will be captured by this survey, will help immediately clarify the nature of exoplanet transit detections from these current and upcoming missions. POKÉMON is using Lowell Observatory's 4.3-m Discovery Channel Telescope (DCT) with the Differential Speckle Survey Instrument (DSSI) speckle camera, along with the NN-Explore Exoplanet Stellar Speckle Imager (NESSI) speckle imager on 3.5-m WIYN; the survey takes advantage of the extremely rapid observing cadence rates possible with WIYN and (especially) DCT. The current status and preliminary results are from the first 20+ nights of observing.

The K2 View of Young Stars

Poster 51

Ann Marie Cody
NASA Ames Research Center

We have entered a golden era for time domain astronomy, particularly when it comes to variability studies of the low-mass T Tauri stars. These 1-10 million year old young stellar objects (YSOs) occupy a key epoch in the evolution from molecular clouds to mature star/planet systems. Many of them host protoplanetary disks, from which gas accretion is mediated by complex magnetic field structure. At the stellar surface, hot spots form at the base of accretion columns, while cold spots appear as a result of local magnetic field structure. Dust orbiting within the inner 0.1-1 AU of the disk occupies clumpy structures, some of which may appear to occult the central star. We review here the astounding progress that has recently been made in classifying and understanding young star variability, thanks in large part to the rise of precision space photometry missions. We highlight recent results from the K2 Mission's campaigns on several young clusters and associations, including discoveries of accretion burst sources and obscuring dust clouds and their connection with disk properties.

Poster 52

Exoplanet Modulations of Stellar Coronal Radio Emissions

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The search for exoplanets in the radio bands has been focused on detecting radio emissions produced by the interaction between magnetized planets and the stellar wind (auroral emissions). Here we introduce a new tool, which is part of our MHD stellar corona model, to predict the ambient coronal radio emission and its modulations created by the planet - a radio transit. We explore the radio flux modulations using a limited parameter space of idealized cases by changing the magnitude of the planetary field, its polarity, the planetary orbital separation, and the strength of the stellar field. We find that the modulations can be significant and observable in the case of hot Jupiter planets - above 10

Poster 53

Axisymmetric and Nonaxisymmetric Dynamo Modes in Spherical Convection Models

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University of Helsinki; Max Planck Institute for Solar System Research; ReSoLVE Centre of Excellence, Aalto University; Leibniz Institute for Astrophysics Potsdam; NORDITA, KTH Royal Institute of Technology and Stockholm University; Department of Astronomy, AlbaNova University Center; JILA and Department of Astrophysical and Planetary Sciences; Laboratory for Atmospheric and Space Physics

Persistent structures such as active longitudes are observed through long-term monitoring of cool late-type stars using photometry, spectroscopy, and spectropolarimetry. Some stars show a difference between the rotation rates of these active longitudes and the rotation rate of the stars themselves. Such a difference is not adequately explained by differential rotation alone, particularly for the rapid rotators. Mean field theory predicts the presence of an azimuthal dynamo wave that rotates as a rigid structure independent of the velocity flow for α^2 dynamos. We present here the results of simulations of convection in spherical wedges with Coriolis numbers (Co or inverse Rossby numbers) from 1.6 to 127. In all simulations where Co > 3, an azimuthal dynamo wave is found. This dynamo wave rotates as a rigid structure, usually with retrograde motion to that of the gas. The cycles of these azimuthal dynamo waves are compared to observations of active longitudes on stars.

TESS Follow-up Observing Program (TFOP) Working Group (WG): A Mission-led Effort to Coordinate Community Resources to Confirm TESS Planets

Poster 54

Karen A. Collins[1]; David W. Latham[1]; Samuel N. Quinn[1]; Jessie Christiansen[2]; David Ciardi[2]; Diana Dragomir[3]; Ian Crossfield[3]; Sara Seager[3]

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The Transiting Exoplanet Survey Satellite (TESS) will observe most of the sky over a period of two years. Observations will be conducted in 26 sectors of sky coverage and each sector will be observed for 27 days. Data from each sector are expected to produce hundreds of transiting planet candidates (PCs) per month and thousands over the two year nominal mission. The TFOP Working Group (WG) is a mission-led effort organized to efficiently provide follow-up observations to confirm or reject planet candidates. The primary goal of the TFOP WG is to facilitate achievement of the Level One Science Requirement to measure masses for 50 transiting planets smaller than 4 Earth radii. Secondary goals are to serve any science coming out of TESS. The TFOP WG is organized as five Sub Groups (SGs). SG1 will provide seeing-limited imaging to measure blending within a candidate's aperture and time-series photometry to identify false positives and in some cases to improve ephemerides, light curves, and/or transit time variation (TTV) measurements. SG2 will provide reconnaissance spectroscopy to identify astrophysical false positives and to contribute to improved host star parameters. SG3 will provide high-resolution imaging with adaptive optics, speckle imaging, and lucky imaging to detect nearby objects. SG4 will provide precise radial velocities to derive orbits of planet(s) and measure their mass(es) relative to the host star. SG5 will provide space-based photometry to confirm and/or improve the TESS photometric ephemerides, and will also provide improved light curves for transit events or TTV measurements. We describe the TFOP WG observing and planet confirmation process, the five SGs that comprise the TFOP WG, ExoFOP-TESS and other web-based tools being developed to support TFOP WG observers, other advantages of joining the TFOP WG, the TFOP WG charter and publication policy, preferred capabilities of SG team members, and the TFOP WG application process.

The K2 Near-Infrared Transit Survey (KNITS)

Poster 55

Knicole Colón[1]; Joseph Rodriguez[2]; Geert Barentsen[3]; José Vinícius de Miranda Cardoso[3]; Andrew Vanderburg[4]

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NASA's K2 mission has discovered several hundred transiting exoplanets and candidates to date, many of which have cool host stars by design. While the exoplanets that have been confirmed or validated from K2 have been subject to spectroscopic observations, high-resolution imaging, or statistical methods, most of these as well as the candidate exoplanets have had no follow-up transit photometry. I will present the latest results from an ongoing program to use the 3.5-meter WIYN telescope at Kitt Peak National Observatory for near-infrared transit photometry of K2 exoplanets and candidates. To date, we have observed more than 25

K2 exoplanets and candidates with WIYN, with about half of these having cool host stars. Our program of high-precision, high-cadence, high-spatial-resolution near-infrared transit photometry is providing refined measurements of the planetary radii by minimizing effects of stellar limb darkening and activity from star spots and flares (particularly in the coolest host stars) and also serves to weed out false positives within the candidate list. I will also present results from our campaign to collect near-infrared photometry with WIYN simultaneous with optical photometry from the Kepler spacecraft in K2 Campaigns 16 and 17. These simultaneous observations of transiting exoplanets as well as low-mass eclipsing binaries in the Beehive cluster offer a unique opportunity to characterize the stellar variability of exoplanet host stars and low-mass eclipsing binaries. Our program ultimately provides a vetted and well-characterized sample of exoplanets that could be targeted in the future by NASA's James Webb Space Telescope.

Poster 56

Correlation of the [FUV-MUV] colour vs Mg II index along the solar cycle

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The UV emission of the hosting star is fundamental to model the habitability of planets. Lovric et al. (2017) employed SORCE/SOLSTICE solar observations to introduce a UV color index that is strongly linearly correlated with the Mg II index. We employ an irradiance reconstruction technique to synthetize the UV color and Mg II index to investigate the physical mechanisms that produce such a strong correlation. The reconstruction shows not only the same trend as the observations, but also that this extends back for almost three decades. We suggest that the strong correlation between the indices results from the Far- and Middle- UV radiation originating in the chromosphere, where atmosphere models of quiet and magnetic features present similar temperature and density gradients.

Poster 57

CO in M Dwarfs: High-resolution IR spectroscopy

Ian Crossfield

MIT

We provide an update on our observational campaign to obtain high-S/N, high-resolution (R 70,000) infrared spectroscopy of bright, nearby M dwarfs in the K and M bands, with the ultimate goal of measuring the isotopic abundances of 12CO/13CO in these stars. This isotopic ratio may provide age measurements of these late-type stars, which are notoriously difficult to date from gyrochronology or low-resolution spectroscopy. We hope that our observations will enable a broad diversity of ancillary stellar science and prepare the way for future, similar studies of brown dwarfs and giant extrasolar planets.

The BDNYC Database of Low Mass Stars, Brown Dwarfs, and Planetary Mass Companions

Poster 58

Kelle Cruz[1,2,3,4]; David Rodriguez[5]; Joe Filippazzo[5]; Eileen Gonzales[2,3]; Emily Rice[2,3,6]; & Jackie Faherty[2].

CUNY Hunter College; American Museum of Natural History; CUNY Graduate Center; Flatiron Institute; Space Telescope Science Institute; CUNY College of Staten Island

We present a web-interface to a database of low-mass stars, brown dwarfs, and planetary mass companions. Users can send SELECT SQL queries to the database, perform searches by coordinates or name, check the database inventory on specified objects, and even plot spectra interactively. The initial version of this database contains information for 198 objects and version 2 will contain over 1000 objects. The database currently includes photometric data from 2MASS, WISE, and Spitzer and version 2 will include a significant portion of the publicly available optical and NIR spectra for brown dwarfs. The database is maintained and curated by the BDNYC research group and we welcome contributions from other researchers via GitHub.

Problems with and Prospects for K dwarf gyrochronology: Insights from the *K2* Survey of Ruprecht 147

Poster 59

Jason L. Curtis

Columbia University

Gyrochronology has been demonstrated to work at least up to the age of the Sun for solar analogs. What comes later remains controversial, where periods for Kepler's asteroseismic touchstone stars have been used to argue for a reduced braking efficiency at older ages. However, this effect should not affect K dwarfs (0.6-0.9 $M_{\odot}$), which are even more problematic to age-date with isochrone methods than F and G dwarfs. The difficulty with calibrating K dwarfs gyrochronology is that few are known with published periods that have precise ages older than the Hyades or Praesepe (650 Myr). This is because asteroseismology is not effective for this class of stars and those located in the older clusters surveyed with *Kepler* (NGCs 6811 and 6819) are too faint. Our *K2* Survey of Ruprecht 147 remedies this by expanding the sample of 2.5 Gyr rotators from 0.85 $M_{\odot}$ from NGC 6819 down to 0.5 $M_{\odot}$ in R147. Our new sample shows tension with expectations from various empirical models (e.g., Barnes 2010, Mamajek & Hillenbrand 2008, Angus et al. 2015), semi-physical models (e.g., van Saders et al. 2013, Matt et al. 2015), and the observed Praesepe period sequence projected forward in time to the age of R147, all of which predict periods for K dwarfs much longer than observed in the Ruprecht 147. We will discuss scenarios to explain this unexpected behavior.

Poster 60

Influence of stellar structure, evolution and rotation on the tidal damping of exoplanetary spin-orbit angle

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It is debated wether close-in giant planets can form in-situ and if not, which mechanisms are responsible for their migration. One of the observable tests for migration theories is the current value of the obliquity, the angle between the stellar spin axis and the normal to the orbital plane. But after the main migration mechanism has ended, the combined effects of tidal dissipation and the magnetic braking of the star lead to the evolution of both the obliquity and the semi-major axis. I will present an improved model for the tidal evolution of the obliquity. This model uses an analytical ab-initio estimation of tidal dissipation based on the physical properties of the host star, and tied to a known mechanism, the excitation and damping of inertial waves in convection zones. We find that tidal dissipation in convective envelopes of low-mass stars is mainly driven by their rotational evolution on the main-sequence. In the range of mass of stars developing a radiative core and a convective envelope, more massive stars remain fast rotators until the end of the main sequence, as a consequence of a less efficient magnetic braking. Thus we predict that their dissipation is not significantly reduced compared to the one of less massive stars. For typical orbital configurations of hot-Jupiters, the damping timescale of the obliquity is then generally shorter than that of the semi-major axis, due to different contributions associated to the components of the dynamical tide. Nevertheless, our simulations do not to produce slower tidal evolution of the obliquity for more massive stars. Thus this would fail to explain the correlation between effective temperature and obliquity observed in well characterised systems. The model needs to be expanded to treat the dissipation in radiative zones, and better magnetic braking laws. What we present here is a first important step in the theoretical effort to produce tidal models accurate enough to constrain migration scenarios.

Poster 61

How Does Large-Scale Coronal Field Topology Affect the Eruptivity of Solar Active Regions?

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We aim to identify whether the presence or absence of particular topological features in the large-scale coronal magnetic field on the Sun are correlated with whether flares from solar active regions are confined or eruptive. Because there exist large flares that are not accompanied by a CME, this raises the question of whether such flares suffer from a lack of access to nearby open fields in the vicinity above the flare (reconnection) site. We show that, for a sample of 56 X-class flares, eruptive flares are preferentially located near coronal magnetic field domains that are open to the heliosphere, as inferred from a potential field source surface model. However, there is a lot of variation in the topologies that produce both confined and eruptive flares, making it difficult to predict whether a particular active region, assuming it flares, will produce a CME.

A search for cold giant planets in wide orbits

Poster 62

Niall Deacon[1,2]; Adam Kraus[3]

MPIA; University of Hertfordshire; University of Texas at Austin

We present preliminary results from a Spitzer search for cold (<400K) giant planets in wide orbits around stars within 8pc. Using Spitzer we have been systematically surveying the areas around stars within 8pc searching for cold common proper motion companions. From our first Spitzer campaign we were able to recover a known brown dwarf companion and estimate the completeness of our data. We also show that we are able to recover the wide orbit planet WD 0806b from archival data. Our survey will provide the best constraints yet on the number of cold companions in wide orbits around nearby stars.

A study of the brightness maxima separation in the light curves of contact binary stars

Poster 63

B. Debski

Astronomical Observatory of the Jagiellonian University

The light curves of contact binaries are known to exhibit intrinsic variability, which leads to some short- or long term asymmetries, typically attributed to a presence of a star spot. While the literature is usually focused on the minima timing variation or the difference between the height of the brightness maxima (the ’O‘Connell effect’), other information-rich ’effects’ are hidden in the light curves. Here we show how much can be understood about the contact binary system by studying only the separation between its brightness maxima. We present the methods of constraining the surface temperatures of the binary components, establishing the mass ratio and the influence of the fill-out factor. Using statistical approach we show that contact binaries with a less massive component being significantly hotter probably do not exist. The study then turns to the topic of star spots on contact binaries: using Kepler data, [1] we show the fast method of finding the indicators of the star spot migration, [2] we constrain the star spots to the polar regions, which redefines the ’migration’ to a ’tilt rotation’ and [3] we propose new types of variability in contact binaries, based on the observed evolution of the O’Connell effect and the changes in the maxima separation.

Poster 64

Insights on physical processes occurring inside stars from lithium abundances in large samples of open cluster stars with ages 1.5-2.3 Gyr

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Indiana University; University of Kansas

WIYN/Hydra Li spectra have been analyzed in hundreds of stars in each of the open clusters NGC 6819 (age=2.3Gyr), NGC 7789 (1.5Gyr), and NGC 2506 (1.7Gyr), from below the turnoff through the giant branch. We report a number of findings: 1) The NGC 6819 dwarf masses go as low as that exhibiting the Li plateau (A(Li) 2.8) seen in late-F dwarfs cooler than the Li-Dip. The Li-Dip is a severe non-standard Li depletion discovered in Hyades (650Myr) mid-F dwarfs, created during the MS after the Pleiades age (100Myr). Various lines of evidence suggest rotational mixing creates the Li-Dip, although diffusion may also play a role. We find that the mass range of the Li-Dip in NGC 6819 is similar to that in the Hyades and Praesepe (650Myr), but the Li depletion is more severe in the cool side of the Li-Dip, and, unlike Hyades/Praesepe, *all* stars are severely Li-depleted. 2) Where is the transition between low-mass dwarfs that spin down and higher-mass stars? As our dwarfs more massive than the Li-Dip evolve toward the red-hook just below the MS turnoff, from 1.5Gyr (early-F) to 2.3Gyr (mid-F), they spin down from a range of 20-90km/sec to the much narrower range of 10-25km/sec. They also deplete their Li, creating a second Li-Dip at a higher mass than the traditional Li-Dip. 3) Standard subgiant Li dilution is expected to decrease the surface A(Li) as the surface convection zone deepens, and establish a diluted Li plateau on the RGB. But rotational mixing during the MS and/or later can cause dilution to begin earlier, influence the shape of the Li-Teff relation, deplete Li to levels lower than the standard plateau, and affect the length of the Li-Teff plateau. Thermohaline mixing can further deplete Li on the upper RGB. Our clusters show evidence of all three processes but to varying degrees from cluster to cluster. 4) Some stars show higher A(Li) than their CMD neighbors. The possibility is discussed that in some cases this Li is being created in situ.

Poster 65

Ground-based transmission spectroscopy of the terrestrial exoplanets GJ 1132b and LHS 1140b

Hannah Diamond-Lowe[1]; Zachory Berta-Thompson[2]; David Charbonneau[1]; Eliza M.-R. Kempton[3,4]

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GJ 1132b and LHS 1140b, two terrestrial worlds transiting nearby mid-M dwarf stars, offer an opportunity for comparative planetology. GJ 1132b is highly irradiated, orbits its host star on a 1.6-day period, and receives 19 times Earth's insolation. On the other hand, LHS 1140b is in the habitable-zone of its host star, orbits on a 25-day period, and receives only 0.4 times Earth's insolation. The relatively high planet-to-star radius ratios for these two terrestrial exoplanets make them amenable to atmospheric characterization via the transmission spectroscopy method. With ground-based telescopes we can test the cases of clear, low

mean molecular weight atmospheres on these worlds. We observed five transits of GJ 1132b with the LDSS3C multi-object spectrograph on Magellan Clay, and one transit of LHS 1140b (the only one observable from the ground in 2017) simultaneously with both the LDSS3C and IMACS multi-object spectrographs on Magellan Clay and Baade. We developed custom Python pipelines to extract, calibrate, and simultaneously decorrelate multiple transits of each object. We completed the analysis of the GJ 1132b transits and disfavor clear, low mean molecular weight atmospheres at >3 sigma confidence. I will summarize these findings and present those for the LHS 1140b transit, and contextualize these results in the current state of the field. These measurements are a basis for comparative planetology of terrestrial exoplanets and will inform future observations with HST and JWST.

Activity of close-in planet hosts: establishing a homogeneous database

Poster 66

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Astronomers have traditionally used chromospheric activity measurements to infer fundamental properties of cool stars including age, rotation rate, convection levels and magnetic activity. With the advent of exoplanetology, activity metrics for planet-hosts may be used to probe star-planet interactions, planetary mass-loss, planet composition determinations, radio detectability and planetary magnetic fields. We use the Robert Stobie Spectrograph on the South African Large Telescope to make Ca ii H & K observations of Southern Hemisphere close-in planet hosts, from which we derive $\log(R'_{\mathrm{HK}})$ – the most commonly used metric for comparing the chromospheric activity of F, G and K stars. Our programme avoids uncertainties caused by systematic offsets between measurements made with different instruments thus creating a uniform database with significantly smaller internal errors than the prior state-of-the-art in planet-host activity work. Noteworthy individual results include systems with $\log(R'_{\mathrm{HK}})$ values lower than any previously published, probably caused by absorption by diffuse gas shrouds of material lost from ablating planets, and systems where there are vigorous star-planet interactions. The observational results contain some powerful implications for the evolution of these close-in planetary systems.

Poster 67

Constraining magnetic variability in Praesepe with simultaneous K2 and spectroscopic observations

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Activity tracers such as H-alpha offer insight into stellar magnetic fields, particularly when compared to rotation. Studies of magnetic phenomena are stymied, however, by single- or few-epoch surveys that fail to account for stellar variability; for example, individual M dwarfs exhibit significant scatter when multiple H-alpha measurements are considered. K2 surveyed the planet-hosting open cluster Praesepe during Campaign 16, from Dec 2017 to Feb 2018. We have acquired simultaneous ground-based spectroscopy for >60 K and M stars in Praesepe throughout this 80-day campaign. I will present our time-series spectroscopy, and how H-alpha variability compares with the photometric variability observed by K2. I will discuss the implications of our results for understanding starspot distributions and the impact of stellar variability on future surveys.

Poster 68

Searching for the Origin of Flares in M dwarfs

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We present an overview of K2 short cadence observations for 40 M dwarfs which have spectral types between M0-L1. All of the stars in our sample showed flares with the most energetic reaching 3×10^{34} ergs. As previous studies have found, we find rapidly rotating stars tend to show more flares, with evidence for a decline in activity in stars with rotation periods longer than approximately 10 days. We determined the rotational phase of each flare and performed a simple statistical test on our sample to determine whether the phase distribution of the flares is random or if there is a preference for phase. We find, with the exception of one star which is in a known binary system, that none show a preference for the rotational phase of the flares. If the analogy between the physics of solar and stellar flares holds and these events occur from active regions which typically host spots, then you would expect to see more flares during the rotation minimum where the starspot is most visible. However, this is not the case with our sample and in fact all of our stars show flares at all rotational phases, suggesting these flares are not all originating from one dominant starspot on the surface of the stars. We outline three scenarios which could explain the lack of a correlation between the number of flares and the stellar rotation phase.

Understanding the formation of cm-sized dust grains or 'pebbles' in young protoplanetary discs leading to exoplanet formation

Poster 69

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We present early commissioning results from Planet Earth Building-Blocks - a Legacy eMERLIN Survey (PEBBLeS; PI Greaves). The PEBBLeS project is mapping 'pebbles' (cm-sized dust grains) at a 5 cm wavelength for a selection of protostars at a variety of evolutionary stages and masses. The survey focuses on nearby star-forming regions (120-230 pc) to systematically study discs that have the highest potential for planet formation. The 40 milliarcsec angular resolution (i.e. beam diameter $\sim$5-9 AU) allows us to separate zones in discs that are comparable to where terrestrial and gas giant planets form in our own solar system. The ability to image grains growing to pebbles within a few AU of young host stars is a unique eMERLIN capability, allowing the investigation of how planetary cores are made and the search for protoplanet candidates.

We present commissioning results of the observations of DG Tau A (a Class I-II, low-mass protostar) at 4-6 cm wavelengths (Drabek-Maunder et al., in prep), where we find the disc to be both resolved and easily distinguished from regions with jet emission. We find the extended source flux to be significantly higher than predicted, suggesting a pile-up of dust grains with sizes around 1 cm, similar to the TW Hya archetype. We compare DG Tau A to the much weaker emission found from MWC 480 (Herbig Ae), which suggests variations in the dust spectral index and potentially in pebble production that can proceed toward planet formation.

The Extreme Ultraviolet Flux of Very Low Mass Stars

Poster 70

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The X-ray and EUV emission of stars is vital for understanding the atmospheres and evolution of their planets. The coronae of dwarf stars later than M6 behave differently to those of earlier spectral types and are more X-ray dim and radio bright. Too faint to have been observed by EUVE, their EUV behavior is currently highly uncertain. We observed three late M dwarfs with Chandra using the off-axis HRC-S "thin Al" filter that is sensitive to EUV emission in the 50-200 årange. The measured fluxes are used to constrain the amount of cooler coronal plasma present, and extend X-ray-EUV flux relations to the latest stellar types.

Poster 71

Spatially Resolved Spectroscopy across Stellar Surfaces

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Center-to-limb changes of spectral line profiles could in the past be studied only on the spatially resolved Sun but are now becoming accessible for also other stars. During exoplanet transits, successive stellar surface portions become hidden and differential spectroscopy between various transit phases provide spectra of small surface segments temporarily hidden behind the planet [1]. Such retrievals of spatially resolved high-resolution photospheric line profiles have now been achieved along the exoplanet transit chords across HD209458 (G0 V) and HD189733A (K1 V), using data from the ESO UVES and HARPS spectrometers [2,3].

Not being subject to rotational broadening, spatially resolved profiles are narrower and deeper than those of integrated starlight while their gradual shifts in wavelength reflect stellar rotation at the latitude of exoplanet transit. Synthetic spectral lines from 3-D hydrodynamic models predict various center-to-limb signatures that differ among stars of different temperature, such as a gradually increasing linewidth toward the stellar limb, caused by horizontal velocities in stellar granulation being greater than vertical ones.

Since even giant planets cover only a tiny fraction of any solar-type star, the directly observable signal is small and extremely precise observations are required. To reach adequate signal-to-noise ratios, requires averaging over numerous lines with similar parameters. The method will likely be applicable to several more stars in the near future, as new targets are being found by ongoing searches for bright host stars with transiting large planets.

[1] Dravins, D., Ludwig, H.-G., Dahlén, E., & Pazira, H. 2017a, Astron. Astrophys., 605, A90 [2] Dravins, D., Ludwig, H.-G., Dahlén, E., & Pazira, H. 2017b, Astron. Astrophys., 605, A91 [3] Dravins, D., Gustavsson, M. & Ludwig, H.-G. 2018, Astron. Astrophys., to be submitted

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Poster 72

Studying Cool Stars & Planetary Systems with the Large UV/Optical/IR Surveyor

Courtney D. Dressing for the LUVOIR Mission Concept Team

University of California Berkeley

LUVOIR is powerful and flexible observatory designed to revolutionize our view of the universe. Operating at the Sun-Earth Lagrange 2 point, LUVOIR will gaze at the skies at far-UV to near-IR wavelengths, with a large aperture of 8-15 m and a sophisticated instrument suite: an ultra-high contrast coronograph (ECLIPS); a high-resolution imager (HDI); a multi-resolution, multi-object UV spectrograph and imager (LUMOS); and a UV spectropolarimeter (POLLUX). LUVOIR will be capable of detecting and characterizing hundreds of planets orbiting nearby stars, simultaneously advancing the field of "comparative exoplanetology" and potentially discovering inhabited worlds. Even if none of the exoplanets detected by LUVOIR exhibit signs of habitable conditions or life, the sample of stars surveyed will be large enough to place meaningful constraints on the frequency of Earth-like planets in the solar neighborhood. LUVOIR will contribute to stellar astronomy by resolving stellar populations, investigating stellar winds, and probing the initial mass function. Furthermore, UV observations with LUMOS will test theories of star and planet formation and the spectropolarimetry capability of POLLUX will enable detailed study of stellar and planetary magnetospheres, accretion onto young stars, the properties of protoplanetary disks, and star/planet interactions.

Untangling the light-curves of the brown dwarf binary J0746+20

Poster 73

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Brown dwarfs and low-mass stars together comprise the group ultracool dwarfs. A number have been detected as radio sources - in some cases, emitting periodic radio pulses. Detections of optical variability in ultracool dwarfs have primarily been attributed to stellar rotation, coupled with either magnetic spots on the surface, the presence of atmospheric dust, or auroral emission. It is possible that a mix of these mechanisms is required to explain some dwarf light curves. Several studies of 2MASSW J0746425+200032AB (hereafter 2M J0746AB), a brown dwarf binary pair (spectral types L0 + L1.5) showed periodic optical variability with periods of approximately 3.3 hours. This signal is presented mainly from one component of the binary. A report of periodic 4.86 GHz radio emission with a 2.07 ± 0.002 hours period due to the secondary component has, so far, not been matched by a corresponding optical detection of the secondary period. Here, we report on 140 hours monitoring in I-band of 2M J0746AB during three epochs in 2017, using the GUFI photometer (Galway Ultra-Fast Imager) on the 1.8m Vatican Advanced Technology Telescope (VATT), on Mt. Graham, Arizona. Our aims are to refine the primary's variability parameters, and to search for the elusive secondary period. We have written a python-based script capable of detecting superposition of two sinusoidal waves to untangle the secondary component's variability signature from that of the dominant primary variability. Utilizing our in-house GUFI Pipeline, all three epochs yielded a rotation period of 3.3 hr from the slower component, with an amplitude of 0.01 magnitude, consistent with previous studies. The results indicate that we discovered the secondary rotation period 2.1 hrs, which agrees with the reported secondary period in radio.

Poster 74

Boosting or mitigating the activity signal in radial-velocity measurements

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The study of stellar activity provides important diagnostics on the structure and evolution of stars and their atmospheres and on stellar magnetic fields. In addition, stellar activity is also a limitation to the detection of Earth-twins orbiting cool stars using the radial-velocity (RV) technique, and therefore finding a way to mitigate stellar activity is crucial for a successful RV follow-up of TESS candidates.

Stellar activity of quiet cool stars can be probed by looking at spectral lines presenting a chromospheric emission, like the Ca II H and K lines, H-alpha or the Ca triplet. However, spectral lines formed in the photosphere should also be affected by activity. Photospheric lines have different sensitivity to temperature, they are formed at different depth, therefore stellar activity that create spots much cooler than the photosphere and that modifies the convection as a function of depth should affect every spectral line in a different way.

By deriving the RV of each individual spectral line in HARPS high-resolution spectra, we found that the RV of some spectral lines are much more sensitive to activity than others. By looking at the radial-velocity data of Alpha Centauri B in 2010, where a clear activity signal is observed, we can either multiply by three the activity signal seen in RV, or mitigate it by a factor of 2.5, depending on the choice of lines used to measure the stellar radial velocity.

By looking at the physical properties of the spectral lines used to increase or decrease the activity signal seen in RV, we are able, using machine learning algorithms, to understand what are the main physical properties of lines that make them sensitive or not to stellar activity.

In conclusion, this new way of deriving RVs can be either used to probe better stellar activity, as the related signal in RV can be increased by a factor of three, or to mitigate its effects by a factor of 2.5, to detect tiny planetary signal in RV measurements.

Poster 75

Near IR Spectroscopy of Cool Dwarf Stars

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High resolution near-infrared spectroscopy reveals the He I transition at 1.08 microns in cool dwarf stars. In the Sun, this line can signal the presence of X-rays near the chromosphere as well as mass motions: both outflows and inflows, depending on the solar feature. We present results from a near infrared survey of the He I line in cool dwarf stars of spectral type F through M taken with the PHOENIX spectrograph at the 4-m Mayall telescope at Kitt Peak National Observatory. Simultaneous photometry from MEarth telescopes and optical spectroscopy from the TRES spectrograph at Whipple Observatory, allow characterization of stellar activity and its relation to the dynamics of the atmosphere.

Dynamical Masses of Cool Stars and Brown Dwarfs

Poster 76

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Evolutionary models are critical infrastructure in astrophysics, from massive stars to brown dwarfs and gas-giant planets. Because mass is the key independent variable, the most direct tests of models use dynamical mass measurements. We present results from two long-term programs to measure masses in complementary ranges, from late-K stars to the bottom of the main sequence and from the substellar boundary to methane-bearing T dwarfs. The cool star sample is focused on stars with low enough mass ($< 0.7\,M_\odot$) that they do not evolve significantly over the age of the Universe and thus form a tight mass–luminosity relation. The brown dwarf sample extends down to 30 $M_{\rm Jup}$, providing the strongest tests of substellar cooling tracks. Both samples use high-precision astrometry from Keck AO to determine orbits, and the brown dwarf sample also includes infrared astrometry from a decade-long program at the Canada-France-Hawaii Telescope to obtain photocenter orbits that enable individual mass measurements. The primary result from the cool star sample is an empirical mass–metallicity–magnitude relation that provides masses accurate to 4% or better from 0.7 $M_\odot$ to 0.075 $M_\odot$ using only K_S-band absolute magnitudes. Comparison of this empirical relation to models indicates that the impact of metallicity on K_S-band flux is observed to be significantly weaker than models predict. The brown dwarf masses probe the L/T transition in detail for the first time, revealing a remarkably weak dependence of luminosity on mass that implies substellar cooling decelerates as clouds disappear and reinforces the need for accurate cloud models. Overall, the brown dwarf masses validate modern substellar cooling models, and we derive brown dwarf cooling ages using the models to enable a novel direct determination of the age distribution of field brown dwarfs (median age of 1.3 Gyr) that is consistent with a constant star formation history over 10 Gyr.

Semi-empirical SEDS on Demand

Poster 77

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$TESS$ will discover many Earth-like planets orbiting the closest small stars, some of which will be suitable for transmission spectroscopy with $JWST$. However, determining the best candidates will require modelling the planet's potential atmosphere and this requires a good estimate for the stellar spectrum. Unfortunately, the astronomical community does not have complete SEDs for the majority of $TESS$ candidates. We present early efforts using Differential Emission Measure to reconstruct the EUV spectrum of an M dwarf in the MUSCLES survey which we hope to use for any M dwarf planet hosts discovered by $TESS$.

Poster 78

M dwarf planetary systems: an observational study to look for prolonged activity in host stars

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University of Hertfordshire; Jet Propulsion Laboratory, California Institute of Technology; Dr Karl Remeis-Sternwarte; University of Montreal

M dwarf stars begin their lives rapidly rotating and with high levels of activity, but as time goes on, they slow down via magnetically channelled winds, whilst their activity decreases. We aim to investigate the possibility of prolonged rotation and activity in M dwarfs due to tidal interaction with close-in planets, an effect previously observed for Sun-like stars with hot Jupiters by Poppenhaeger and Wolk (2014). As a prelude to our main programme, we are conducting a pilot survey of M dwarfs + white dwarf wide binary systems to study the age-activity relationship for M dwarfs by using the white dwarf as an age calibrator, a method that still remains biased against cool white dwarf components. We aim to identify an age-comprehensive population of common proper-motion/distance binaries using Gaia DR2 and our previously constructed SDSS/2MASS/WISE M dwarf catalogue (Cook et al. 2016). With this method we can also look for over-active M dwarf in our oldest systems. Preliminary results include a sample of common proper motion white dwarf + M dwarf pairs, some of them consisting in cool white dwarfs whose companion M-type stars need to be confirmed.

Poster 79

The Living with a Red Dwarf / Goldiloks Programs: The Activity-Rotation-Age Relationships of M and K Dwarfs

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Over the past several years, the database of M dwarfs with determined ages has continually expanded, allowing us to furnish Activity-Rotation-Age Relationships as part of the Living with a Red Dwarf program. We have now expanded this program to include K dwarfs - the Goldiloks program. Both M and K dwarfs suffer from the same limitation - due to their long lifetimes and very slow nuclear evolution, the best method for determining ages for a large number of M and K dwarf targets is through ”magnetic tracers” such as X-UV activity levels and stellar rotation rates. We report on the current results of our relationships: deriving photometric rotation rates; gathering X-UV measures with HST, IUE, Chandra and XMM (both proposed by us, and archival); and assessing their impacts on our understanding of the evolutions and habitability of these stellar types. We gratefully acknowledge the support from NSF/RUI Grant AST 1009903, Chandra Grants GO-13200633, GO-19200559, GO-19200703 and HST Grants GO-12124X and GO-13020X.

X-rays from Cepheids: Why?

Poster 80

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SAO; Villanova; Univ. of Toronto; MIT; Iowa State Univ.; Univ. of Athens

Recent Chandra and XMM X-ray observations have found a burst of X-rays at the surprising phase just after maximum radius. At this phase the photospheric spectrum is indestinguishable from a nonvariable supergiant. Significant photospheric disruptions, however, are seen just after minimum radius, as the pulsation wave generated lower in the envelope passes through. The X-ray burst is thought to be caused either from by a shock in the pulsation process or a flare, possibly triggered by the collapse of the atmosphere. We present a first examination of these possibilities by calculating the energy ranges and timescales for each mechanism. A flare-like event is expected to have a strong dependence on local magnetic field strength and present a more rapid energy release due to reconnection. Finally, we estimate how much a hydrodynamic and magnetohydrodynamic compression wave propagating outward in a stratified medium, such as the stellar coronae, could heat the ambient material.

Characterising the Solar wind in time using young stellar proxies

Poster 81

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The stellar winds produced by young, Sun-like stars are expected to be orders of magnitude more powerful than those of the present-day Sun. These strong winds affect the stars themselves through angular momentum loss, and they potentially reduce the habitability of orbiting planets by eroding their atmospheres.

The Starwinds project aims to extend understanding of the Solar wind in time by presenting a collection of stellar wind maps for young, Sun-like stars, based on published surface magnetic measurements from the TOUPIES study. The first set of wind maps are for stars aged 25 to 250 Myr, an age in which the Sun's magnetic field is believed to have undergone important changes. From the wind maps we calculate stellar parameters such as mass loss, angular momentum loss, and high-energy radiation emission. We characterise the wind ram pressure, a key parameter determining atmospheric erosion, at a range of distances including 1 AU.

The wind is modelled as a magnetohydrodynamic fluid using the Space Weather Modelling Framework. The models include both turbulent heating and a polytropic equation of state.

The Starwinds project should produce the largest three-dimensional wind atlas of young, Sun-like stars to date. We expect that the results should improve understanding of the young Sun's behaviour and have relevance to models of planetary evolution in our Solar system and beyond.

Poster 82

X-ray Observations of HD162020 : One of the X-ray Luminous Low-mass Stars with a Hot Jupiter

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We show X-ray observational results of HD162020 with Suzaku and XMM-Newton Observatory. Interactions between stars and their giant planets via magnetic field and tidal force are thought to enhance stellar activity (e.g., Cuntz et al. 2000 ApJ, 533, L151). X-rays from stellar coronae are an ideal tool to investigate such star-planet interactions (SPI). However, there is much debate on observational signatures of the SPI (Poppenhageer et al. 2011 A&A, 515, 98). To investigate influence of the giant planet to the host star, we studied HD162020, one of the X-ray luminous low-mass star (K2V) having a hot Jupiter (14.4 Mjupiter, semi-major axis of 0.074 AU, eccentricity of 0.277, and an orbital period of 8.428 days). Observations were conducted near periastron and apastron. X-ray spectra were represented by a two-temperature thermal plasma model with kT of 0.3 and 0.9 keV which coincides with typical coronal emission from late type stars. The X-ray luminosity Lx on average was 8×10^{28} erg/s in 0.3-6 keV with Lx/Lbol of 8×10^{-5}, which is two orders of magnitude larger than the Sun. No significant change in the X-ray properties was found between periastron and apastron except for signature of about 30 % increase near periastron. From these results, we consider that HD162020 isan X-ray active star due to its young age ($<$1 Gyr) and possibly the SPI. We discuss the SPI effect and prospects with future X-ray observatories XARM and Athena.

Poster 83

Kernel-Phase Interferometry for Super-Resolution Detection of Faint Companions

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Direct detection of close in companions (exoplanets or binary systems) is notoriously difficult. While coronagraphs and point spread function (PSF) subtraction can be used to dig out signals of companions under the PSF, there are still significant limitations in separation and contrast. Non-redundant aperture masking interferometry (NRM or AMI) can be used to detect companions well inside the PSF of a diffraction limited image, though the technique is severely flux limited since the mask discards $\sim$95

Super Jupiters at Different Ages

Poster 84

Jackie Faherty

American Museum of Natural History

In recent years, several research teams have used kinematics paired with spectral and photometric peculiarities to identify seemingly field brown dwarfs that belong to young moving groups. This sample of warm (1200 - 2200 K) but extremely low mass (5 - 30 MJup) objects defines an intriguing bridge between giant exoplanets and substellar mass objects. Since 2012, we have been collecting uniform medium resolution (3000 - 6000) spectra of the population of so-called isolated super Jupiters in groups that range from 5 - 300 Myr. Using parallaxes and an abundance of observed data we create spectral energy distributions and derive semi-empirical effective temperatures. The vast collection of medium resolution data we have accumulated contains a wealth of detailed spectral information. In this talk I will show trends in molecular absorption and alkali line features identified as a function of effective temperature rather than spectral type. Binning the sample by age and effective temperature, I speculate that the diversity seen in the features results from variations in atmosphere conditions.

A Flexible Model for Investigating Properties of Starspots: Model Validation

Poster 85

Gregory Feiden; Amanda Ash; Jessica Hamilton

University of North Georgia

Stellar evolution models exhibit noted discrepancies with measured properties of young stars in open clusters. Models tend to predict that young stars should be warmer and smaller than observations suggest. Attempts to explain these anomalies often invoke so-called non-standard physics, such as magnetic fields and starspots. To assess whether these hypotheses provide plausible explanations, we developed a flexible model to investigate how starspots affect stellar structure and photometric magnitudes. We present results of an effort to validate predictions from our starspot model by cross validating against a large set of synthetic clusters with random richness, age, and starspot properties. We recover the input starspot properties with a precision of 13 percent in surface coverage and 10 percent in temperature contrast, provided the starspot surface coverage is above 20 percent. If starspots occupy less than 20 percent of the stellar surface, photometric variations between different families of starspot models are largely indistinguishable in color-magnitude diagrams, confounding our recovery effort. Our ability to correctly predict starspot properties is largely independent of the cluster richness and age. These results suggest that our starspot model can be used to reliably predict properties of starspots required to rectify noted stellar evolution model discrepancies among cool stars in young open clusters.

Poster 86

The Effect of Magnetic Variability on Angular Momentum Loss for the Sun and Other Stars

A. Finley

University of Exeter

The rotational evolution of cool stars is governed by magnetised stellar winds which slow the stellar rotation during their main sequence lifetimes. Magnetic variability is commonly observed in Sun-like stars, and the changing strength and topology of the global field is expected to effect the torque exerted by the stellar wind. We use three different methods for computing the angular momentum loss in the solar wind. Two are based on MHD simulations and scaling relationships from Finley & Matt (2018), plus observed mass loss rates for the solar wind. One using the open flux in the solar wind and one using remotely-observed surface magnetograms. Both methods agree in the variation of the solar torque seen through the solar cycle, showing a factor of 0.6 - 0.7 decrease in the average torque between cycle 23 and 24. The two methods calculate different average values, 2.88×10^{30}erg for the open flux and 0.70×10^{30}erg for the surface field method. This discrepancy is a result of the already well-known difficulty with reconciling the surface magnetograms with observed open flux, which is currently not understood and thus leads to an inability to discriminate between these two calculated torques. The third method is based on the observed spin-rates of Sun-like stars, which decrease with age and thus directly probe the average angular momentum loss. This method gives 6.20×10^{30}erg for the averaged solar torque, larger than the other two methods, which could have a few explanations, but notably may be indicative of further variability in the solar torque on timescales much longer than the magnetic cycle. This will impact future applications of the formula to other Sun-like stars, where only surface field measurements are available.

Poster 87

The Solar Wind in Time

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Trinity College Dublin

The solar wind has evolved over time, primarily due to angular momentum loss and varying solar magnetism. Recently, it has been suggested that winds of solar-type stars might undergo a change in properties at old ages, whereby stars older than the Sun would be less efficient in carrying away angular momentum than what was traditionally believed. Additionally, recent observations suggest that old solar-type stars show a break in coronal properties, with a steeper decay in X-ray luminosities and temperatures at older ages. We use these X-ray observations to constrain the thermal acceleration of winds of solar analogues. Our sample is based on solar twins from the 'Sun in time' project with ages between 120-7000 Myr. The break in X-ray properties leads to a break and steeper decay in mass-loss rates after 2 Gyr. The latter could be the reason why older stars are less efficient at carrying away angular momentum, which would explain the anomalously rapid rotation observed in older stars. We quantified the effect this break has on Earth-like terrestrial planets by coupling our simulations with a magnetic terrestrial dynamo model.

A Search for the Direct Detection of 2 Myr Old Hot Jupiter Orbiting CI Tau

Poster 88

Laura Flagg[1]; Christopher Johns-Krull[1]; Lisa Prato[2]; Larissa Nofi[2]; Joe Llama[2]; Kendall Sullivan[2]; Daniel T. Jafee[3]; G. N. Mace[3]

Rice University; Lowell Observatory; University of Texas

Characterizing young exoplanets is critical for putting limits on planet formation scenarios. However, as of yet, only a few young exoplanet candidates have even been discovered, and no young planet with a model-independent mass has had its spectrum or brightness measured. A good candidate for such a detection is CI Tau b, an $m \sin i = 8.1$ Mjup planet in a 9 day orbit around a 2 Myr old classical T Tauri star. We use high spectral resolution K band echelle spectroscopy to look for direct signatures of the planet itself, taking advantage of the large expected radial velocity variations of the planet as it orbits CI Tau. We report on our efforts to directly detect the spectrum of CI Tau b and present a tentative measurement of CO absorption in this young exoplanet. The properties of the planet determined from this CO detection are consistent with those described in the discovery paper and favor ”hot start” formation models.

On the Lack of Circumbinary Planets Orbiting Isolated Binary Stars

Poster 89

D. P. Fleming[1,2]; R. Barnes[1,2]; D. E. Graham[1]; R. Luger[1,2]; T. R. Quinn[1,2]

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To date, no binary star system with an orbital period less than 7.5 days has been observed to host a circumbinary planet (CBP), a puzzling observation given the thousands of binary stars with orbital periods < 10 days discovered by the Kepler mission (Kirk et al., 2016) and the observational biases that favor their detection (Munoz & Lai, 2015). We develop a model that explains the observed lack of CBPs via coupled stellar-tidal evolution of isolated binary stars. Tidal forces between low-mass, short-period binary stars on the pre-main sequence slow the stellar rotations, transferring rotational angular momentum to the orbit as the stars approach the tidally locked state. This transfer increases the binary orbital perRevealing the Complex Environmentiod, expanding the region of dynamical instability around the binary, and destabilizing CBPs that tend to preferentially orbit just beyond the initial dynamical stability limit. After the stars tidally lock, we find that angular momentum loss due to magnetic braking can significantly shrink the binary orbit, and hence the region of dynamical stability, over time impacting where surviving CBPs are observed relative to the boundary. We perform simulations over a wide range of parameter space and find that the expansion of the instability region occurs for most plausible initial conditions and that in some cases, the stability semi-major axis doubles from its initial value. We examine the dynamical and observable consequences of a CBP falling within the dynamical instability limit by running N-body simulations of circumbinary planetary systems and find that typically, at least one planet is ejected from the system. We apply our theory to the shortest period Kepler binary that possesses a CBP, Kepler-47, and find that its existence is consistent with our model. Under conservative assumptions, we find that coupled stellar-tidal evolution of pre-main sequence binary stars removes at least one close-in CBP in 87 percent of multi-planet circumbinary systems.

Poster 90

A Direct Imaging Search for Wide Companions as a Test for Gravitational Instability

Clémence Fontanive

Institute for Astronomy, University of Edinburgh

One of the most important longstanding questions in planet formation is: what role, if any, does disk gravitational instability (GI) play in producing the observed population of giant planets? While evidence suggests that most short-orbit ($<$1 AU) gas giants form by core accretion, it is very difficult to form massive ($>$10 $M_{\rm Jup}$) companions via this mechanism. Such objects may preferentially form at larger separations by GI in circumstellar disks and, in the presence of an additional more massive, distant companion, be scattered inwards via the Kozai mechanism. To test this formation theory, we identified a sample of systems with known planets or low-mass brown dwarfs on very short orbits that are too massive to explain their formation with traditional core-accretion models. Using high-resolution imaging facilities at VLT and Gemini North, we searched for wide companions potentially responsible for the Kozai scattering of the inner planets. Here we present results from this survey together with a thorough statistical analysis of companion populations and distributions for such multi-planet systems.

Poster 91

Dusting Off Boyajian's Star

Peter Foukal

None

Photometry of the main sequence F3 star KIC 8462852 ("Boyajian's star") continues to provide new information on its unusual brightness variations. The reddening of its dimming events is compatible with either a cooling of its photosphere or with obscuration by dust. But the dust explanation requires different opacities to account for both the deep (up to 20 per cent) short term dimmings over days to weeks and also the slower decreases of a few percent over years. Moreover, it is difficult to see how dust obscuration can explain the star's recent brightening by several percent. The absence of any rotational modulation of the short term dimmings and the lack of calcium emission, rule out a modulation of Teff due to surface magnetic activity. However, both cooling and heating of the photosphere might be caused by changes in heat transport efficiency since the star lies close to the transition between radiative and convective transport. Thermal shadows of submerged magnetic fields might also contribute. Numerical simulations of thermal shadowing add to previous evidence that intrinsic luminosity variation explains the photometric behavior of KIC 8462852 better than unexplained sources of dust.

SPIRou Input Catalogue: Global properties of 580 M dwarfs observed with ESPaDOnS at CFHT

Poster 92

P. Fouqué[1,2]; C. Moutou[1,3]; L. Malo[1,4]; E. Martioli[5]; and the SPIRou collaboration

CFHT; Université de Toulouse; CNRS; Université de Montréal; Laboratorio Nacional de Astrofisica

Present and future high-precision radial-velocity spectrometers dedicated to the discovery of low-mass planets orbiting low-mass dwarfs need to focus on the best selected stars to make an efficient use of telescope time. In the framework of the preparation of the SPIRou Input Catalog, the CoolSnap program aims at screening M dwarfs in the solar neighborhood against binarity, rapid rotation, activity, ... To optimize the selection, we describe the methods used to compute effective temperature, metallicity, projected rotation velocity of a large sample of 580 M dwarfs observed in the visible with the high-resolution spectro-polarimeter ESPaDOnS at CFHT. It also summarizes known and newly-discovered spectroscopic binaries, and stars known to belong to visual multiple systems. A calibration of the projected rotation velocity versus measured line widths for M dwarfs observed by the ESPaDOnS spectropolarimeter is derived, and the resulting values are compared to equatorial rotation velocities deduced from rotation periods and radii. A comparison of the derived effective temperatures and metallicities with literature values is also conducted. Finally, the radial velocity uncertainty of each star in the sample is estimated, to narrow down the selection of stars included into the SPIRou Input Catalogue (SPIC).

Exact cylindrically symmetric solutions of polarized radiative transfer equation: some more benchmarks for numerical calculations

Poster 93

J. Freimanis

Ventspils International Radio Astronomy Centre of Ventspils University College

While modelling astronomical objects in general, and dust envelopes of cool stars in particular, only numerical solutions of radiative transfer equation (RTE) can give realistic pictures of real objects. However, analytic solutions of RTE (and other equations of mathematical physics) for simplified, symmetric model cases are desirable as tests of correctness and precision of computer programs. Besides, sometimes astronomical objects can be looked upon as approximately having some particular symmetry, and analytic solution of RTE can be used for evaluation purposes.

Continuum radiation from dust envelopes of AGB and post-AGB stars is often polarized due to form and morphology of the envelope, orientation of dust grains and asymmetry of the primary sources of radiation. Polarization gives valuable astrophysical information, and solution of RTE without accounting for polarization is basically incorrect.

Some exact model solutions of monochromatic polarized RTE in polydisperse, statistically homogeneous, isotropic and mirror-symmetric medium, in case if the radiation field has cylindrical symmetry, are reviewed in this talk. Cylindrically symmetric Green's function for infinite medium is mentioned, stressing its complexity. Cylindrically symmetric inner eigenfunctions of RTE are presented as much simpler alternative, which can be used if the

scattering medium (e.g. dust cloud) is a homogeneous cylinder of infinite length but finite radius, and the medium is irradiated from outside. It is proven that cylindrically symmetric homogeneous polarized RTE has solutions (eigenfunctions) indexed by asymptotic azimuthal index (AAI) adopting arbitrary integer values. There are at least one convergent inner eigenfunction and one divergent formal outer eigenfunction for each value of AAI; clear analytic expressions are given for them. If the modulus of AAI does not exceed 3 then these are the only eigenfunctions of cylindrically symmetric RTE.

Poster 94

CHEOPS: Characterising ExOPlanet Satellite - the mission and observing opportunities

Malcolm Fridlund for the University of Bern/CHEOPS Mission Consortium and the ESA CHEOPS Project Team

CHEOPS Science Team

CHEOPS (CHaracterising ExOPlanet Satellite) is the first exoplanet mission dedicated to the search for transits of exoplanets by means of ultrahigh precision photometry of bright stars already known to host planets. It is the first S-class mission in ESA's Cosmic Vision 2015-2025. The mission is a partnership between Switzerland and ESA's science programme, with important contributions from 10 other member states. Targetting completion of satellite-level tests by the end of 2018, CHEOPS will provide the unique capability of determining radii of planets in the super-Earth to Neptune mass range to about 10precision. It will also provide accurate radii for new planets discovered by the next generation of ground-based or space transit surveys (from super-Earth to Neptune-size). The high photometric precision of CHEOPS will be achieved using a single photometer covering the 330 - 1100 nm waveband, designed around a single frame-transfer CCD which is mounted in the focal plane of a 30 cm equivalent aperture diameter, f/5 on-axis Ritchey-Chretien telescope. 20time in the 3.5 year nominal mission will be available to the Community through the Guest Observers Programme that will be run by ESA. The call for the first year of observing will come out on 10th September 2018 and will be open to the world-wide community. In the first poster we give an overview of the CHEOPS mission, and in the second an overview of Observing with CHEOPS, with a particular focus on the ESA CHEOPS Guest Observers Programme.

The Mega-MUSCLES Treasury Survey: Measurements of the Ultraviolet Spectral Characteristics of Low-mass Exoplanetary Systems

Poster 95

C.S. Froning for the Mega-MUSCLES team

University of Texas at Austin

Understanding what happens to rocky planets and their atmospheres in the habitable zones of low mass stars is an ongoing challenge in current astronomical research, one that will take on even more importance in the era of TESS and JWST, which will be able to discover and observe these atmospheres in transiting systems. To interpret such observations, we must understand the high-energy emission of their host stars: X-ray/EUV irradiation can erode a planet's gaseous envelope and FUV/NUV-driven photochemistry shapes an atmosphere's molecular abundances, including potential biomarkers like O2, O3, and CH4. The role of stellar activity in the form of flares and CMEs on shaping the exoplanet evolution is also a key question for low mass systems. At present, we do not have sufficient observations and stellar models to interpret observations of the atmospheres of potentially habitable planets in these systems. To address this, our team is using XMM, Chandra, HST, and ground-based observatories to construct panchromatic (5 A - 5 micron) SEDs of a population of low mass stars. MUSCLES is the most widely used database for early-M and K dwarf (>0.3 M sun) irradiance spectra and has supported a wide range of modeling work, from the development of semi-emperical stellar models incorporating coronal and chromospheric emission to models of the structure and photochemistry of exoplanet atmospheres. The new Mega-MUSCLES project will follow on the successful survey by extending to lower stellar masses (<0.3 Msun) and to a range of rotation periods to probe XUV emission evolution over gigayear time scales. Here, I will present current results and plan for future work with Mega-MUSCLES, with a focus on what the observations are showing in the areas of stellar activity in the XUV and its ties to optical behavior, signatures of star-planet interactions in exoplanet systems, and the construction of broadband SEDs for low mass stars.

Constraining the True Ultracool Binary Fraction with Spectral Binaries

Poster 96

Daniella Bardalez Gagliuffi[1]; Adam Burgasser[2]; Sarah Schmidt[3]; Christopher Theissen[2]; Jonathan Gagné[4]; Jacqueline Faherty[1]; Kelle Cruz[1,5]; Christopher Gelino[6]

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Multiplicity statistics are a direct result of the brown dwarf formation process. However, different binary detection methods yield different binary fractions because each one is sensitive to a specific region of the separation distribution. High resolution imaging places the brown dwarf binary fraction at $10-20\%$, with over 85% of systems identified this way, while radial velocity and astrometric variability yield binary fractions of $3-30\%$ and 5%, respectively. The peak in the separation distribution is at $4-7$ AU, coincidental with the resolution limit

of state-of-the-art imaging techniques, suggesting that the binary fraction may be underestimated. We have developed a separation-independent method to identify and characterize binary systems of brown dwarfs as spectral binaries by identifying traces of methane in the low resolution, near-infrared spectra of late-M and early-L dwarfs. We use this method and a binary population synthesis to recover the true ultracool binary fraction from a volume-limited sample of M7-L5 dwarfs up to 25pc that would be suitable primaries for this type of binary systems. We find a true ultracool binary fraction of $27 \pm 4\%$. This method can be extended to identify planetary-mass companions to young brown dwarfs, as a way to explore the binary properties of this low-mass population to understand its origins, and disentangle the signatures from binarity and photometric variability.

Poster 97

The Revolution Revolution: towards a complete stellar spin-down model

Cecilia Garraffo[1]; Jeremy J. Drake[1]; Aaron Dotter[1]; Jieun Choi[1]; Douglas Burke[1]; Sofia P. Moschou[1]; Julian D. Alvarado-Gomez[1]; Vinay Kashyap[1]; Ofer Cohen[1, 2]

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Detailed MHD stellar wind models have demonstrated that surface magnetic field topology has a strong influence on wind-driven angular momentum loss. Observations suggest that faster rotating stars store a larger fraction of their magnetic flux in higher order components of the magnetic field. In this poster I will present a new model for stellar spin-down that accounts for the magnetic modulation of angular momentum loss rates. I will discuss how a magnetic complexity that evolves from complex toward simple configurations as a star spins down can explain the salient features of stellar rotation evolution, including the bimodal distribution of both slow and fast rotators seen in young open clusters.

Poster 98

Ultracool companions to high proper motion stars from the VISTA Hemisphere Survey

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Wide (>50 AU) ultracool companions in binary and multiple systems play an important role in substellar studies, because properties such as distance, metallicity and age can be inferred from the brighter, and more easily characterizable, primary star. This in turn allows a more thorough characterization and offers the opportunity to better understand their physical and chemical properties. This talk will discuss the search for very low-mass stars and brown dwarfs as co-moving companions to high proper motion stars in the VISTA Hemisphere Survey (VHS), and present the newly identified and spectroscopically characterized systems found within the early VHS data covering about 8,500 square degrees. Within these systems we found over a dozen of new late M, L and T dwarf companions at angular separations from 7 to 800 arcsec, corresponding to wide orbits ranging from $\sim$100 to tens of thousands AU and masses from very-low mass stars down to planetary mass regime.

The Keck Observatory Archive: What Have Two 10-Meter Telescopes Done For You?

Poster 99

Christopher R. Gelino[1]; Bruce Berriman[1]; Matthew Brown[2]; Mihseh Kong[1]; Anastasia Laity[1]; Jeff Mader[2]; Josh Riley[2]; Luca Rizzi[2]; Melanie Swain[1]

Caltech/IPAC-NExScI; W.M. Keck Observatory

The Keck Observatory Archive (KOA) archives and serves all raw science and calibration data acquired by the active and decommissioned instruments at the W. M. Keck Observatory (WMKO). Observed targets run the gamut from asteroids to high-z quasars, and include a wealth of data on stars and brown dwarfs. Of the nearly 2800 exoplanet host stars, more than half have been observed with the Keck telescopes, including 126,000 publicly available science files. A similar number of public science files can be found for the prime Kepler field and K2 Campaign target positions. The near-IR capabilities of Keck have made it an invaluable tool in the study of faint brown dwarfs, with more than 54,000 available science files. Such optical and near-IR observations include low and high dispersion spectra, seeing-limited images, high angular resolution images, and coronagraphy. In addition to these raw data, KOA also serves reduced, browse quality products for several instruments: HIRES, NIRC2, NIRPSEC, OSIRIS, and LWS. In this poster, we will discuss the current KOA holdings relevant for (sub)stellar astronomy, science results that have utilized the archive, and future plans such as an on-line, HIRES high precision radial velocity pipeline service possible through a collaboration between KOA, WMKO, NExScI, and the California Planet Survey.

Carbon and Nitrogen Abundances in Red Giants in Galactic Globular Clusters

Poster 100

Jeffrey M. Gerber; Eileen D. Friel; Enrico Vesperini

Indiana University

We present our recent findings on the abundances of carbon and nitrogen in low mass, red giant and asymptotic giant branch stars in Galactic globular clusters. Using the multi-object spectrograph, Hydra on the WIYN 3.5m, we have obtained sample sizes of over 100 stars in two clusters covering a range of magnitudes that begin at the sub-giant branch and extend to the tip of the RGB. We studied the CN and CH band features of these spectra to determine carbon and nitrogen abundances. Stars were separated into CN-enhanced and CN-normal populations, and abundance patterns were analyzed with respect to population and as a function of magnitude. We then determined the rate of carbon depletion in RGB stars as a function of magnitude to compare rates in different clusters as well as with different populations in each cluster. We also compare the percentage of AGB stars that belong to the CN-enhanced generation to the same percentage in RGB stars to see if the CN-enhanced stars reach the same stages in evolution as the CN-normal stars. These results will allow further insight into the complex mechanisms that occur during the post sub giant branch phases of evolution in low mass stars.

Poster 101

Retired A Stars Revisited: An Updated Giant Planet Occurrence Rate as a Function of Stellar Metallicity and Mass

Luan Ghezzi[1]; Benjamin Montet[2]; John Johnson[3]

Observatorio Nacional; University of Chicago; Harvard-Smithsonian Center for Astrophysics

Exoplanet surveys of evolved stars have provided increasing evidence that the formation of giant planets depends not only on stellar metallicity ([Fe/H]), but also the mass ($M_\star$). However, measuring accurate masses for subgiants and giants is far more challenging than it is for their main-sequence counterparts, which has led to recent concerns regarding the veracity of the correlation between stellar mass and planet occurrence. In order to address these concerns we use HIRES spectra to perform a spectroscopic analysis on an sample of 245 subgiants and derive new atmospheric and physical parameters. We also calculate the space velocities of this sample in a homogeneous manner for the first time. When reddening corrections are considered in the calculations of stellar masses and a -0.12 $M_\odot$ offset is applied to the results, the masses of the subgiants are consistent with their space velocity distributions, contrary to claims in the literature. Similarly, our measurement of their rotational velocities provide additional confirmation that the masses of subgiants with $M_\star \geq 1.6$ $M_\odot$ (the "Retired A Stars") have not been overestimated in previous analyses. Using these new results for our sample of evolved stars, together with an updated sample of FGKM dwarfs, we confirm that giant planet occurrence increases with both stellar mass and metallicity up to 2.0 $M_\odot$. We show that the probability of formation of a giant planet is approximately a one-to-one function of the total amount of metals in the protoplanetary disk $M_\star 10^{[Fe/H]}$. This correlation provides additional support for the core accretion mechanism of planet formation.

Poster 102

Spectral Calibration of K−M Giant Stars from medium resolution Near-Infrared HK-band Spectra

Supriyo Ghosh; Soumen Mondal; Ramkrishna Das; and Dhrimadri Khata

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We present here medium resolution spectra ($\lambda/\Delta\lambda \sim 1200$) of K − M type giant stars covering wavelength range 1.50-1.84 and 1.95-2.45 μm. The sample includes 72 K0 − M8 giants from our observations and 35 giants from archival Spex spectral library. We have calibrated here the empirical relationship between fundamental parameters and measured equivalent widths of some important spectral features (e.g., Si I, NaI, CaI, ^{12}CO and ^{13}CO) and the H_2O-K2 spectral index with effective temperature and spectral type. We found that the ^{12}CO first overtone band at 2.29 μm and second overtone band at 1.62 μm are reasonably good temperature indicator above 3400 K. While the H_2O-K2 index are tightly correlated with effective temperature below 3600 K and spectral type later than M4 and hence it could be a powerful tool for later subtype M4.

The Chromospheric Activity, Rotation and Age of the Solar-Type Stars in the Open Cluster M67

Poster 103

M. Giampapa[1]; A. Brandenburg[2,3,4]; A. M. Cody[5]; B. Skiff[6]; J. Hall[6]

National Solar Observatory; LASP, JILA & APS Dept., University of Colorado; NORDITA, KTH Royal Institute of Technology & Dept. of Astronomy, AlbaNova University Center, Stockholm University; NASA Ames Research Center; Lowell Observatory

We report the results of a program to measure rotation periods and chromospheric activity in solar-type members of the approximately solar age and metallicity open cluster, M67. We utilize Kepler/K2 data from Campaign 5 along with contemporaneous spectroscopic observations of the Ca II H and K resonance lines as obtained with the 3.5-m WIYN telescope on Kitt Peak in conjunction with its Hydra multi-object spectrograph. We adopt the parameter, R'_{HK}, which is the total chromospheric flux in the H and K line cores normalized by the total bolometric flux, as the measure of chromospheric activity in our sample of solar-type members. We include 63 members with K2 data, 51 of which have newly acquired HK measurements. The average value of log R'_{HK}, including single and binary members, is -4.85 with a dispersion of 0.15. For the binary members only, the mean log R'_{HK} is -4.78 $\pm$ 0.18 while for the single solar-type stars we find a mean value of log R'_{HK} = -4.90 $\pm$ 0.11. These may be compared to the mean value for the Sun, as inferred from synoptic data obtained during 1976 – 2009, of log R'_{HK} = -4.89 $\pm$ 0.04. Our new Ca II data continue to exhibit significant overlap with the solar cycle but with objects with R'_{HK} values greater than solar maximum and less than solar minimum. Even when a plausible level of interstellar extinction within the H and K bands is taken into account, the presence of quiescent objects that may be Maunder-minimum candidates persists though at a markedly reduced percentage of the total sample. Based on gyrochronology relations and age-activity correlations, we find a mean chromospheric age of 4.4 $\pm$ 1.3 Gyr and a mean gyroage of 4.2 $\pm$ 1.0 Gyr. We find that solar-type members warmer than the Sun tend to have enhanced chromospheric emission than is otherwise predicted by empirical relations for chromospheric decay combined with rotational evolution models.

Characterizing the Palomar Radial Velocity Instrument for Dwarf Star and Exoplanet Studies

Poster 104

Rose Gibson[1,2]; Rebecca Oppenheimer[2]; Gautam Vasisht[3]; Tom Lockhart[3]; The PARVI Team

Columbia University; American Museum of Natural History; NASA Jet Propulsion Laboratory

The most common stars in the galaxy have largely been ignored in exoplanet science. With new technology it is now possible to expand the search for exoplanets in low mass star systems. The Palomar Radial Velocity Instrument (PARVI) will be the first of its kind, optimized to detect radial velocity signals of cool M stars. PARVI will operate in the λ = 1.1-1.75 wavelength range with a spectral resolution of $\lambda/\Delta\lambda \sim$100,000 and will be able to measure radial velocities with a precision of 0.3 m/s. The instrument, which is to operate on the Palomar 5.1m Hale telescope, will use Palomar's P3K adaptive optics system, distinct advantages provided by single-mode fibers, and a novel H-band laser frequency comb to probe and characterize the population of planets around cool, red stars. In this work we describe the performance

of the guide camera we will use in this system, a C-RED2 camera from First Light Imaging. The C-RED2 will be part of of a tip-tilt loop to eliminate any residual guide errors and ensure the starlight stays centered on fiber, which requires fast detector readout at low noise levels. At -40°C and a frame rate of 400 fps the C-RED2 has a read noise 19.6 e^-/s/pix and a dark current of 600 e^-/s/pix. The device is also capable of using a non-destructive read mode for up-the-ramp sampling with a slope error of ~ 10 e^-/s/read at a frame rate of 12.5fps. In our anticipated operating mode with a subarray of the detector (96$\times$96 pixels) we observe 5 e^- read noise at a frame rate of 2.3 ms (437 fps).

Poster 105

Results from the EBLM project and future prospects

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The EBLM project is an on-going effort to characterize very low-mass stars that transit FGK dwarf stars. Hundred of the EBLM-type eclipsing binaries have been discovered as a by-product of the successful planet-hunting WASP survey. The primary goal of the EBLM project is to understand the M-dwarf radius problem, whereby evolutionary models under-predict the radius of M-dwarfs by around 5 percent and their temperature by a few hundred degrees. We have published accurate parameters for 4 EBLM systems and spectroscopic orbits for more than 100 systems. These include a star at the hydrogen-burning limit (J0555-57) and an M-dwarf 600 K hotter than expected (J0113+31). We present the latest results of the project, adding 18 more systems with accurate parameters to the sample, and discuss emerging trends which may explain why some low-mass stars are not matched by evolutionary models. The project is gaining pace as data from space telescopes is becoming available. This will provide an opportunity to probe the properties of very low mass stars in much greater detail than has been possible to-date.

Poster 106

Young low-mass eclipsing binaries in the K2 clusters

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Young open clusters are fruitful astrophysical laboratories because their members share broad coevality, composition and distance. Multiple eclipsing binaries (EBs) in the same cluster offer a particularly strong test of stellar evolution theory, as they share the same age and metallicity but span a range of masses. Observational constraints on stellar evolution theory are very valuable, particularly at young ages and low masses, where theory is severely underconstrained.

K2 has recently targeted a number of nearby young open clusters spanning 1-800 Myrs. I will present our program to characterise young planets and EBs in the K2 clusters using

our innovative Gaussian process regression techniques. I will focus on four new EBs in Praesepe, which are particularly interesting: they increase the known cluster EB population below $0.6\ M_{\odot}$ by 40%; two are circularised but not synchronised, which contradicts the theory of equilibrium tides; and one contains a transiting brown dwarf, which is the first such system detected in a young open cluster. Finally, I will conclude with a look at how current and future missions will further our understanding of the early stages of stellar evolution.

K2 Ultracool Dwarfs Survey: The Rotation of Ultracool Dwarfs

Poster 107

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We present results from our ongoing K2 survey of nearby ultracool (M7-L8) dwarfs. The long cadence time coverage of K2 has allowed us to identify reliable rotation periods for nearby very-low-mass stars and brown dwarfs. We present supporting multi-wavelength observations using Spitzer Space Telescope and Gemini observatory. We discuss evidence for magnetic starspots and long-lived clouds in these cool atmospheres.

NuSTAR Observations of X-Ray Flares from Young Stellar Objects

Poster 108

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Young stellar objects (YSOs), which tend to flare more frequently and at higher temperatures than what is typically observed on Sun-like stars, are excellent targets for studying the physical processes behind large flaring events. In the hard x-ray regime, radiation can penetrate through dense circumstellar material, and it is possible to measure thermal emission from hot plasma and to search for nonthermal emission from accelerated particles, which are key components for understanding the nature of energy release in these flares. Additionally, high-energy x-ray emission can ionize material in the disk, which may have implications for planet formation. To investigate hard x-ray emission from YSOs, three 50ks observations of a star-forming region called rho Ophiuchi have been taken with the Nuclear Spectroscopic Telescope Array (NuSTAR). Through use of direct focusing optics, NuSTAR provides unprecedented sensitivity in the hard x-ray regime, making these YSO observations the first of their kind. Multiple stellar flares have been identified in the data set; here we present the current spectral and timing analyses of the brightest of the these events, exploring the way energy is released as well as the effects of these large flares on the surrounding environment.

Poster 109

Investigating the T Dwarf Class with Low-Resolution Near-Infrared Spectra Band by Band

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Exoplanet direct detections are reaching the temperature regime of cool brown dwarfs, motivating further understanding of the coolest substellar atmospheres. T dwarfs are numerous and isolated in the field, thus making them easier to study in detail than objects in companion systems. Brown dwarf spectral types are derived from spectral morphology and generally appear to correspond with decreasing mass and effective temperature (T_{eff}). However, spectral subclasses of the colder objects do not share this monotonic temperature correlation, indicating that secondary parameters (gravity, metallicity, dust) significantly influence spectral morphology. We seek to disentangle the fundamental parameters that underlie the spectral morphology of T dwarfs, using comparisons to atmospheric models. We investigate the relationship between spectral type and T_{eff} from the best fit model parameters for a sample of 151 T dwarfs with low resolution (R$\sim$75-100) near-infrared SpeX Prism spectra. Using a Markov-Chain Monte Carlo (MCMC) analysis to determine robust best fit parameters with uncertainties, we perform our analysis on the full spectrum and on narrower wavelength ranges where directly detected exoplanets are typically characterized.

Poster 110

Rotational braking and magnetic activity evolution on Sun-like stars

P. Gondoin

European Space Agency - ESTEC

Understanding the long-term evolution of magnetic activity on Sun-like stars is important not only for stellar physics but also for determining the high-energy radiation environment in which planets evolve.

In the past decades, many photometric surveys of open clusters have produced extensive rotation period measurements on Sun-like stars of different ages. Since magnetic activity on cool stars is closely linked to stellar rotation, this information can be used to gain new insights on the evolution of their magnetic activity.

A method is presented that infers the long-term evolution of Ca II chromospheric and X-ray coronal emission on solar mass stars as a function of their initial rotation period after circumstellar disk dispersion. It combines a best fit parametric model of their rotation evolution with empirical rotation-activity relationships. The derived scenario is compared with measurements of magnetic activity indices from Sun-like stars in nearby open clusters.

Is TRAPPIST-1 a unique M-dwarf host star?

Poster 111

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TRAPPIST-1 is an M7.5 dwarf that hosts seven rocky earth-size planets, three of which are in its habitable zone. Given the abundance of M dwarfs throughout the Galaxy as well as the ease by which rocky planets might be uncovered around low mass stars with future studies like TESS, an inquiry into the uniqueness of the nature of the TRAPPIST-1 system is particularly relevant today. TRAPPIST-1 is classified as a field dwarf with kinematics that suggest it is an ”old disk” star. However, the near infrared spectrum of TRAPPIST-1 exhibits a subtle peculiarity that causes it to be classified as an intermediate gravity (INT-G) object using spectral indices. To understand this subtle peculiarity as well as to place TRAPPIST-1 in context with other nearby M dwarfs, we have created a distance-calibrated spectral energy distribution (SED). Combining the most recent parallax measurement with optical and infrared spectra and all available photometry, we re-evaluate bolometric luminosity and effective temperature. We compare the resultant SED to a sample of old, young, and field age objects of similar properties. Using a FIRE echelle spectrum, we also investigate the near-infrared Y, J,H, and K bands to compare observables linked to gravity, atmosphere, metallicity and age effects.

TRENDS: Compendium of VLM Benchmark Objects

Poster 112

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The physical properties of faint stellar and substellar objects often rely on indirect, model-dependent estimates. For example, the masses of brown dwarfs are usually inferred using evolutionary models, which are age dependent and have yet to be properly calibrated. With the goal of identifying new benchmark objects to test low-mass stellar and substellar models, we have carried out a comprehensive adaptive optics (AO) survey as part of the TRENDS high-contrast imaging program. Using legacy radial velocity (RV) measurements from HIRES at Keck, we have identified several dozen stars that show long-term RV accelerations. We present follow-up high-contrast imaging observations from the campaign and report the discovery of 38 co-moving companions, as well as 9 strong candidate companions, to solar-type stars with well-determined parallax values and metallicities. Of our sample, $\sim 60\%$ of the companions are within 1” separation of the primary star and are likely bound, span a range of magnitude differences as large as $\sim$6 magnitudes fainter in the K-band, and include a faint companion to an M star. Benchmark objects of this nature can lend themselves to orbit determinations and dynamical mass estimates as well as independent compositional assessment. This compendium of benchmark objects will serve as a convenient test group to substantiate theoretical evolutionary and atmospheric models near the hydrogen fusing limit.

Poster 113

Catching more bees with Hydra: membership, binarity, and kinematics of the Beehive Cluster

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The coeval populations of open clusters facilitate statistical studies of stellar and planetary evolution. To produce robust statistics, however, we first require complete catalogs of cluster members and binaries. The repurposed Kepler mission, K2, has enabled detailed analysis of open clusters with a range of ages, including Upper Scorpius ($\sim$10 Myr), Pleiades (125 Myr), Hyades (650 Myr), and Praesepe (600 Myr). Praesepe is a rich, nearby cluster for which the low-mass membership and multiplicity are not well-constrained. Matching K2 observations with complementary ground-based data provide unprecedented insight into these benchmark clusters. We have observed Praesepe over 2.5 years with the Hydra multi-object spectrograph on the WIYN 3.5m Telescope, obtaining up to ten epochs each for >270 stars with spectral types K0-M3. The Hydra data yield radial velocities with approximately 1 km/s precision, providing a complementary sample to Gaia radial velocities that are limited to brighter sources. Over 75 percent of our sample has K2 light curves and measured rotation periods. We present preliminary results on cluster membership, multiplicity, and dynamics. We also discuss how binarity impacts planet occurrence rates and the evolution of stellar rotation.

Poster 114

The Eroding Disk of the Young M Star AU Mic

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AU Mic (M1V, d=9.91pc, t=24+/-3 Myr) hosts a debris disk which has been extensively studied since its 2004 discovery. A distinctive feature is the presence of a series of arc-like structures which were first seen in the SE arm. In 2014, comparison of Sphere commissioning data with HST coronagraphic imagery from 2010/2011 revealed the features were moving outward at between 4-10 km/s, and that 3 were already moving at greater than escape velocity. Subsequent monitoring showed the outward motion continues. HST observations resumed in 2017 October and confirm the disk is now more diffuse, and the features are now well-resolved. For the first time we find a velocity component orthogonal to the outer disk in addition to the motion along the disk. These findings are compared with available models.

Stellar Activity Levels from X-ray Observations of Solar-Analog Superflare Stars

Poster 115

S. Graf; L. Winter

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Soft X-ray observations provide an excellent measurement of stellar magnetic activity, exhibiting cyclic changes from solar minimum to solar maximum. For the Sun, X-ray measurements have been taken every 1-min with the GOES X-ray telescopes providing 40 years and four solar cycles worth of monitoring. The X-ray flux correlates with sunspot number and allows for historical comparison of activity and flare information collected over the past several hundred years (Clette et al. 2014). The last solar superflare occurred in 1859, disturbing the technology of the time (telegraph systems) and producing powerful aurorae. In order to better understand the conditions leading to superflares, which are extremely rare events with recurrence of 500-5000 years (Maehara et al., 2012), we must study superflares from large statistical samples of solar-analogs. From recent Kepler studies, superflares are identified in only a few slowly rotating, solar-analogs. Here we present XMM-Newton data for three of these slowly-rotating, high orbital period, Kepler stars. Stellar magnetic activity levels derived from the X-ray observations of these known superflare solar-analog stars are then compared with historical magnetic activity in the Sun.

Herschel Observations of Protoplanetary Disks in Lynds 1641

Poster 116

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We analyze Herschel Space Observatory observations of 105 young stellar objects with protoplanetary disks in the $\sim$1.5 Myr star-forming region Lynds 1641 (L1641) within the Orion A Molecular Cloud. We present spectral energy distributions from the optical to the far-infrared including new photometry from the Herschel Photodetector Array Camera and Spectrometer (PACS) at 70 microns. Our sample, taken as part of the Herschel Orion Protostar Survey, contains 24 transitional disks, eight of which we identify for the first time in this work. We analyze the full disks with irradiated accretion disk models to infer dust settling properties. Using forward modeling to reproduce the observed $n_{K_S-[70]}$ index for the full disk sample, we find the observed disk indices are consistent with models that have depletion of dust in the upper layers of the disk relative to the mid plane, indicating significant dust settling. We

perform the same analysis on full disks in Taurus with Herschel data and find that Taurus is slightly more evolved, although both samples show signs of dust settling. These results add to the growing literature that significant dust evolution can occur in disks by $\sim$1 Myr.

Poster 117

A High Resolution H- and K-Band Spectroscopic Sequence of Ultracool Dwarfs

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We present a preliminary analysis of a high-resolution H- and K- band spectral sequence of ultracool dwarfs with spectral types ranging from M6 V to T2. All spectra were obtained using the Immersion Grating INfrared Spectrometer (IGRINS) on the 4.3 m Discovery Channel Telescope at a resolving power of R 45,000. Our sample contains both field objects and known low gravity objects, which we are using to empirically search for gravity sensitive features. We will also present a comparison of the spectra to the latest model spectra of Marley and collaborators.

Poster 118

Enhanced and Rejuvenated: Are Dwarf Carbon Stars Spun Up By Mass Transfer?

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Carbon stars (with $C > O$) were long assumed to all be giants, because only AGB stars dredge up significant carbon into their atmospheres. We now know that dwarf carbon (dC) stars are actually far more common than C giants. These dC stars have likely all accreted a significant amount of C-rich envelope material from an AGB companion. Many such systems have undergone a planetary nebula phase, eventually yielding a white dwarf and a dC star that has gained both significant mass and angular momentum. Recent studies indicate that most dCs are from older, metal-poor populations, so would not be expected to show significant X-ray emission related to chromospheric activity. However, accretion spin-up might be expected to rejuvenate dynamos in these post mass-transfer binary systems. We describe our *Chandra* study of several dCs selected from the SDSS, to test whether the X-ray emission strength and spectral properties are consistent with a rejuvenated dynamo.

Spectrophotometry of HR 8799 c, d, and e from 1.5 to 2.4 μm with GPI

Poster 119

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High contrast, extreme-AO imagers like the Gemini Planet Imager (GPI) can directly probe thermal emission of gas giant planets and sub-stellar companions around young, nearby stars. In the case of HR 8799, studying differences between its multiple imaged planets provides clues about their formation. The extreme contrasts between host stars and planetary mass companions often necessitates advanced post-processing to subtract the stellar PSF. Recovering unbiased observables from directly imaged planets (i.e., photometry, astrometry, and spectroscopy) is even more challenging when the library of PSF reference images contains the planet signal, as in angular and spectral differential imaging. We use an analytic approach to forward model self-subtraction of the companion signal, as described in Pueyo (2016) to measure GPI spectra from 1.5-2.4μm of HR 8799 c, d, and e. We highlight differences between the spectra of the inner three planets and show how they compare to a library of brown dwarf spectra and atmospheric models.

Identifying TESS Objects of Interest

Poster 120

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TESS is an Explorer-class mission designed to detect small planets around nearby bright stars using the transit method and find 50 exoplanets with masses $<4\ M_{\oplus}$. TESS Objects of Interest (TOIs) are transiting planet candidates and anything else of astrophysical interest found in light curves generated from TESS data. We describe the workflow to identify TOIs using using a new web interface developed by the MIT branch of the TESS Science Office (TSO) called the TESS Exoplanet Vetter (TEV) to facilitate individual and group human vetting of candidates. The TOI working group delivers TOI lists with planet candidate ephemerides to the Mikulski Archive for Space Telescopes (MAST) and the TESS Follow-up Observing Program (TFOP), and plans to release TOI alerts on planet candidates for rapid follow-up response. We have tested and refined the TOI vetting process with two dry-run data sets: an end-to-end test of the TESS analysis pipeline with a sector's worth (27 days) of simulated data and the second with K2 C17 data (Crossfield et al., 2018).

Poster 121

A radial velocity search for exoplanets around young stars in open clusters and moving groups with CARMENES

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In this poster we present the preliminary results of our radial velocity (RV) search with CARMENES for exoplanets around members of the Pleiades Open Cluster and Taurus-Auriga star-forming region as well as of moving groups younger than 600 Myr, including IC2391, Beta Pictoris, Ursa Majoris, etc. CARMENES is an ultra-stable, two-channel, high-resolution spectrograph mounted on the Calar Alto 3.5m telescope, which provides a wide and continuous wavelength coverage from 520 to 1710 nm. We have developed a method to correct the RV measurements from the activity induced signals present in most of these young stars. First, we look for correlations between the RV measurements and activity indicators such as Halpha, CCF bisector, rotational period or the chromatic index, a measurement of the wavelength dependence of the RV. Then, we correct the RV values from the activity using these correlations and analyze the resulting data using Generalized Lomb-Scargle periodograms to search for periodic planet signals. Here, we will summarize the results of this analysis, show the cases in which we have reduced the rms of the RVs, set constraints on the presence of super-Earths in those stars and present the most promising candidates.

Poster 122

Starspots that induce no temporal variability confound fundamental stellar properties.

Michael Gully-Santiago

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Longitudinally asymmetric starspots modulate observed stellar flux as stars rotate, an assumption underpinning the majority of stellar rotation studies and gyrochronology. Longitudinally symmetric starspots induce no lightcurve modulation, and remain largely unquantified owing to their lack of temporal variability. Growing evidence for polar starspots suggests that the areal coverage fraction of starspots may be significantly underestimated, questioning the reliability of standard pre-main sequence evolutionary models and derived stellar masses and ages. I have developed a flexible two-component spectral inference framework to measure starspot area and temperature from composite spectra of spotted stars. The framework provides exceptional constraints on the total starspot coverage of a stellar hemisphere, especially when combined with high-resolution high-bandwidth near infrared spectroscopy, such as IGRINS or iSHELL. I propose a path forward for evaluating starspot-induced biases in star cluster ages, eclipsing binary radii, and exoplanet transit depths.

X-ray news from RW Auriga: Optical dimming associated with iron rich corona and exceptionally high absorbing column density

Poster 123

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RW Aur is a young, low-mass star which is variable on a wide range of time scales, as rotation, magnetic fields, outflows, and circumstellar disk interact. RW Aur A has undergone a visual dimming event in 2011 ($\Delta V \sim 2$ mag) lasting about half a year and further dimming 2014-2016 (ΔV up to 3 mag). Visual and IR observations indicate that the cause for this dimming is a gray absorber that moved into the line-of-sight. This dimming is also associated with changes in the outflow. We report on new *Chandra* X-ray data taken in 2017, when the optical flux was almost 2 mag below the long-term average. The observed X-ray spectrum is more absorbed by a column density of a few $10^{23}\ \mathrm{cm}^{-2}$ and shows significantly more hot plasma than in X-ray observations taken before the dimming. An emission feature at 6.62 keV is present indicating an Fe abundance an order of magnitude above Solar, in contrast with previous sub-Solar Fe abundance measurements.

Comparing X-ray absorbing column density N_{H} and optical reddening A_V, we find that either the gas-to-dust ratio in the absorber is orders of magnitude higher than in the ISM or the absorber has undergone significant dust evolution. Given the high column density coupled with changes in the X-ray spectral shape, this absorber is probably located in the inner disk. We speculate that a break-up of planetesimals or a terrestrial planet could supply large grains causing gray absorption; some of these grains would be accreted and enrich the stellar corona with iron which could explain the inferred high abundance.

Poster 124

Patterns of Variability in Sun-Like Stars

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We present representative time series from 25 years of Ca II H&K observations of a magnitude-limited (V < 8) sample of 419 stars with the Solar-Stellar Spectrograph (SSS) at Lowell Observatory. We have observed 100 of these with high enough cadence to examine their variability in detail; among them we find examples of singly- and multiply-periodic cycling stars, flat activity stars, and transitions between activity states, including what appears to be a clear transition in one star from flat activity to cycles of steadily increasing amplitude, akin to the Sun's emergence in the 1700s from the Maunder Minimum. We compare the variations of our ensemble, focused on the closest bright solar analogs, to those of the somewhat broader sample of the Mount Wilson Observatory (MWO) HK project, and present examples both of consistent as well as evolving activity behavior from the MWO epoch (1966-1991) to the SSS epoch (1992-2018).

Poster 125

A Flexible Model for Investigating Properties of Starspots: Model Characterization

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Starspots are sites of intense magnetic fields near a star's optical surface that actively suppress convective flows causing the area to be dimmer and cooler than the surrounding ambient photosphere. It is typically assumed that starspots trap energy below a star's superadiabatic layer, forcing the star to thermally restructure to maintain thermal equilibrium. For this reason, starspots have been proposed to explain noted discrepancies between stellar evolution model predictions and measured properties of young stars, whereby measurements find real stars appear cooler than model predictions at a fixed luminosity. However, there is little observational evidence to firmly support the assumption that starspots force stars to thermally restructure. To establish where within a star energy becomes trapped, and how a star responds to the trapped energy, we develop a flexible model to predict how starspots affect a star's observable properties. We find that different families of starspot models lead to unique color-magnitude diagram morphologies that roughly correlate with the location and duration of trapped energy. We present a study of three starspot model families to explore how stellar colors and magnitudes respond to varying starspot surface coverages and temperature contrasts. The three families include: (1) short duration starspots that do not cause thermal restructuring, (2) deep rooted starspots that lead to thermal restructuring, and (3) shallow rooted starspots where trapped energy is redistributed throughout the surrounding photosphere by radiation. When compared against measured properties of real stars, our model can be used to test whether starspots are responsible for the anomalous properties of young stars and potentially delineate between different starspot formation mechanisms.

Exploring the optimal RV observations to precisely determine the masses of the individual components in double-lined eclipsing binaries.

Poster 126

Eunkyu Han; Philip S. Muirhead

Boston University

Double-lined (SB2) eclipsing binaries (EBs) offer the best way to empirically determine self-consistent mass-radius-luminosity relationships for M dwarf stars. However, empirical measurements from the SB2 EBs often show larger than expected radii for their measured mass, metallicity and age. One proposed mechanism for this radius inflation involves strong magnetic fields arising from the rapid stellar rotation that inhibit internal convection and create starspots. Another possible explanation for inflated radii involves inaccurate modeling and quality of the data. There is a disagreement between different groups' measurements arising from using different sets of data and the EB fitting mechanism (Han et al. 2017). From this study, it is possible that other M dwarf EBs that show hyper-inflation are not inflated, and the masses and radii are inaccurate. Because these measurements directly inform the physical properties of exoplanets found to orbit isolated stars, it is important to constrain the relationships among the stellar parameters of M dwarf stars. To precisely determine the mass-radius relationship for M dwarfs, we need high fidelity photometric and spectroscopic data. Thanks to the Kepler spacecraft, rich sets of high fidelity photometric data are available. TESS soon will add more to this and therefore, obtaining the precise radial velocity (RV) measurements is the bottleneck to build a pristine mass-radius relationship. We explored the optimal RV observations in terms of the number of observations and the quality of data to be able to measure the component masses accurately at the point of diminishing returns.

Kepler Planet Occurrence Rates for Mid-Type M Dwarfs as a Function of Spectral Type

Poster 127

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Previous studies of planet occurrence rates have largely relied on photometric stellar characterizations. We present new spectroscopic observations of 333 M dwarfs in the primary Kepler field, which have allowed us to constrain spectral type, temperatures, and in some cases metallicities for these stars. Combining our data with Gaia parallaxes, we have computed precise ($\sim$3 percent) stellar radii, and present updated planet parameters and planet occurrence rates for mid-type M dwarfs. With our refined spectral classifications, we further compute occurrence rates for spectral types M3 V, M4 V, and M5 V, and find an increasing trend of planet occurrence toward later mid-type M dwarf spectral types. With our refined radius measurements, we also find Kepler-1649 b to be an Earth-sized planet receiving similar insolation flux to Earth.

Poster 128

The SUPERWIDE Catalog of Wide Binaries

Zachary Hartman; Sébastien Lépine

Georgia State University

We present the results of our search for wide binaries in the SUPERBLINK proper motion catalog of 2.8 million stars with proper motions greater than 40 mas/yr, which has been recently enhanced with data from the GAIA mission. In a first step, we conduct a Bayesian analysis taking into account angular separations and proper motion differences provided by the SUPERBLINK catalog, and identify all possible pairs with separations up to 60 arcminutes. In the second step we expand the analysis using the differences in the distances provided by the parallaxes from the Gaia DR2 release, and calculate probabilities for each pair to be a gravitationally bound system. The result is a list of $\sim$18,000 pairs with probabilities of being real binaries greater than 99 percent. We show that the distribution of projected physical separations of these wide, field binaries follows a decreasing power law, and shows no evidence of being bimodal, i.e. there is no evidence of a secondary population of pairs with separations $> 10^4$ AU. In addition, we find clear evidence that at least 30 percent of these wide binaries are triples/multiples, based on one of the components being overluminous.

Poster 129

Starspot properties of the K-subgiant, KOI-340

Leslie Hebb; Magdy Gad

Hobart and William Smith Colleges

We derive the latitude, longitude, and size of starspots on the primary star of the low mass eclipsing binary, KOI-340. KOI-340 consists of a K-subgiant primary star with a 12.9 day rotation period orbited by a late type M-dwarf secondary every 24 days. The primary star shows strong in-transit star spot crossing features that are observed as "bumps" in the bottom of each transit. We apply our comprehensive starspot modeling program, STSP, to derive the properties of the spots. We use the resulting spot properties to derive the fractional area of spots on the surface of this subgiant star.

CRIRES$^+$: a high-resolution near-infrared spectropolarimeter for the Very Large Telescope

Poster 130

Ulrike Heiter[1]; Alexis Lavail[1,2]; Artie Hatzes[3]; Roman Follert[3]; Ansgar Reiners[4]; Ulf Seemann[4]; Heiko Anwand-Heerwart[4]; Katja Hauptner [4]; Tim Umlauf[4]; Peter Jeep[4]; Petra Rhode[4]; Christof Schmidt[4]; Christopher Marvin[4]; Ernesto Oliva[5]; Nikolai Piskunov[1]; Thomas Marquart[1]; Eric Stempels[1]; Ansgar Wehrhahn[1]; Reinhold J. Dorn[2]; Jean Louis Lizon[2]; Anna Brucalassi[2]; Paul Bristow[2]; Marcus Haug[2]; Ignacio Molina-Conde[2]; Siegfried Eschbaumer[2]; Claudio Cumani[2]; Christophe Moins[2]; Derek Ives[2]; Barbara Klein[2]; Sebastian Tordo[2]; Renate Hinterschuster[2]; Yves Jung[2]; Jerome Paufique[2]; Andreas Haimerl[2]; Jörg Stegmeier[2]; Jean-Paul Kirchbauer[2]; Elena Valenti[2]; Luca Pasquini[2]

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CRIRES$^+$ is the upgrade of the CRyogenic InfraRed Echelle Spectrograph at the ESO Very Large Telescope. This upgrade comprises the addition of a cross-disperser unit that will result in a tenfold increase in simultaneous wavelength coverage while maintaining the high spectral resolution (R=100000) of CRIRES. The instrument will feature new state-of-the-art detectors and a new calibration unit, as well as an improved stability and repeatability. An innovative spectropolarimetry mode will also be offered. First light is expected for January 2019.

CRIRES$^+$ will be an excellent instrument to investigate the following science cases: atmospheric characterization of transiting planets, origin and evolution of stellar magnetic fields, and search for super-Earths in the habitable zone of low-mass stars among others.

In this poster we describe the performances of CRIRES$^+$ and showcase some of its science cases.

Poster 131

A GAIA HR-Diagram of 1600 High Proper Motion M dwarf and M subdwarfs with Spectroscopic Metallicity Measurements

N. Hejazi[1]; S. Lepine[1]; D. Homeier[2]

Georgia State University; Heidelberg University

We present a spectroscopic catalog of around 1600 high proper motion (> 0.4"/yr) M dwarfs and M subdwarfs, collected from medium-resolution observations at the MDM observatory. Since a high proper motion sample is over-represented with high-velocity stars which are sampled over a larger volume as compared to low-velocity stars, our catalog includes a significant number of stars belonging to old Galactic populations, i.e., thick disk and halo. Using synthetic-model fitting, we have obtained the metallicity, -element abundances, effective temperature and surface gravity of our stars. We have also been able to construct the H-R diagram of these stars, based on the accurate parallaxes from Gaia DR2. This diagram shows stars with different metallicity ranges fall into clearly distinct loci which can be used to develop photometric metallicity calibrations, in particular, for metal-poor M subdwarfs. In addition, we have identified co-moving pairs in our catalog which can provide excellent targets for future high-resolution surveys of M dwarfs and M subdwarfs.

Poster 132

Probing Stellar Tidal Dissipation with Hot Jupiters

René Heller

Max Planck Institute for Solar System Research

Due to their high masses and stellar proximities, hot Jupiters are exquisite tracers of stellar interiors. A key riddle connecting stars and hot Jupiters is in the very existence of these close-in planets. If they migrated into their orbits, why didn't they ultimately fall into their stars? Conventional models of stellar tidal dissipation, usually parameterized with a tidal dissipation constant Q (about 10^5 to 10^6), predict orbital decay within less than the lifetime of their host stars. Hence, these hot Jupiters should have fallen into their stars long time ago. I present a new model of tidally-induced orbital evolution that is based on two-layer, 2D stellar evolution models, which suggest strong tidal dissipation due to the dynamical tide in the extended convective envelopes of young, shrinking sun-like stars. The resulting Q values of about 10^3 imply that any hot Jupiter migrating inwards would stop migration at the stellar co-rotation radius near about 0.05 AU. During the next 100 Myr - 1 Gyr, tidal dissipation decreases by orders of magnitude (while Q increases to $\sim 10^8$) and the stellar rotation slows down due to magnetic breaking. Although hot Jupiters at 0.05 AU would soon be inside the co-rotation radius and be subject to tidal infall, this tidally-driven orbital evolution is much weaker than previously estimated due to the substantially lower tidal dissipation rates in sun-like main sequence stars. In fact, hot Jupiters as close as 0.05 AU around sun-like stars can easily survive for tens of billions of years from a tidal point of view. This model explains the observed hot Jupiter pile-up near 0.05 AU and connects the population of hot Jupiters with the observed fast rotation of young stars and it provides estimates of the tidal dissipation in sun-like stars.

Magnetic Fields and Planets of Weak-line T Tauri Stars

Poster 133

C. A. Hill

Institut de Recherche en Astrophysique et Planétologie IRAP / University of Toulouse

T-Tauri stars are late-type pre-main-sequence stars that are gravitationally contracting towards the main sequence. Magnetic fields largely dictate the angular momentum evolution of these stars and can affect the formation and migration of planets. Thus, characterizing their magnetic fields is critical for testing and developing stellar dynamo models, and theories of low-mass star and planet formation. I will present the results so far of the MaTYSSE project, that aims to map the magnetic fields of these stars, and detect close-in giant planets.

The First Mid-Infrared Observations of Substellar Companions Using JWST

Poster 134

Sasha Hinkley[1]; Andrew Skemer[2]; Beth Biller[3]; Aarynn Carter[1]; Laurent Pueyo[4]; Elodie Choquet[5]; Max Millar-Blanchaer[5]; Mickael Bonnefoy[6]; Alexandra Greenbaum[7]; Stephanie Sallum[2]; Jonathan Fortney[2]; Isabelle Baraffe[1]; Glenn Schneider[8]

University of Exeter; UCSC; ROE Edinburgh; STScI; JPL; IPAG-Grenoble; U. Michigan; Arizona

To prepare for the upcoming launch of JWST, a broad range of proposals have been selected by STScI under the Director's Discretionary Early Release Science Program (ERS). Our accepted 52-hour JWST ERS program will directly characterize two recently-discovered, directly imaged low mass companions (VHS 1256b and HIP65426b) over their full spectral range from 2-28 microns using photometry and spectroscopy. Ours will be among the first JWST observations of such low mass companions at these wavelengths, and will be crucial test cases for atmospheric retrieval codes that have mostly operated in the visible and near-infrared. Further, these observations will demonstrate the degree to which atmospheric abundance analysis can be obtained from JWST spectroscopy, placing valuable constraints on the atmospheric abundances of brown dwarfs and substellar companions. Within the first few months of JWST operations, our program will rapidly produce publicly-available datasets in modes to be commonly used by those communities intending to use JWST to characterize substellar and brown dwarf companions going forward. In addition, I will describe how our team of 120 investigators will deliver science enabling products (e.g. post-processing pipelines, retrieval codes) to empower a broad user base to develop successful future investigations of brown dwarfs and substellar companions in Cycle 2.

Poster 135

Exploring the atmospheres of ultracool objects at (extra)galactic abundances

Derek Homeier

Landessternwarte, Zentrum für Astronomie Heidelberg

Energy transport and dynamics in the atmospheres of the coolest stars and substellar objects are dominated by convective processes and overshoot. While 1D models play a crucial role in modelling these atmospheres with their complex molecular chemistry and highly non-grey opacities, extending to the formation of absorbing condensate clouds towards the end of the main sequence, 3D radiative hydrodynamic (RHD) simulations have identified limitations of the classical description of convective energy transport within the framework of mixing length theory (MLT) employed in the former. Refinements to the standard MLT formulation in the PHOENIX stellar atmosphere code, based on non-grey RHD simulations with CO^5BOLD, have enabled a much improved description of the atmospheric structures of ultracool dwarfs into the brown dwarf regime, while maintaining the computational efficiency of 1D models that allows the speedy construction of extensive model grids. The extension of the PHOENIX grid to a full range of galactic and primordial abundance patterns in metallicity and alpha-element enhancement is presented together with ongoing efforts to probe this widened parameter domain with CO^5BOLD RHD models for calibration. With decreasing metallicity, 3D effects and associated inhomogeneities are already known to have a growing effect from warmer models. Covering this region with realistic, non-grey RHD models at temperatures where molecular line absorbers dominate requires improved techniques for treating the strongly wavelength-dependent opacities in a numerically efficient scheme. This is key for covering stars to the end of the main sequence and beyond down to the most ancient galactic populations.

Poster 136

Studying the Benchmark Transiting Brown Dwarf LHS6343C with High-Resolution Spectroscopy

Callie Hood[1]; Henriette Schwarz[1]; Jayne Birkby[2, 3]; Ben Montet[4]; Jonathan Fortney[1]; David Charbonneau[3]; John Johnson[3]

UC Santa Cruz; University of Amsterdam; Harvard University; University of Chicago

Robust tests of brown dwarf formation and evolution models require benchmark objects that can be precisely characterized. However, there are currently no cool, old, field brown dwarfs with model-independent measurements of their masses and radii. LHS 6343C, a brown dwarf transiting one member of a wide M+M binary system, provides a unique opportunity to make such mass and radius measurements. Here we are using the techniques developed for high-resolution spectroscopic characterization of exoplanets but applying it to the brown dwarf/M-dwarf system. First, we clean the data of telluric contamination and stellar lines, then identify the brown dwarf target signal in the residuals using cross-correlation with a grid of molecular templates across a range of radial velocity semi-amplitudes. By tracing the radial velocity curve of LHS 6343C directly with high-resolution spectroscopy, the system is transformed into a double-lined eclipsing spectroscopic binary. Therefore, we can measure a model-independent mass and radius for the brown dwarf while also measuring its

atmospheric abundances. I will present preliminary results from applying this technique to K-band spectra of LHS 6343 observed with NIRSPAO on Keck II.

The habitability impacts of Evryscope superflares on the nearby cool stars

Poster 137

Ward S. Howard[1]; Nicholas M. Law – PI[1]; H.T. Corbett[1], Carl Ziegler[1]; Jeffrey K. Ratzloff[1]; Octavi Fors[1,2]; Daniel del Ser[1,2]; Erin E. Goeke[1], Aaron D. Pietraallo[1]; Matt A. Tilley[3]; Allison Youngblood[4,5]; R. O. Parke Loyd[4,5]; Evgenya L. Shkolnik[6]; Marin M. Anderson[7]; Gregg Hallinan[7]; Robert Quimby[8,9]

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Terrestrial planets in the habitable zones of nearby M-dwarfs provide incredible opportunities for detailed planetary characterization and investigation of potential habitability, especially those caught transiting by TESS. Unfortunately, high levels of X-ray and UV flux during superflares, coupled with increased stellar winds from CMEs, may damage the planetary atmosphere and allow deadly UV flux to reach the surface. We monitor thousands of g' < 15 Southern M-dwarfs for 10^{33} erg superflares with Evryscope. The Evryscope is an array of 24 61mm telescopes together imaging 8000 square degrees of sky every two minutes. Since its 2015 installation at CTIO in Chile, the Evryscope has continuously monitored 15 million stars on over 500 clear nights. For superflares observed by Evryscope on M-dwarfs with known planets, we estimate the loss to the planetary atmosphere's ozone column depth and the UV flux to reach the planet surface. In collaboration with Owens Valley Long Wavelength Array (LWA) all-sky monitoring, Evryscope also provides optical counterparts to radio flare, CME, and exoplanet-magnetosphere stellar activity searches. Finally, Evryscope-North construction is nearing completion. Based at Mount Laguna Observatory in collaboration with SDSU, Evryscope North will enable whole-sky monitoring of stellar activity in the TESS and LWA fields within the year.

Poster 138

Refined Measurements of Radial and Rotational Velocities of 200+ Ultracool Dwarfs from NIRSPEC High-Resolution Spectroscopy

Dino Chih-Chun Hsu; Adam Burgasser; Chris Theissen; Jessica Birky

UC San Diego

Precise measurements of radial (RV) and rotational (vsini) velocities of stars are essential for studying stellar kinematics (space velocities and dispersions), binary orbits, and rotational dynamics (angular momentum evolution). However, the high-resolution spectroscopy necessary to make these measurements is challenging for ultracool dwarfs, stellar or substellar objects with effective temperatures of less than 3,000 K, due to their intrinsic faintness, and samples are correspondingly small. Using nearly twenty years of observed and archival high-resolution data from the Keck NIRSPEC near-infrared spectrometer, we are refining measurements of RV, vsini, and other physical parameters for over 200 late-M, L, and T dwarfs through forward modeling techniques. Here we present our initial analysis of the sample, based on modifications of the Python-based NIRSPEC Data Reduction Pipeline and a Markov Chain Monte Carlo forward modeling tool incorporating stellar atmosphere and telluric models. We compare our RV and vsini measurements to prior work, and examine trends in spectral type, effective temperature, surface gravity, metallicity, RV, vsini, cluster membership, and Galactic orbits. We also identify radial velocity variables among previously identified spectral binaries.

Poster 139

Using High Resolution X-Ray Spectra to Probe Accretion, Abundances, and Coronal Activity in the Young Cluster IC 348

David Huenemoerder[1]; David Principe[1]; Norbert Schulz[1]; Joel Kastner[2]; David Weintraub[3]

MIT; RIT; Vanderbilt U.

We present Chandra High Energy Transmission Grating Spectrometer (HETGS) observations of the 3 Myr old pre-main sequence (pre-MS) stellar cluster IC 348. The pre-main-sequence stars in IC 348, because of their age, are key objects to study for understanding the evolution of high energy processes as low mass stars evolve toward the main sequence. Because IC 348 is nearby (310 pc) and compact (200–400 members within a radius of 10 arcmin), the HETGS can spatially resolve and obtain spectra of multiple sources in a single pointing, making this project an extremely efficient use of Chandra. A comparison of the IC 348 data to more extreme cases, like the Orion Nebula Cluster, which is comparable in age but contains high mass stars that are absent in IC 348, will reveal the importance of different high energy processes in the early phases of stellar evolution. We compare X-ray spectral signatures (luminosity, temperature, column density, and abundances) of the X-ray brightest pre-MS stars in IC 348 with spectral type, multiwavelength signatures of accretion, and the presence of circumstellar disks at multiple stages of pre-MS stellar evolution. Assuming all IC 348 members formed from the same primordial molecular cloud, any disparity between coronal abundances of individual members, as constrained by the identification and strength of emission lines, will constrain the sources of coronal chemical evolution at a stage of pre-MS evolution vital to the formation of planets.

Constraining UCD Radio Emission Mechanisms and Implications for the TRAPPIST-1 Planetary System

Poster 140

A. Hughes; A. Boley

University of British Columbia

Most terrestrial planets are expected to orbit M dwarfs, so understanding the fraction of potentially habitable planets in the galaxy. Strong, extended stellar magnetic fields and high flux of incident energetic particles in particular can threaten surface life. While the magnetic field strength and electron energy distribution are relatively well constrained for early- to mid- M dwarfs, recent observations have shown that UCD radio emission is different. For example, the Gudel-Benz relation between X-ray and radio luminosity holds for F to early M stars, but drastically underpredicts radio flux for UCDs. Processes such as electron cyclotron maser instability or auroral emission fail to explain the radio flux values observed at frequencies $>$ 30 GHz. Gyrosynchrotron radiation due to the UCDs' magnetic fields appears to be the most plausible mechanism for the observed emission, but has not been demonstrated conclusively. Gyrosynchrotron radiation is indicative of a substantial magnetic field and also accelerates electrons in stellar atmospheres to MeV energies. This in turn could inject high-energy particles into the stellar environment, posing a threat to planet habitability. We present ALMA observations of TRAPPIST-1 at 97 GHz and discuss the implications of its radio emission on the surrounding planetary system.

Magnetism in the cool precursors of intermediate-mass stars

Poster 141

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ESO, Germany; IRAP/Universite Toulouse/CNRS/CNES/UPS, France; Universite Grenoble Alpes/CNRS/IPAG; LESIA/Observatoire de Paris/CNRS, France; Institut de Physique de Rennes, France; University of Exeter, UK; University of Geneva, Switzerland; Rice University, USA; Uppsala University, Sweden; University of Southern Queensland, Australia; LUPM/Universite de Montpellier/CNRS, France

On the main sequence, only 5-10% of intermediate mass stars ($> 1.2M_{\odot}$) host strong large-scale surface magnetic fields. The magnetic fields in these stars tend to have relatively simple topologies that are stable over decades. However, all stars with masses between $1.2-4M_{\odot}$ undergo a T Tauri star stage during their pre-main sequence, during which they possess outer convective envelopes, and by analogy with their lower mass counterparts, can host solar-type dynamo activity. We present the results of our spectropolarimetric study of a sample of 38 intermediate-mass PMS stars. Magnetic fields are detected in the cooler half of our sample, and strongly suggest that the magnetic incidence drops very quickly (within 0.1 Myr) as soon as the radiative core exceeds 0.75R_* (or $0.98M_*$). The properties of the spectropolarimetric signatures also imply an increase in the field complexity as the radiative core develops; this is a first indication that intermediate-mass T Tauri stars show similar behaviour to their low-mass counterparts.

Poster 142

Bayesian spot modelling for *Kepler* light curves of superflare stars using adaptive parallel tempering

Kai Ikuta[1]; Hiroyuki Maehara[1]; Yuta Notsu[1]; Kosuke Namekata[1]; Shota Notsu[1]; Satoshi Honda[2]; Daisaku Nogami[1]; Kazunari Shibata[1]

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Superflares on many solar-type stars are discovered by *Kepler* space telescope (Maehara et al. 2012). The light curves of such superflare stars show quasi-periodic brightness modulation since large starspot groups exist on the stellar surface and rotate along with the stellar rotation (Notsu et al. 2013b). To investigate large starspot properties, we conducted estimation of stellar and spot parameters by optimizing *Kepler* light curves of superflare stars with theoretically reproduced ones using adaptive parallel tempering in Bayesian frameworks. This method is one of the extended Markov chain Monte Carlo methods, and enables estimation of more parameters and many optimal solutions without being trapped in local maxima of the likelihood function. Our result suggests that some large starspots ($\sim$ 0.1 percent of the hemisphere) live over at least 180 days (2 *Kepler* observation Quarter length) (Ikuta et al. 2018 in preparation). In our presentation, we show the numerical procedures and the calculation results.

Poster 143

Exploring Flaring Activity as an Age Indicator Using Open Cluster Data

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The presence and strength of stellar magnetic activity is rooted in a star's fundamental parameters such as mass and age. Age-resolved investigations of chromospheric activity indicators, and large scale magnetic field observations suggest that one can access an individual star's age via its magnetic activity. Can flares, magnetically driven energetic outbursts of energy on the surfaces of stars, serve as an accurate stellar "clock" then? For a star with given mass, the probability to encounter a flare scales as a power law with its total released energy. If there is an activity-age relation in the form of a flaring-age relation we expect the observed flaring rates and energies to vary significantly in these objects. Thus, the slope and intercept of the power law fit to the flare frequency distribution would be a function of both mass and age. The Kepler mission provides the means to test this hypothesis - high precision time domain photometry of thousands of stars in more than 10 open clusters spanning a wide range of ages. Using Kepler's K2 Campaigns 4 and 5 we explore the possibility to calibrate such a clock on the example of three open clusters: M67 (4.3 Gyr), M44 (0.63 Gyr) and the Pleiades (0.125 Gyr), and present first results.

High-Resolution Near-Infrared Spectroscopy of Barnard's Star with IRD/Subaru

Poster 144

Hiroyuki Tako Ishikawa[1]; Wako Aoki[2,1]; Takayuki Kotani[3,2,1]; Masashi Omiya[2,3]; Masayuki Kuzuhara[3,2]; Tomonori Usuda[2,1]; Saeko Hayashi[2,1]; IRD core team

SOKENDAI; NAOJ; Astrobiology Center

Recent studies have been detecting many planets around M dwarfs. Determining the detailed chemical compositions of M dwarfs is crucial for revealing the formation processes of the planetary systems and constraining the internal structures of the terrestrial planets around them. However, their intrinsic faintness and dominant molecular absorption hinder the well-established measurements of accurate chemical composition with high-resolution optical spectra.

The problems are mitigated in near-infrared wavelength. The high-resolution near-infrared spectroscopy is now promising because of the increasing development of new spectrometers enabling it. IRD is such a new instrument for the Subaru Telescope constructed for a planet search around nearby M dwarfs. IRD is the first instrument for 8m-class telescopes to cover the Y, J, and H bands simultaneously with a maximum spectral resolution of 70,000. The large diameter and broadband coverage have made it possible to observe more atomic lines than ever before in near-IR spectra of faint M dwarfs. We verified that the quality of IRD spectra is comparable to the existing ones such as CRIRES spectra in terms of wavelength assignment and resolution.

We report the interpretation of IRD spectra of Barnard's Star. We identified the absorption lines throughout the Y, J, and H bands. We detected more than 100 FeH lines, which are dominant in Y band, and examined their behavior. We also determined the elemental abundances for Fe, Ti, Cr, Na, Mg, Al, Si, K, Ca, V, and Mn, based on the equivalent width of the corresponding atomic lines. Besides, we observed LHS 1140 with a similar temperature to the Barnard's Star and found that it is metal-richer and alpha-poorer than Barnard's Star.

Spotted stars as a mine of knowledge about the magnetic fields: $13\,000$ stars in the OGLE sky survey of the Galactic bulge

Poster 145

Patryk Iwanek

Warsaw University Observatory

It is widely known that stellar spots are an indicator of stars' magnetic fields, thereby spotted stars are the best laboratory for testing the dynamo theory and improving theoretical models. I would like to present the discovery and statistical analysis of almost $13\,000$ stars with spots in and towards the Galactic bulge, which is the largest sample of spotted stars known to date. Our study is based on a long-term, V- and I-band massive photometry obtained by the Optical Gravitational Lensing Experiment (OGLE) since the beginning of our project. We unveil two distinct groups of stars with spots based on their observational parameters, i.e. rotation periods, dereddened color indices and amplitudes. The first group consists of fast-rotating ($P < 2.5$ d), bluer ($(V-I)_0 < 0.75 \sim$mag) stars with amplitudes smaller than 0.1 mag, while the second group contains slowly-rotating ($P \geq 2.5$ d), redder ($(V-I)_0 \geq 0.75$ mag)

stars with brightness variations up to 0.5 mag. We discover dependence between luminosities and rotation periods for spotted stars. Moreover, we confirm the period–color relation for spotted giants. Our continuous observations have allowed us to discover two different correlations between changes in brightness and changes in color of spotted stars with their rotation. We are able to divide these stars into three groups according to the type of spots which prevail on their surfaces. During my talk, I will discuss possible explanations of such a division. We believe that these different manifestations of magnetic field are associated with different ways of generating it. Moreover, among all spotted stars we have found several dozen flaring objects. We discover that stars with larger spots coverage exhibit higher brightenings during outbursts. I will present plans for future research of spotted stars within the OGLE survey.

Poster 146

How to get dominant azimuthal fields on active cool stars

E. Işik[1,2]; S.K. Solanki[1]; R.H. Cameron[1]; N. Krivova[1]

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Zeeman-Doppler imaging of active FGK stars indicate a gradual increase in the fraction of east-west oriented magnetic fields with increasing rotation and activity. To explain this behaviour, we propose a mechanism which takes into account finite durations of emergence of bipolar magnetic regions within a surface flux transport model. When the local radial speed of emergence decreases with increasing rotation and activity, the azimuthal field can dominate over the radial field, which becomes visible in our magnetic maps degraded to observed resolution levels.

Poster 147

High Cadence Detections Of Stellar Flares With The Next Generation Transit Survey (NGTS)

J.Jackman; P. Wheatley

University of Warwick

J. Jackman; P. Wheatley

A Gap in the Lower Main Sequence

Poster 148

Wei-Chun Jao[1]; T. Henry[2]; D. Gies[3] N. Hambly[4]

Georgia State University ; RECONS Institute; CHARA/GSU; University of Edinburgh

We present the discovery of a gap near $M_G \approx 10$ in the main sequence on the Hertzsprung-Russell Diagram (HRD) based on measurements presented in *Gaia* Data Release 2 (DR2). Using an observational form of the HRD with M_G representing luminosity and $G_{BP} - G_{RP}$ representing temperature, the gap presents as a nearly horizontal feature that dips slightly toward lower luminosities at redder colors. The gap is seen in samples extracted from DR2 with various distances, and is not unique to the *Gaia* photometry — it also appears when using near-IR photometry ($J - K_s$ vs M_{K_s}). The gap is very narrow ($\sim$0.05 mag) and is near the luminosity-temperature regime where M dwarf stars transition from partially to fully convective, i.e., near spectral type M3.0V. This gap provides a new feature in the H-R Diagram that hints at an underlying astrophysical cause and we propose that it is linked to the onset of full convection in M dwarfs.

Slingshot prominences: nature's wind gauges

Poster 149

M. Jardine; A. Cameron

University of St Andrews

Mass loss rates for the tenuous, hot winds of cool stars are extremely difficult to measure, yet they are a crucial ingredient in the stars' rotational evolution. We present a new method for measuring these mass loss rates in young, rapidly-rotating stars. These stars are known to support systems of "slingshot prominences" fed by hot wind material flowing up from the stellar surface into the summits of closed magnetic loop structures. The material gathers and cools near the co-rotation radius until its density becomes large enough that it is visible as a transient absorption feature in the hydrogen Balmer lines and strong resonance lines such as Ca II H& K. Here we present the key insight that the sonic point usually lies well below the condensation region. The flow at the wind base is therefore unaffected by the presence of an overlying prominence, so we can use the observed masses and recurrence times of the condensations to estimate the mass flux in the wind. These measurements extend the relationship between mass loss rate per unit surface area and X-ray flux to span 5 orders of magnitude. They demonstrate no evidence of the suspected weakening of stellar mass loss rates at high X-ray flux levels.

Poster 150

Using stellar twins to climb the cosmic distance ladder

Paula Jofre

Nucleo de Astronomia, Diego Portales University, Santiago de Chile

Twin stars are assumed to have the same luminosity. Thus, when the distance of one star is known from the parallax, we work out the distance of its twin with the difference of their perceived brightnesses. We find twins by comparing their spectra, which must be identical. The method offers a way to determine distances that is model-free, in which the spectra is used solely to assess wheather stars are twins and not to derive information on their atmospheric parameters, which are subject of large uncertainties. In the current era of large spectroscopic stellar surveys of the Galaxy, our method has enormous potential to complement Gaia mission in climbing the cosmic ladder, as it allows one to determine distances of stars for which distance informations is not accessible by using standard trigonometric distance determinations. In this talk I will present the current progress on this method, discussing applications for Gaia-DR2.

Poster 151

A Survey for Molecular Hydrogen Emission Around Stars Forming Terrestrial Planets

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Rice University; University of Colorado; AURA; Peking University; SAO; NOAO

There is a discrepancy between the frequency of rocky planets in the inner AU known around Sun-like stars and the frequency of stars observed to be undergoing the collisions that form these planets. The discrepancy may indicate that rocky planets are less common than believed or that they form very differently than we have imagined, producing little or no debris signature. A third, less dramatic possibility is that planet-forming systems retain a tenuous reservoir of gas that whisks away the warm dust (debris) produced by planet-forming collisions. Over the past decade, it has been recognized that fluorescent FUV molecular hydrogen emission is an excellent tracer of gas in the planet forming regions of disks around young stars. We are using HST+COS with the G130M grating to survey the FUV spectrum between 1140 - 1450 Ang for molecular hydrogen emission from a sample of 30 stars in the 11 Myr old Upper Scorpious star forming region. These data will test whether small amounts of disk gas remove the debris from planet forming collisions, or whether rocky planet formation possibly proceeds much differently than currently thought. Here we report initial results from this survey.

An Information Theory Approach to Flare Dynamics

Poster 152

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Andrews University; Johns Hopkins University, Applied Physics Laboratory

Solar and stellar flares are powered by energy stored in magnetic fields, so their occurrence should depend on the evolution of the underlying magnetic field. As such, flare sequences contain information about the underlying dynamics of the stellar activity cycle, which can be seen in long-term variability of the flaring rate. However, the distribution of flares over shorter time scales appears to be random and is thought to be well described as a nonstationary Poisson process. The waiting time distribution of flares is thought to be produced by processes sufficiently complex to appear random, or the randomness may be a property of the evolution of the magnetic field configurations. To understand the information contained in flare sequences, we have applied information theory to examine the flow of information. We have found that in contrast to a Poisson process, there is significant mutual information between subsequent flares, suggesting that the dynamics is not so well described as a non-stationary Poisson process. Using the GOES X-ray database for the sun, we investigate how the dynamics changes through the solar/stellar cycle and the underlying origins of the information flow.

Simulations of Stellar Variability

Poster 153

L. J. Johnson[1]; C. Norris[1]; Y. Unruh[1]; S. Solanki[2]; N, Krivova[2]

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Observations of rotating late-type stars reveal brightness fluctuations and periodic oscillations. This is due in part to magnetically driven activity phenomena such as cool starspots and hot faculae on the stellar surface. To facilitate analysis of this phenomenon, we present ACTReSS, a software tool for calculating the incident flux from a model active stellar surface as it varies throughout a rotation. The model uses limb-dependent intensities calculated from MURaM 3D magneto-convection simulations for quiet photospheres and magnetic active regions of varying field strength on stars of spectral types G - M. This allows us to investigate the simulated response from these features on rotational lightcurves for late-type stars with varying feature distributions and rotation axis inclinations. Simulated lightcurves are calculated at a range of inclinations for a low activity (faculae-dominated) solar analogue.

Poster 154

Classically and Asteroseismically-constrained 1D Stellar Evolution Models of α Centauri A & B using Empirical Mixing Length Calibrations

Meridith Joyce; Brian Chaboyer

Dartmouth College; SAAO

The bright, nearby binary α Centauri provides an excellent laboratory for testing stellar evolution models, as it is one of the few stellar systems for which we have high-precision classical (mass, radius, luminosity) and asteroseismic (p-mode) observations. The solar-like features of α Cen A and α Cen B (masses of $\sim 1.1 M_{\odot}$ and $\sim 0.93 M_{\odot}$, effective temperatures of ~ 5790 K and ~ 5230 K) likewise make the system an ideal model calibrator. Stellar models are created and fit to the classical and seismic observations of both stars by allowing for the free variation of convective mixing length parameter α_{MLT}. This system is modeled using five different sets of assumptions about the physics governing the stellar models. There are 31 models (out of $\sim 150,000$ generated) which fit the classical, binary, and seismic observational constraints of the system within $3\,\sigma$. Models with each type of physical prescription are found to be viable, but the optimal mixing lengths for Cen A and Cen B remain the same regardless of the choice of input physics. The optimal mixing lengths are $\alpha_{\text{MLT,A}}/\alpha_{\odot} = 0.927$ and $\alpha_{\text{MLT,B}}/\alpha_{\odot} = 1.090$. That Cen A and Cen B require sub- and super- solar mixing lengths, respectively, to fit the observations is a trend consistent with recent findings, such as in Kervella et al. (2017), Joyce & Chaboyer (2018), and Viani et al. (2018).

Poster 155

How do Substellar Objects Generate Magnetic Fields?

Melodie M. Kao[1,2]; Gregg Hallinan[2]; J. Sebastian Pineda[2,3]; Evgenya Shkolnik[1]; Adam Burgasser[4]; David J. Stevenson[2]

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Magnetic fields play a pervasive role in planetary systems, impacting interior structure, atmospheric evolution, and habitability. Characterizing planetary systems therefore depends upon remote detection or prediction of magnetic fields. Doing so calls for dynamo scaling laws that relate magnetic field properties (e.g. strength, time variation, topology) to measurable quantities like mass, temperature, and age. Scaling laws grounded in the theory of fully convective dynamos are particularly important because such dynamos are ubiquitous in low mass stars, brown dwarfs, gas giant planets, and even small rocky planets. To understand fully convective dynamos, we must systematically test dynamo models against magnetic field measurements. Brown dwarf measurements are especially valuable because these stellar/gas giant intermediaries can probe planetary characteristics. We will present the motivation and review the state of the art for these measurements and models.

Swift detection of two long-duration X-ray superflares on RS CVn type active binaries UX Ari and SZ Psc

Poster 156

Subhajeet Karmakar; J. C. Pandey

Aryabhatta Research Institute of Observational Sciences [ARIES]

We present an in-depth study of two very large long-duration flares observed from two RS CVn type binaries UX Ari and SZ Psc. The flare from the spectroscopic binary UX Ari triggered Swift Burst Alert Telescope (BAT) on 15 July 2014, whereas the flare from the eclipsing binary SZ Psc triggered BAT on 15 January 2015. Although the rise phase of the superflare from UX Ari was not observed it lasts more than 33 hrs and is the second longest X-ray superflare ever observed as the best of our knowledge. The decay phase consists of two parts the first shallower decay up to 20 minutes followed by more steeper decay up to more than 33 hours. The e-folding decay time of the flare was derived to be of $\sim$3 hrs. Spectral analysis indicates a presence of two temperature corona with cooler plasma temperature remains constant during the flare at 19 MK. The flare-temperature peaked at 104 MK which is $\sim$6 times more than the minimum value observed at post-flaring (PF) phase. Using hydrodynamic loop modeling we derive a loop-length of 2.5$\times 10^{11}$ cm. The peak X-ray luminosity for this flare in the 0.3–50 keV energy band reached up to (L_X) of $\sim 2.6 \times 10^{33}$ erg s^{-1}. The flare from SZ Psc was found to be out of eclipse and it lasts more than 28 hrs. The exponential rise and decay time of the flares were derived to be 2 and 5 hr, respectively. The peak L_X was reached up to a value of 4.8 x 10^{33} erg s^{-1}, Spectral analysis indicates a presence of one temperature corona, which represents the flare temperature. The temperature is one of the highest observed spectroscopically with a peak at 258 MK, which is $\sim$10 times more than the observed minimum value. The peak stellar abundances were derived to be 0.7 times more than solar abundances, The Emission Measure followed the flare light curve. The length of the flaring loop was derived to be 7.3 x 10^{11} cm.

Non Linear Force Free Field modeling of a pseudostreamer before and during eruption

Poster 157

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Coronal mass ejections (CMEs) are the most violent eruptions in our Solar System. CMEs are responsible for large solar energetic particle events and severe geomagnetic storms. In this study, we present a magnetic configuration of a pseudostreamer before and during eruption observed on April 19, 2015 on the Southern West limb embedding a prominence cavity. The eruption resulted in a relatively wide CME with a round front and prominence core. In SOHO/LASCO C2 partial halo was observed. The prominence eruption begins with a slow rise and then evolves to a fast rise phase. We first constructed a non-linear force free field (NLFFF) model of this pseudostreamer using the flux rope insertion method. The NLFFF model produces the 3D coronal magnetic field constrained by observed coronal structures and photospheric magnetogram. SDO/HMI magnetogram was used as an input for the model. The field configurations representing the eruption are not in force-free equilibrium. We magnetofrictionally relax the model until the flux rope expands to three solar radii and compare

CME propagation with the SOHO/LASCO C2 observations. From the simulation results, we determine the process for the eruption by identifying where reconnection takes place and how much flux is reconnected. We determine the pre-eruption twist and decay index and how the twist is transferred as the simulation progresses. In addition, we perform a topology analysis of the models in order to determine the location of quasi-separatrix layers (QSLs). QSLs are used as a proxy to determine where strong electric current sheets develop in the corona and also provide important information about the connectivity in this complicated magnetic field configuration.

Poster 158

The Flares of Proxima Cen

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Flares on Proxima Cen are ubiquitous. As on the Sun, they are expected to be distributed as power-laws of the form $N(E) \propto E^{-\alpha}$. We track the variations of α over the stellar cycle, using data from multiple observatories using ASCA, Swift, Chandra, and XMM. After correcting for coronal temperature variations, we find a remarkable consistency in the shape of the flare distributions across the epochs, with $\alpha > 2$. If flare onset is attributable to self-organized critical proccesses, this suggests that the characteristics of the magnetic field structure like the filling factor and the plasma heating mechanism on Proxima Cen remain stable throughout the cycle.

Poster 159

M Subdwarfs May Be Smaller Than You Would Think

Aurora Kesseli[1,2]; Davy Kirkpatrick[2]; Sergio Fajardo-Acosta[2]; Michael Cushing[3]

Boston University; Infrared Processing and Analysis Center; University of Toledo

M subdwarfs are low-metallicity M dwarfs that dominate the halo populations of the Galaxy. Metallicity controls the opacity of the atmosphere; in metal poor stars, the photosphere is expected to lie deeper inside the star where the gas temperature is higher, leading to smaller radii for a given effective temperature. We compiled a large sample of subdwarf stars that spans spectral classes K7 to M6 and includes stars with metallicity classes from solar-metallicity dwarf stars to the lowest metallicity ultra-subdwarfs to test how metallicity changes the radius. We fit models to optical spectra to derive effective temperatures ($T_{\rm eff}$) and we measured bolometric luminosities (L_{bol}) by combining broad wavelength coverage photometry with Gaia parallaxes. Radii were then computed by combining the $T_{\rm eff}$ and $L_{\rm bol}$ using the Stefan-Boltzman law. We find that for a given temperature, ultra-subdwarfs can be as much as five times smaller than their solar-metallicity counterparts. To aid in future radius determinations of low-metallicity M subdwarfs, we present color-radius relations that extend down to [Fe/H] of -2.0 dex.

Probing Effect of External UV Radiation on Young Stellar and Substellar Mass Objects: Is Orion a Special Place for Observing External Photoevaporation of Disks?

Poster 160

J. Serena Kim[1]; Min Fang[1]; Cathie Clarke[2]; Stefano Facchini[3]; Ilaria Pascucci[4]; Daniel Apai[1]

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Does star and planet formation environment matter for their circumstellar disk evolution and their properties? What are the observational signatures and theoretical implication? UV radiation from massive stars may affect the disk properties including disk mass, disk size, accretion rate, and disk lifetime. The final mass of the young objects may be affected due to early loss of circumstellar materials. The evidence of short-lived radioactive nuclides found in meteorites suggest that the planet forming solar system disk has been affected by massive stars and their death. These massive stars not only influence their neighbouring stars via their dying processes, but while they are in main sequence via UV radiation and winds. We have been conducting systematic survey of the Orion star forming region where we have direct evidence of interplay between massive stars and young objects in their vicinity: photoevaporating protostellar disks (proplyds) evaporating away from massive stars. We have extensively studied the Orion star forming region including Orion Nebula Cluster (ONC), its sibling NGC 1977, NGC 1980, and Lynds 1641. Most of the proplyds have been found in Orion, while only handful of such objects have beeb found outside the Orion region around early to mid O stars. A B1V star, 42 Ori, in NGC 1977 is so far the lowest mass objects with multiple proplyds around it. We present our multi-wavelength observational and modeling results on proplyds around 42 Ori, candidate free-floating planetary mass proplyds in ONC and NGC 1977, and discuss the impact of external UV radiation environment on young stellar and substellar object formation.

Velocity-space Substructure of the Local Galactic Halo from K and M Dwarfs and Subdwarfs in the SUPERBLINK and Gaia Catalogs

Poster 161

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We present a study of the kinematics of nearby ($d < 1$ kpc) high-velocity K and M dwarfs and subdwarfs from the SUPERBLINK proper motion catalog ($\mu > 40$ mas/yr), incorporating data from the second Gaia Data Release (Gaia DR2). All K and M stars were selected based on their $G_{\mathrm{BP}} - G_{\mathrm{RP}}$ colors and reduced proper motions, and distances were calculated from Gaia parallaxes. We plot transverse velocities v_T of stars in six different directions on the sky, to examine the distribution of local K and M stars in the *UVW* velocity space system. Our analysis suggests that the velocity-space distribution of local thick disk and halo stars, much like the velocity-space distribution of disk stars, is inhomogeneous and shows the signature of at least one global ”stream” consisting of stars drifting toward Galactic center.

Poster 162

Age-dating low mass stars using galactic kinematics.

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Graduate Center, CUNY; American Natural History Museum; Hunter College; Center for Computational Astrophysics;Columbia University; Leibniz-Institute for Astrophysics Potsdam [AIP]

M dwarfs are an excellent group to study the evolution of the stellar thin disk because they represent the majority of stars of the Milky Way. However, the age of stars is difficult to directly measure and we need to use methods based on models or observations to estimate stellar ages. With the Gaia-Cupid project, we seek to combine Gaia kinematic information with spectral data from SDSS IV to investigate correlations between features related to the ages of M dwarfs, such as effective temperature and $H\alpha$ luminosity, and precise kinematic properties of the stars. The goal is to get age probability distributions for the stars using this relations and bayesian analysis. We are using a catalog of over 70,000 M dwarfs with low resolution optical spectra from SDSS DR7 and kinematics. By combining it with ROSAT and GALEX, we compiled a catalog containing $LH_\alpha/Lbol$, X-ray and UV data for the M dwarfs. While waiting for Gaia DR2, we use kinematics from this catalog to demonstrate the relation between the ages of M dwarfs and the dispersion in vertical action. We hope to extend the kinematics-age relations to lower masses in order to constrain the ages of Brown Dwarfs, a notoriously difficult group of objects to age-date.

Poster 163

Determination of Stellar Parameters of Nearby M-type Dwarfs Using Medium-Resolution Optical Spectra

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M-type dwarfs are now considered promising to detect Earth-like habitable planets because of their small masses and low temperatures. It is vital to understand the properties of target stars, since those are crucial to characterize the potentially detected planets and the observed planetary systems. We have obtained the medium-resolution spectra of nearby 270 M-type dwarfs to derive their spectral types and effective temperatures ($T_{\rm eff}$), using several spectrometers with the spectral resolutions of 1200–2000. The spectral types of the observed M-type dwarfs range from M3 to M6, and the stars with the spectral type of M4–M5 are the most common. The theoretical model spectra for cool dwarfs have been fit to our spectra to derive their $T_{\rm eff}$, which are also calibrated with the spectra of the M-type dwarfs with $T_{\rm eff}$ well determined by the previous studies. Our fit is based on the VO absorption band (7320 –7570 Å) and optical region (5000–8000 Å). As a result, the $T_{\rm eff}$ of our M-type dwarfs are inferred with the average precisions of 80–300 K. We have also analyzed the spectral energy distributions of our samples, finding that the radii of those to be 0.08 to 0.46 $R_\odot$ with the error of 0.01 $R_\odot$ on average. This catalog helps the ongoing and upcoming planet surveys by providing the important stellar properties of many nearby M-type dwarfs.

VRI and Hα Variability in Low-Mass T Tauri Stars with the WIYN Half-Degree Imager

Poster 164

Lena Komarova[1]; Reid Contente[2]; Mufid Alfaris[2]; Samuel Clyne[2]; Kimberly Ward-Duong[3,4]; Michael Petersen[2]; Miranda Eiben[2]; Silvana Delgado[2]; Madeline Boyce[2]; Frank Tavares[3]; Anjali Desai[1]; Avery Hanlon[5]; Kate Follette[3]; Suzan Edwards[1]

Smith College; UMass Amherst; Amherst College; Five College Astronomy Department; Mt. Holyoke College

We present preliminary results from a multiwavelength photometric monitoring study of young, low-mass stars and transition disk systems with the WIYN 0.9m/Half-Degree Imager. Young stellar objects have been observed to rotate at fractions of rates expected from formation and accretion processes, with significant differences for populations of low-mass and high-mass stars. As accretion from circumstellar disks can trigger magnetospheric winds that transport angular momentum out, the observed spread in rotation rates could be attributed to differences in disk properties. With observations in the VRI bands, and Hα to constrain accretion processes and timescales, we present variability results for 29 T Tauri stars in the mass range 0.06 - 0.8 $M_{\odot}$, with the goal of examining the relationship between derived rotation rates, stellar mass, and disk properties. VRI+Hα lightcurves taken over eight nights of observation exhibit a wide range in variability amplitude and periodicity, associated with physical processes such as cool/hot spots, variable accretion, and disk obscuration. We find aperiodic, quasi-periodic, and periodic variables with amplitudes in the range of 0.06 - 1.5 magnitudes and rotation rates ranging from 8 hours to 8 days.

Effect of starspots on exoplanet atmopshere detection

Poster 165

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Starspot are known to affect both the detection and characterisation of exoplanets. Areas of different temperature on the stellar surface can affect the radial velocity measurements, causing noise which can hinder the detection of small planets and the determination of their precise parameters, and at times even mimicking planetary signatures. Starspots are also known to affect exoplanet radii determined from transit light curves, and spin-orbit alignments from Rossiter McLaughlin effect. We have recently started working on simulating the effect of starspots on exoplanet atmosphere detections using transmission spectroscopy. The signature of the exoplanet atmosphere is always tiny compared to the signal coming from the star itself. Small changes in the surface temperature of the star when planet transits the stellar disc could potentially be interpreted as a signature of the exoplanet atmosphere. Here, we present our first simulations and discuss preliminary results.

Poster 166

Modeling realistic observables for local helioseismology.

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In time-distance helioseismology, wave travel times are measured between points on the solar surface to infer vector flows in the solar interior. The travel time measurements are subject to unmodeled systematic effects, which depend on the nontrivial relationship between wave displacement and helioseismic observables (Doppler velocity or intensity).

Here we solve the radiative transfer equations in a solar model atmosphere at each point on the solar sphere, given the displacements and the perturbations in thermodynamical quantities caused by acoustic oscillations. The wave field is obtained by solving a vectorial wave equation in a solar model that includes an atmosphere. Wave perturbations cause opacity and local optical depth changes in the model atmosphere, which in turn lead to perturbations in the emergent intensity on the solar surface. In this study we investigate the contribution of the thermodynamical and geometrical effects on emergent intensity at each point on the surface and estimate their impact on helioseismic travel time measurements.

Poster 167

Signatures of Electron Beams with High Low-Energy Cutoffs in Stellar Flares

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The low-energy cutoff of nonthermal electron beams is a critical parameter for input to radiative-hydrodynamic models of stellar flares, and it has implications for the efficiency of particle acceleration among stars over a range of magnetic field environments. Hard X-ray data of most solar flares are consistent with a low-energy cutoff of $E \leq 25$ keV, which is where the bulk of the nonthermal power resides. However, there are instances where the X-ray spectra of "late impulsive peaks" in solar flares exhibit evidence of a much higher cutoff near $E \sim 100$ keV. A high cutoff value for nonthermal electrons is a possible explanation for the heating that produces white-light radiation in dMe flares, since large optical depths can be heated to $T \sim 10,000$ K without extreme current densities and electric fields. We present a grid of radiative-hydrodynamic flare heating models with high low-energy cutoffs calculated with the RADYN code. This grid includes an updated, accurate prescription for the broadening of the hydrogen lines. We discuss the observational signatures of a high low-energy cutoff, such as the NUV and optical flare continuum flux ratios and line-to-continuum ratios. The effects of magnetic field mirroring and similarities to proton beam heating will be discussed.

Atmospheres and UV Ground Environment for Planets Orbiting Red Giants

Poster 168

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During the red giant stellar evolutionary phase for a planetary system, habitable zone (HZ) limits move past the original frost line to large orbital separations. Planets could remain in this new HZ for 200 Myr to 9 Gyr depending on the host star mass, with semimajor axes in the detectable parameter space of direct imaging. We model the changing atmospheric photochemistry and ground UV environments of HZ Earth-like planets using a variety of red giant masses throughout this phase of stellar evolution. Atmospheric mass loss and orbital evolution are factored into our models.

Observations of Galactic Carbon Stars with SOFIA/FORCAST and Gaia

Poster 169

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Boston College; STScI, UNC-Chapel Hill; Ithaca College; Koninklijke Sterrenwacht van België

We present results from observations of the mid-infrared spectra of carbon stars in the Milky Way using the FORCAST instrument on SOFIA. We observed a set of 31 carbon stars over the course of three cycles, covering a wavelength range of 5-13.7 um, which includes prominent dust and gas diagnostics. The SOFIA sample concentrates on overtone pulsators and very dusty carbon stars, neither of which are well represented in existing Galactic samples from older infrared space telescopes such as the Infrared Space Observatory (ISO) or the Infrared Astronomy Satellite (IRAS). We compare their derived properties to the ISO sample and to samples from the Magellanic Clouds that were observed with Spitzer's Infrared Spectrograph (IRS). We are working to improve the atmospheric ozone correction, which affects the quality of the FORCAST-derived properties. Observations from Gaia promise to revolutionize our understanding of the Galactic sample by providing accurate distances. We are investigating the quality of the distances for these stars from Gaia Data Release 2 and present color-magnitude diagrams based on those data.

Financial support for this work was provided by NASA through awards SOF 03-0079, SOF 03-0104, and SOF 04-0129 issued by USRA. This work is based on observations made with the NASA/DLR SOFIA, which is jointly operated by USRA under a NASA contract and the DSI under a DLR contract to the University of Stuttgart. It has also made use of data from the ESA mission Gaia processed by the Gaia DPAC.

Poster 170

A Spectroscopic and Kinematic Survey of the Taurus-Auriga Star-Forming Complex

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To understand the distinct stellar populations that comprise our galaxy, we must first understand the environments and regions in which stars are born. We can begin to address these questions by surveying nearby star forming regions and characterizing their young stellar populations. The Taurus-Auriga star-forming complex is one of the most comprehensively studied regions of star-formation in the Milky Way. The census of Taurus members has been built over the last eighty years, but questions remain as to its completeness. In particular, the discovery of a distributed stellar population at large distance from the central molecular clouds and ongoing star formation has further drawn into question the completeness of the census and Taurus' star formation history. We have obtained spectra of hundreds of Taurus candidate members using the Tull coudé spectrograph on the 2.7m Harlan J. Smith telescope at McDonald Observatory in order to address the above questions of census completion. We have derived youth indicators and radial velocities to refine membership, and, in combination with Gaia DR2 proper motions and parallaxes, perform complete 3D kinematic analysis of our sample. We will present a census of Taurus updated with confirmation of previously known candidate members and identification of new member stars. We plan to implement new methods to analyze the spatial and kinematic distributions of different age subpopulations in Taurus. Only in the era of Gaia can we begin to study the detailed kinematic structure of star-forming regions to such high precision. Future directions for this project include the expansion of our analysis to other stellar associations and star-forming regions, and exoplanetary searches using a variety of ground-based and space observation techniques.

Poster 171

Photosphere Deceleration by Photon Drag

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The radiative torque from the rotating photosphere of even a sun-like star can have a significant effect on its outermost differential rotation. We compute and then observe this property for the Sun using a multi-year timeseries of Helioseismic and Magnetic Imager satellite data.

Spots, flares, accretion, and obscuration in the pre-main sequence binary DQ Tau

Poster 172

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Pre-main sequence stars are intimately linked with their circumstellar material. This relationship manifests in a variety of phenomena that makes young stars highly variable at a wide range of wavelengths. The photometric variability of young stars can be traced back to four main origins: variable accretion, rotational modulation due to hot or cold stellar spots, variable line-of-sight extinction, and stellar flares. Here we present results on a very special young star, DQ Tau, which displays all of these effects. Thanks to the unprecedented precision of Kepler K2 and Spitzer data, we could separate the signature of the individual effects. DQ Tau is a young low-mass spectroscopic binary, consisting of two almost equal-mass stars on a 15.8 d period surrounded by a circumbinary disk. Our light curve analysis revealed that the rotational modulation appears as sinusoidal variation with a period of 3.017 d. In our model this is caused by extended stellar spots 400 K colder than the stellar effective temperature. During our 80-day-long monitoring we detected 40 stellar flares with energies up to 1.2×10^{35} erg and duration of a few hours. The flare profiles closely resemble those in older late-type stars, and their occurrence does not correlate with either the rotational or the orbital period. We observe elevated accretion rate up to 5×10^{-8} $M_{\odot}$/yr around each periastron. Our Spitzer data suggests that the increased accretion luminosity heats up the inner part of the circumbinary disk temporarily by about 100 K. We found an inner disk radius of 0.13 au, significantly smaller than expected from dynamical modeling of circumbinary disks. Interestingly, the inner edge of the disk is in corotation with the binary's orbit. DQ Tau also shows short dips of $<$0.1 mag in its light curve, reminiscent of the well-known ”dipper phenomenon” observed in many low-mass young stars.

New population synthesis approach : the golden path to constrain mixing of giant stars

Poster 173

Nadège Lagarde; Céline Reylé; Annie Robin

Besançon Observatory - Institut UTINAM

The cornerstone mission of the European Space Agency, Gaia, together with complementary spectroscopic (Gaia-ESO and APOGEE) and seismic surveys (CoRoT, Kepler, and K2), will revolutionize our understanding of the formation and history of our Galaxy, providing accurate stellar masses, radii, ages, distances, as well as chemical properties for very large samples of stars across different Galactic stellar populations.

To exploit all potential of the combination between spectroscopic and seismic observations, the population synthesis approach will be a very crucial and efficient tool. We develop the Besançon Galactic model (BGM, Lagarde et al 2017) for which stellar evolution predictions are included, providing the global asteroseismic properties and the surface chemical abundances along the evolution of low- and intermediate-mass stars. For the first time, a

population synthesis code can explore the effects of an extra-mixing (and also different theoretical prescriptions) on the chemical properties of giant stars. Using this new version of the BGM and comparing synthetic populations and spectroscopic observations from Gaia-ESO and APOGEE survey, we discuss also how we could constrain transport processes occurring in red-giant stars across the Galactic thin and thick discs populations.

Poster 174

Magnetic transitions and radius inflation in low-mass stars

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There are increasing evidences that low-mass stars undergo at least one magnetic transition throughout their pre- and main-sequence evolution. The stronger evidence is the identification of two main rotation sequences, slow and fast, in open clusters and young loose associations of ages between 100 and 600 Myr, with a gradual disappearance of the fast-rotator sequence. It has proven difficult to explain such a depletion of the fast-rotator sequence in the observed time-scale without invoking some sort of magnetic transition. Rotation breaking laws with a dependence on the cube of the rotational velocity naturally produce a convergence in rotation at a given mass, but they fail to produce the rotational evolution observed between 100 and 600 Myr, which suggest a rapid and stochastic transition from the fast to the slow-rotator sequence. It has recently been suggested that such a transition may be linked to a transition from a weak to strong core-envelope coupling in the context of a metastable dynamo model. We have recently found evidences of radius inflation in star with intermediate equatorial rotational velocity, i.e. those which are experiencing a transition between the fast- and the slow-rotator sequence. Magnetic fields are deemed responsible for radius inflation through their role in inhibiting convective and radiative energy transport. The increase in stellar radius is accompanied by a decrease of the effective temperature, such that luminosity remains approximately constant, which is not accounted for by standard stellar models. The inhibition of convection also affects those layers where lithium depletion occurs, providing further constraints on stellar interior models. The possibility that radius inflation occurs in stars undergoing some sort of magnetic transition opens new and exiting opportunities in solving long-standing issues regarding stellar structure and evolution. Here we provide hints on what it is involved.

High-resolution observations of H2O masers in proto-planetary nebulae

Poster 175

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University of New Mexico

Proto-planetary nebulae (PPN) are thought to represent a short transition period of late-type stars, during which their spherical symmetry changes into an aspherical one often observed for planetary nebulae (PNs). Due to the short PPN lifetime, few observational details are available during this specific stage. However, as PPNs exhibit bipolar outflows, it is now believed that jets are important in shaping multi-polar planetary nebulae. To study the effects of jets in PPNs, kinematical information concerning the outflows is crucial. In "water fountain" nebulae, high-velocity H2O masers are believed to trace outflows, and provide a method to investigate the outflows. We will present high resolution observations using the Very Long Baseline Array of the water masers present in one of these objects, and discuss the outflow kinematics in the context of planetary nebulae morphology.

A sudden change of the global magnetic field of the active M dwarf AD Leo

Poster 176

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Uppsala University; Royal Military College of Canada

We present an analysis of high-resolution spectropolarimetric observations of the active M dwarf AD Leo in all four Stokes parameters. We derived the least-squares deconvolved Stokes profiles and detected linear polarisation signatures in spectral lines. This is the first report of a detection of Zeeman linear polarisation in the spectral lines of an M dwarf. Simultaneously, we discovered that the circular polarisation profiles corresponding to our data set are significantly weaker and broader than those present in all archival spectra of AD Leo, which exhibited approximately constant profiles over the period 2006-2012.

Magnetic maps obtained using Zeeman Doppler imaging confirm a significant - and apparently rather sudden - change in the surface magnetic field. On the one hand, the topology of the magnetic field is mostly unchanged and remains close to an axisymmetric dipole. On the other hand, the total energy of the large-scale magnetic field has decreased by about 20 percent between 2012 and 2016 and the filling factor of this component has decreased by about a factor of two. These results suggest that the field responsible for the observed circular polarisation signatures corresponds to a stronger field component occupying a smaller fraction of the stellar surface in the more recent map.

These results represent the first evidence that an active M dwarf with dipole-dominated axisymmetric field topology can undergo a long-term global magnetic field evolution.

Poster 177

Observing the Simulations - Applying ZDI to 3D non-potential flux transport simulations

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A question frequently asked is: how reliable are surface magnetic field observations using the Zeeman-Doppler-Imaging (ZDI) technique?

We approach this question by using highly resolved non-potential flux transport simulations as our point of reference. The simulations combine a flux transport model on the photosphere with a non-potential coronal evolution model using the magnetofrictional technique. We analyse the simulations of three different stellar models (a solar-like star and two more active stars) and produce synthetic Stokes IV profiles for ten different surface magnetic field maps and two inclinations (60° and 20°) per star. These synthetic profiles are then used as input for a ZDI code. We compare our sixty reconstructed ZDI maps with the large-scale field of the input models in order to provide estimates for the reliability of the recovered field, with a particular focus on their toroidal and axisymmetric properties.

We will also present a quick method to determine the large-scale field of high-resolution surface magnetic field simulations and to evaluate which ZDI approach is most reliable to recover the simulated map.

Poster 178

Active longitudes and what do we really know about them

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Max Planck Institute for Solar System Research; University of Helsinki

One of the characteristic phenomena of stellar activity is the presence of active longitudes, long lived nonaxisymmetric structures seen for example in the spot distribution or the surface magnetic fields. An emerging observation of these structures is that they make a full appearance only above a certain activity level or rotation rate, indicating an onset of nonaxisymmetric dynamo modes at faster rotation. This behaviour is qualitatively supported by modern dynamo models, but there remain still a number of unanswered questions. These include how does the transition between axisymmetric and nonaxiasymmetric activity function, what can we say about the commonly seen azimuthal drifts, and what does the internal structure of active longitudes look like. We discuss detailed observational results of active longitudes on stars with different activity levels and compare the findings to recent dynamo models.

The revised SUPERBLINK-GAIA catalog of stars with proper motion larger than 40 mas/yr

Poster 179

Sebastien Lepine

Georgia State University

We examine the astrometric measurements and physical properties of ∼2.5 million stars with proper motions larger than 40 mas/yr, which were originally charted in the SUPERBLINK proper motion catalog, and for which data from the GAIA second release (GAIA DR2) is now available. These represent the stars with the fastest proper motions observed by GAIA, the vast majority of which consist of low-mass K and M dwarfs in the vicinity of the Sun (d$<$200pc). We find that the GAIA proper motions are in excellent agreement with the SUPERBLINK values, and show how the new GAIA parallaxes and optical magnitudes significantly enhance the all-sky census of faint stars with large proper motions.

Selecting Carbon Stars by MSX Colors

Poster 180

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The BAaDE (Bulge Asymmetries and Dynamical Evolution) project is an SiO maser survey in the Galactic Disk and Bulge whose name-sake goal is to use the line-of-sight velocities of AGB sources to probe the dynamics of the Galaxy. The data from BAaDE, in combination with MSX (Mid-course Space eXperiment) infrared color data, can, however, shed light on much more than dynamics, and the BAaDE project is rife with opportunities to learn about AGB stars themselves. Detection rates and line-ratios as a function of color can be used to interpret the stellar and circumstellar conditions that lead to detections of certain lines. In particular, BAaDE can distinguish carbon-rich and oxygen-rich sources through the detection of SiO and CS respectively, and we have found that there is a clear separation in MSX D-E (14 microns-21microns) color between high SiO detection rates and high CS detection rates. This can be applied to divide C and O type stars based solely on their MSX color. In addition, this distinction can be used to more securely identify spectral lines within the BAaDE survey (in turn providing more accurate line-of-sight velocities), to select or deselect O-type stars in future surveys, and to constrain the ratio of O-type to C-type stars as a function of Galactic longitude.

Poster 181

An extensive grid of DARWIN models for M-type AGB stars

S. Liljegren
Uppsala University

Asymptotic giant branch (AGB) stars are luminous, cool giants with non-spherical morphology and substantial mass loss. Dust formed in the stellar atmospheres plays a key role for the mass-loss mechanism: radial pulsations of the surface layers of the stars levitate material to distances where dust can form, which then is accelerated outward by radiation pressure. AGB stars are significant dust donors to the interstellar medium through these stellar winds.

To model these dense winds, we have constructed an extensive grid of M-type AGB stars (stars with oxygen dominated chemistry) using DARWIN models (Dynamic Atmosphere and Radiation-driven Wind models based on Implicit Numerics). The mass-loss process is modelled from first principles, with frequency-dependent radiation-hydrodynamics, and dust growth and evaporation. In the grid we cover a wide range of the relevant stellar parameters (0.75-3 $M_\odot$, 1000-70 000 $L_\odot$ and 2200-2300 K). Direct outputs from the models include mass loss rates, wind velocities, dust-to-gas ratios and grain sizes.

We plan to combine this grid with stellar evolution codes, where parameterised relationships (e.g. Reimer's classical mass-loss formula) are widely used to describe the mass-loss rates of AGB stars. This can then be used to estimate the dust contribution for entire populations of AGB stars.

Poster 182

Long-term Radio Monitoring of Two Very Low Mass Dwarf Binaries

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The very lowest-mass (VLM) stars and brown dwarfs, with effective temperatures T < 3000 K, exhibit mixed magnetic activity trends, with H-alpha and X-ray emission that declines rapidly beyond type M7/M8, but persistent radio emission in roughly 10-20

Poster 183

Computing Models of M-type Host Stars and their Panchromatic Spectral Output

Jeffrey L. Linsky; Dennis Tilipman; Kevin France
University of Colorado

We have begun a program of computing state-of-the-art model atmospheres from the photospheres to the coronae of M stars that are the host stars of known exoplanets. For each model we are computing the emergent radiation at all wavelengths that are critical for assessing photochemistry and mass-loss from exoplanet atmospheres. In particular, we are computing the stellar extreme ultraviolet radiation that drives hydrodynamic mass loss from exoplanet atmospheres and is essential for determining whether an exoplanet is habitable. The model atmospheres are computed with the SSRPM radiative transfer/statistical equilibrium code developed by Dr. Juan Fontenla. The code solves for the non-LTE statistical equilibrium populations of 18,538 levels of 52 atomic and ion species and computes the radiation from all species (435,986 spectral lines) and about 20,000,000 spectral lines of 20 diatomic species.

The first model computed in this program was for the modestly active M1.5 V star GJ 832 by Fontenla et al. (ApJ 830, 152 (2016)). We will report on a model for the more active M5 V star GJ 876 and compare this model and its emergent spectrum with GJ 832. In the future, we will compute and intercompare semi-empirical models and spectra for all of the stars observed with the HST MUSCLES Treasury Survey, the Mega-MUSCLES Treasury Survey, and additional stars including Proxima Cen and Trappist-1.

This talk is dedicated to the memory of Dr. Juan Fontenla who passed away in January 2018. This multiyear theory program is supported by a grant from the Space Telescope Science Institute.

The optical-infrared L dwarf spectral sequence of young planetary-mass objects in the Upper Scorpius association

Poster 184

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The distribution of stars and brown dwarfs in young open clusters and star-forming regions is key to understand the processes of star formation and their evolution. From a deep (J=20.5 mag) infrared (ZYJ) photometric survey, we have identified a large population of substellar and planetary-mass members in the Upper Scorpius association (145 pc; 10 Myr), extending our previous studies below the deuterium-burning limit. We have confirmed spectroscopically the coolest (Teff <= 1900K) and least massive (<= 15 Jupiter masses) members at both optical and infrared wavelength with the ESO Very Large Telescope and the Gran Telescopio de Canarias, yielding the first sequence spanning late-M to late-L in a cluster/association. These objects are among the least massive planetary mass objects known to date. We will present their main spectroscopic features and compare their spectral energy distribution to members of young moving groups and older open clusters (Pleiades, Hyades), as well as older field dwarfs. We will discuss the differences and similarities observed in spectral indices defined in the literature and bolometric corrections as a function of age. Our sequence of late-M/L dwarfs represent a reference for studies focussing on young clusters and moving groups as well as for the exoplanet community due to the overlap in temperatures and physical properties.

Poster 185

Where's That Flare: A new solar X-ray flare catalog

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NOAA's Space Weather Prediction Center publishes the current definitive public solar soft X-ray flare catalog, derived using data from the X-ray Sensor (XRS) on the Geostationary Operational Environmental Satellites (GOES) series. However, this flare list has shortcomings for use in scientific analysis. Its detection algorithm has drawbacks (missing smaller flux events and poorly characterizing complex ones), and its event timing is imprecise (peak and end times are frequently marked incorrectly, and hence peak fluxes are underestimated). It also lacks explicit and regular spatial location data. We present a new database, the Where's That Flare (WTF) catalog, which improves upon the precision of NOAA's current version, with more consistent and accurate spatial locations, timings, and peak fluxes. Our catalog also offers several new parameters per flare (e.g. background flux, integrated flux). We use data from the GOES Solar X-ray Imager (SXI) for spatial flare locating. Our detection algorithm is more sensitive to smaller flux events close to the background level and more precisely marks flare start/peak/end times so that integrated flux can be accurately calculated. It also decomposes complex events (with multiple overlapping flares) by constituent peaks. The catalog dates from the operation of the first SXI instrument in 2003 until the present. We give an overview of the detection algorithm's design, review the catalog's features, and discuss preliminary statistical analyses of light curve morphology, complex event decomposition, and integrated flux distribution. The WTF catalog will be useful in studying X-ray flare statistics and correlating X-ray flare properties with other observations.

Poster 186

Chromospheric heating by the Farley-Buneman instability

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Semi-empirical models of the quiet-Sun chromosphere show a temperature minimum of 4000 K, followed a region of intense heating where the temperature increases to 6500 K. The mechanism causing this intense heating remains unknown, and the total energy input required for this temperature increase exceeds the energy needed in the transition region to heat the corona. Previous research shows the Farley-Buneman instability is capable of heating parts of the chromosphere around the temperature minimum. This instability occurs in weakly ionized plasmas where a neutral flow across a magnetic field drives a modified two-stream instability between magnetized electrons and collisionally dominated ions. New simulations show the inclusion of thermal effects, partial ion magnetization, and Coulomb collisions changes the instability threshold at higher altitudes, allowing the instability to heat a larger region of the chromosphere. In this study the combined instability threshold is examined in order to determine the regions of the chromosphere where the instability can be triggered based on radiative MHD simulations by Bifrost.

Far Ultraviolet Flares on Old and Young M Stars and Implications for Planetary Atmospheres

Poster 187

R. O. Parke Loyd[1]; Evgenya L. Shkolnik[1]; Adam C. Schneider[1]; Travis S. Barman[2]; Victoria S. Meadows[3]; Isabella Pagano[4]; Sarah Peacock[2]

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More than half of the energy emitted by M stars in the far ultraviolet could come from flares. This emission is critical to understanding the atmospheres of orbiting planets. FUV emission photolyzes molecules in their atmospheres and related extreme ultraviolet (EUV) emission drives thermal atmospheric escape. The ultraviolet emission of M stars is known to be elevated for several hundred Myr after their formation. Whether the same is true of ultraviolet flare activity is a key concern for the evolution of exoplanet atmospheres. Recently, HST observations by the HAZMAT program (HAbitable Zones and M dwarf Activity across Time) captured seven FUV flares with energy $> 10^{30}$ erg and $\sim$5 less energetic flares on young (45 Myr) M stars in the Tucana-Horologium association over 10 h of observations. These imply that flares on young M stars occur $\sim$100$\times$ as frequently, within a given energy range, as those on "inactive," old (Gyr) M dwarfs. The most energetic flare observed was accompanied by bright blackbody emission at $\sim$16,000 K, which contributed substantial flux across wavelengths where water and ozone have broad peaks in their cross sections for photolysis. In this presentation, we discuss the first results of the HST HAZMAT investigation into young M star flares and implications for developing planets.

Radial Velocities of Subgiant Stars and New Astrophysical Insights into RV Jitter

Poster 188

Jacob K. Luhn; Fabienne A. Bastien; Jason T. Wright

Penn State University

For nearly 20 years, the California Planet Search (CPS) has simultaneously monitored precise radial velocities and chromospheric activity levels of stars from Keck observatory to search for exoplanets. This sample provides a useful set of stars to better determine the dependence of RV jitter on flicker (which traces surface gravity) first shown in Bastien et al. (2014). We expand upon this initial work by examining a much larger sample of stars covering a much wider range of stellar parameters (effective temperature, surface gravity, and activity, among others). For 600 stars, there are enough RV measurements to distinguish this astrophysical jitter from accelerations due to orbital companions. To properly isolate RV jitter from these effects, we must first remove the RV signal due to these companions, including several previously unannounced giant planets around subgiant stars. We highlight some new results from our analysis of the CPS data. A more thorough understanding of the various sources of RV jitter and the underlying stellar phenomena that drive these intrinsic RV variations will enable more precise jitter estimates for RV follow-up targets such as those from K2 or the upcoming TESS mission.

Poster 189

Exploring the Galactic Chemical Evolution of Chlorine with HCl features in Cool Stars

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Chlorine (Cl) is an odd-Z light elements thought to be made through secondary nucleosynthesis processes. Few measurements of Cl have been made in stars due to low abundances and few optical absorption lines. Abundance measurements are needed, however, to shed light on the predicted nucleosynthesis of Cl in the Galaxy. The production of Cl is thought to be complex; both stable isotopes are thought to be produced via oxygen burning in core collapse supernova, ^{35}Cl may be made through neutrino spallation, and ^{37}Cl may be made by the s-process in both massive stars and AGB stars. The isotope ratio of ^{35}Cl/^{37}Cl also depends on where Cl was produced, for example the mass and metallicity of the progenitor star during a core collapse supernova can affect the Cl isotope ratio.

We have measured Cl in stars to determine the Galactic chemical evolution of Cl and to constrain how Cl is produced in the Universe. We have used HCl features at 3.7 microns to measure Cl abundances in M giants and dwarfs. We previously measured ^{35}Cl abundances in 16 stars that spanned -0.7 $<$ [Fe/H] $<$ 0.2. We suggested that Cl chemical evolution models under-produce Cl over this metallicity range. We have also recently measured Cl isotope ratios in six stars and find ratios spanned 1.76 $<$ ^{35}Cl/^{37}Cl $<$ 3.42. Our average Cl isotope ratio of 2.66 $\pm$ 0.58 is larger than the predicted Cl isotope ratio of 1.8 in the solar neighborhood. Finally, we present new Cl abundances measured in $\sim$ 60 stars in the solar neighborhood.

Poster 190

Starspots on late-type stars and their correlation with flare activity

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Recent space-based observations (e.g., Kepler mission) found thousands of “superflares” on G-, K-, and M-type stars. These superflare stars show quasi-periodic brightness variations caused by the rotation of the star with starspots. We analyzed the statistical properties of starspots on G-, K-, and M-type stars and their correlation with the flare activity. The analysis shows that the fraction of stars showing large-amplitude rotational variations, which are thought to be the signature of the large starspots, decreases as the rotation period increases. We found that there is a good correlation between the bolometric energy of the largest superflares and area of starspots estimated from the amplitude of rotational light variations. The bolometric energy released by the largest flare on the star is consistent with the magnetic energy stored near the starspots. We also found that the frequency of superflares correlates with the starspot area. The average frequency of flares with a given bolometric energy is roughly proportional to the area of starspots. Our results suggest that flare activity level (e.g., energy of the largest flares, occurrence frequency) of the late-type stars can be determined by the area of starspots.

Spectral synthesis of CARMENES M-type stars: stellar atmospheric parameters

Poster 191

E. Marfil[1]; D. Montes[1]; H. M. Tabernero[2, 1]; J. A. Caballero[3]; J. I. González Hernández[4, 5]; F. J. Lázaro Barrasa[1]; and the CARMENES consortium

Departamento de Física de la Tierra y Astrofísica, Universidad Complutense de Madrid; Departamento de Física, Ingeniería de Sistemas y Teoría de la Señal, Universidad de Alicante; Departamento de Astrofísica, Centro de Astrobiología CSIC-INTA; Departamento de Astrofísica, Universidad de La Laguna; Instituto de Astrofísica de Canarias

We show our very first results regarding the stellar atmospheric parameter determinations (T, log g, [Fe/H], and macro-turbulence velocity) of M-type stars observed with CARMENES by means of the spectral synthesis method. Our approach is based on the synthesis of carefully-selected sets of spectral ranges around iron lines found in the spectra of these stars. We took GX And (M1.0 V), Luyten's star (M3.5 V), and Teegarden's star (M7.0 V) as references to split up the parameter space in terms of effective temperature. This, in turn, will help us simplify the analysis of the whole CARMENES sample. Our spectral synthesis code relies on a grid of PHOENIX-ACES stellar atmospheres and the radiative transfer code Turbospectrum to obtain the synthetic spectra over the spectral ranges. The atomic line data of the lines found in the ranges were downloaded from the VALD3 database. Our code is then able to derive stellar atmospheric parameters from a Markov Chain Monte Carlo process based on the comparison between the real and the synthetic spectral ranges.

CatWISE: a full sky WISE-selected catalog from WISE & NEOWISE data

Poster 192

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There are times in astronomy when a giant leap forward can be made simply by additional processing of existing data. Such a leap will be taken by CatWISE, which is adapting AllWISE software to generate a full sky catalog for the community, from data combined across all phases of NASA's Wide-field Infrared Survey Explorer mission (WISE; Wright et al. 2010). The CatWISE catalog will include motion estimates based on the ensemble of WISE and NEOWISE data, covering a total baseline of 6 years.

The increased depth and improved motion sensitivity will allow access to crucial astrophysical populations, from cold, planetary mass objects in the immediate solar neighborhood, to massive galaxy clusters during the epoch of cluster formation and the brightest quasars from Cosmic Dawn. In particular, CatWISE will wonderfully complement Gaia, by measuring the motion of thousands of cold, fast moving objects that the ESA satellite does not see.

The CatWISE catalog will be a unique hunting ground for the coldest constituents of the solar neighborhood (analog to WISE J0855-0714; Luhman 2014), planetary mass members of young moving groups, and substellar companions to nearby stars.

I will present the current status of catalogue generation and initial performance testing (showing 10x greater motion sensitivity compared to AllWISE) as well as the expected final performance and proposed content of the catalogue.

Poster 193

Searching for Wide-Orbit, Planetary-Mass Companions through PSF-Fitting of Spitzer/IRAC Archival Data

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The University of Texas at Austin

The last decade has seen the discovery of a growing population of planetary-mass companions (< 20 M$_{Jup}$; hereafter PMCs) to young stars which are often still in the star-forming regions where they formed. These objects have been found at wide separations (>100 AU) from their host stars, challenging existing models of both star and planet formation. Do these systems represent the low-mass end of the stellar binary model? Are they an extremely high-mass scenario of current planet formation theories? Determining the answers to these questions will come once a statistically robust sample of directly-imaged PMCs are observed and characterized.

The extensive Spitzer/IRAC data set of every major star-forming region and association within 300 pc has great potential to be mined for wide companions to stars. In this poster I will discuss the current development of an automated pipeline to find wide-orbit PMCs of stars via point spread function (PSF) subtraction in Spitzer/IRAC images. A Markov Chain Monte Carlo (MCMC) algorithm is the backbone of this PSF subtraction routine that efficiently creates and subtracts χ^2-minimizing instrumental PSFs, measuring infrared photometry of these systems across the four IRAC channels (3.6μm, 4.5μm, 5.8μm, and 8μm). I will present a re-analysis of archival Spitzer/IRAC images of 11 young, low-mass (0.044-0.88 $\mathrm{M}_\odot$; K3.5-M7.5) stars in 3 nearby star-forming regions (Chameleon, Taurus, and Upper Scorpius; ~ 150pc) known to host faint companions over a range of projected separations (1.7”-7.3”). Finally, I will discuss the prospect for an automated companion search of all known young stars with existing Spitzer/IRAC data and describe potential avenues for follow-up observations of candidate binary and PMC systems.

Magnetic cycles & rotation in late type stars, and their influence in radial velocities

Poster 194

A. Suárez Mascareño[1]; C. Lovis[1]; X. Dumusque[1]; S. Udry[1]; R. Rebolo[2]; J. I. González Hernández[2]

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High precision radial velocity measurements give astronomers the possibility of detecting small exoplanets, down to the mass of the Earth. At this stage, signals induced by stellar activity are one of the main causes for false positives. Intrinsic variations of the magnetic regions on the stellar surface induce RV variations both at the timescales of the stellar rotation and the magnetic cycle of the stars. The detection and analysis of those signals is not only important in order to dissentangle keplerian induced signals from stellar activity signals, but also to better understand the behaviour and the structures of late type stars.

We present the results of a study conducted over more than 600 stars in the solar vicinity, with spectral types ranging from F0 to M6, combining measurements from different ground sources (from HARPS and HARPS-N, to the Mount Wilson HK project), aimed at the detection, characterization of such signals and their statistical properties. These results should allow for a better understanding of the behaviour of late type stars and their dynamo mechanisms.

Exploring the Effect of Near-Surface Shear on Global Stellar Dynamos

Poster 195

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The advent of helioseismology has determined in detail the average rotation rate of the Sun as a function of radius and latitude. These data immediately reveal two striking boundary layers of shear in the solar Convection Zone (CZ): a ”tachocline” at the base, where the differential rotation of the CZ transitions to solid-body rotation in the Radiative Zone, and a 35-Mm-thick Near-Surface Shear Layer (NSSL) at the top, where the rotation rate slows by about 5

Poster 196

Resolving the Radio Surfaces of AGB Stars

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Stars on the asymptotic giant branch (AGB) have detectable “radio photospheres” that lie at roughly twice the classic photospheric radius measured at optical wavelengths. Radio continuum studies of AGB stars therefore provide a means to probe the atmosphere just inside the critical region where dust formation occurs and the stellar wind is launched. For the nearest AGB stars (d <200 pc), it is possible to resolve the radio photosphere at millimeter wavelengths using the long-baseline configurations of the VLA and ALMA, thereby enabling the deviation of fundamental stellar parameters and the direct imaging of surface features. We will showcase recent findings from high-resolution imaging observations of the radio surfaces of several AGB stars, including results from a new sparse model image reconstruction algorithm. We find evidence that the shapes and other parameters of the radio photosphere vary over time. In addition, the data reveal signatures of brightness asymmetries and non-uniformities. Together these trends are consistent with manifestations of large-scale irregular convective flows on the stellar surfaces, although effects from non-radial pulsations cannot be excluded.

Poster 197

Detached eclipsing binary stars as benchmark targets for PLATO

P. F. L. Maxted

Keele University, UK

PLATO is an ESA M-class mission due for launch in 2026 that will discover transiting terrestrial exoplanets in the habitable zone of solar-type stars and characterise their host stars using asteroseismology. In this poster I will present results for long-period detached eclipsing binaries from the Kepler K2 mission that show the potential of these systems for improving stellar models so that the specified accuracy in asteroseismic ages from PLATO (10

Further constraints on the age and helium abundance of NGC 6791 from modeling of the asteroseismic oscillations.

Poster 198

Jean McKeever; Sarbani Basu

Yale University

NGC 6791 is an old ($\sim$8 Gyr), metal rich ([Fe/H]$\sim$0.3) open cluster in which previous studies have indicated also has a high helium abundance. The cluster happened to lie within the *Kepler* field of view and had unprecedented light curves for many of the red giant branch (RGB) stars in the cluster. Asteroseismic studies have constrained the age through grid based modeling of the global asteroseismic parameters ($\Delta\nu$ and $\nu_{\rm max}$). However, with *Kepler* data it is possible to do detailed asteroseismology of individual mode frequencies to better constrain the stellar parameters, something that has not been done for these cluster stars as yet. In this work, we use the radial ($l = 0$) and quadrupole ($l = 2$) modes in $\sim$40 hydrogen shell burning RGBs to better constrain the age and initial helium abundance (Y_0). We have created a grid of stellar evolution models using MESA that span the expected ranges of mass, initial [Fe/H], Y_0, and mixing length in the cluster RGBs. We compute model oscillation frequencies at each timestep along the RGB in the expected $\log g$ range of our stars with the pulsation code GYRE. The distribution of parameters for all the giants are then combined to create a final probability distribution for age and helium of the entire cluster.

Optimal Observing Strategy for Finding Low-mass, Close-in Planets around Subgiant Stars

Poster 199

A. A. Medina; J. A. Johnson; J. D. Eastman; P. A. Cargile

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Evolved intermediate mass stars ($M < 1.3M_\odot$) have high occurrence rates of Jupiter-mass planets with predominately large semi-major axes ($a > 1.0$ AU). There is a prominent paucity of close-in ($a < 0.6$ AU), intermediate period ($5 < P < 100$ days), low-mass ($M_{\rm planet} < 0.7M_{\rm Jup}$) planets, known as the 'Planet Desert'. Current radial velocity methods have yet to detect these close-in, low-mass planets around evolved intermediate mass stars because the planetary signals could be hidden by the (5-10) m s^{-1} radial velocity variations caused by pressure mode oscillations. We find that by implementing an observing strategy of taking 3 observations per night separated by an optimal cadence, which is a function of the pressure mode periods and amplitudes, we can average over the stellar jitter and improve our sensitivity to low-mass planets. We find that our method decreases the root-mean-square of the stellar jitter due to pressure modes by a factor of 3 over current single epoch observing strategies used for evolved intermediate mass stars. Our observing strategy provides a means to test whether the Planet Desert extends to lower masses.

Poster 200

The subterahertz Sun: equatorial and polar radii from SST and ALMA

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The nominal solar radius is $R^N_\odot = 6.957(1) \times 10^8$ m. It is equivalent to a angular radius of 959.63" from 1 AU and corresponds to the solar photospheric radius. However, this value changes with observations at other wavelengths because the altitude of the dominant electromagnetic radiation is produced at different heights in the solar atmosphere. Therefore the solar radius is a very important parameter for the calibration of solar atmospheric models enabling a better understanding of the atmospheric structure. In Menezes and Valio (2017), the average solar radii measured with extensive data from the *Solar Submillimeter-wavw Telescope* (SST) were $966.5" \pm 2.8"$ for 0.2 THz and $966.5" \pm 2.7"$ for 0.4 THz and also the radius temporal variation was observed to be anti-correlated with the solar activity at both frequencies. Here we report the measurements of the solar radius at equatorial and polar latitudes for the same frequencies. The slight differences obtained int these radii may be related to solar limb brightening variations over the solar cycle. As a validation, we compared the SST measurements with the solar radius at 0.239 THz observed by ALMA.

Poster 201

A new spin on age-rotation-activity relations and the evolution of magnetic cycles

Travis Metcalfe

Space Science Institute

The Kepler mission dramatically changed our understanding of how rotation and magnetism evolve in sun-like stars. Rotation in the open clusters with ages up to 2.5 Gyr agreed with previous expectations, but field stars with asteroseismic ages revealed a very different behavior. Beyond middle age, the angular momentum of stars no longer appeared to decrease over time, possibly due to a shutdown of magnetic braking. Ground-based spectroscopy of the older stars revealed that chromospheric activity continues to decrease with age, even while the rotation period remains constant. For stars with known activity cycles, this transition appears to be accompanied by a gradual lengthening of the stellar cycle before it eventually becomes undetectable or disappears entirely. The TESS mission will soon provide new tests of this scenario, by yielding asteroseismic masses and ages for stars observed for decades by the Mount Wilson survey. I will review the evidence for this new theory of magnetic evolution, and discuss future observational tests with the potential to radically transform age-rotation-activity relations.

Simulation of photometric time series: from the Sun to the stars

Poster 202

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Simulations of photometric time series allows to properly interpret observation of stellar activity and estimate how other stars are similar or differ from the Sun, to tests possible analysis methods and to estimate the impact of activity on exoplanet detectability. In this talk I will present a model which has been tested on the Sun, extended to old main sequence solar-type stars using a grid of coherent physical parameters to describe the star properties, in particular its dynamics and activity. The model provides photometric, radial velocity, astrometric and chromospheric emission time series for various star inclinations and a large range of activity configurations. I will present the first results and comparisons between photometric time series and Kepler observations, and will address the following questions: What can we learn from such comparisons? How does the Sun help us to interpret the results? What are the limitations of such an approach?

G Dwarf Exoplanet Surface Density Distribution: A log-normal fit from 0.06 to 100 AU

Poster 203

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We fit a log-normal function to the G dwarf orbital surface density distribution of gas giant planets, over the mass range 1-10 times that of Jupiter, from 0.06-100 AU. We use a Markov Chain Monte Carlo approach to explore the likelihoods of various parameter values consistent with point estimates of the data given our assumed functional form. This fit is consistent with radial velocity, transit, and direct imaging observations, is well-motivated from a phenomenological viewpoint, and makes predictions of future surveys. We present probability distributions for each parameter as well as a Maximum Likelihood Estimate solution. We suggest this function makes more physical sense than other widely used functions, and explore the implications of our results on the design of future exoplanet surveys.

Poster 204

The Sun as a Model for Stellar Activity

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Department of Physics, Harvard University

To detect Earth-like exoplanets in the habitable zones of Sun-like stars, Precise Radial Velocity spectrographs require sensitivities below 10 cm/s. To realize these design goals, non-planetary variability in the measured radial velocity (RV) must be understood and its effects accounted for. On timescales of the stellar rotation period, these non-planetary RV variations are dominated by the effects of magnetic features, such as spots and faculae, which have velocity signatures exceeding 1 m/s.

In this work, we use the Sun as a model system for the effects of magnetic processes on RV measurements. We use a purpose-built solar telescope to measure the Sun as a point source, and extract solar RVs using the High Accuracy Radial velocity Planet Searcher for the Northern hemisphere (HARPS-N) spectrograph on La Palma. In parallel, we use magnetograms from the Helioseismic and Magnetic Imager onboard the Solar Dynamics Observatory and simultaneous photometry from Solar Radiation and Climate Experiment to extract information about how magnetic features interact with solar convection and change the solar rotation profile, and how these effects change the solar RVs. By combining these data sources, we estimate the relative contributions of solar magnetic variations to the solar RVs, and investigate how these contributions vary with time.

Poster 205

Methane in Analogues of Young Directly Imaged Exoplanets

Brittany E. Miles

UC Santa Cruz

Free floating and wide separation planetary mass objects can share the same color space as self luminous, directly-imaged gas giant exoplanets. However, they are significantly easier to study and are excellent testing grounds for understanding the atmospheres of extrasolar gas giants. PSO 318.5 and VHS 1256 b are both young, low gravity planetary mass objects that are similar to the HR 8799 planets because they have non-existent near infrared methane signatures despite their cool effective temperatures. We detect low abundances of methane in 3 - 4 micron medium resolution spectra of both objects, indicating strong vertical mixing keeping the atmosphere out of chemical equilibrium. We will also discuss the inferred cloud properties of our objects and other implications for future JWST and ground based observations.

Time-resolved linear polarization observations of the planetary transits around Trappist-1

Poster 206

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The M8 star Trappist-1 is currently the only ultra-cool dwarf (spectral type > M7) known to harbor planets, and so, it is the only object in which new techniques to search for planets around very low-mass stars and brown dwarfs can be investigated. In this talk we will present our J-band polarimetric monitoring of Trappist-1 during the transits of planets b, d, and e. Our data show that the linear polarization signal of Trappist-1 is modulated when one of the planets blocks the stellar disk. The confirmation of this effect will prove the potential of polarization to search for and validate transiting planets around late-M and L dwarfs.

Estimating deep photospheric velocities and magnetic fields with 4-m class solar telescopes

Poster 207

I. Milic; A. Lagg; H.N. Smitha

Max Planck Institute for Solar System Research

4-m class telescopes (DKIST, EST), will provide us with unprecedented spatial resolution which is extremely important as it allows us to observe the fine structure of magnetic and velocity fields in the solar atmosphere. However, in order to extract maximum information we must tune and test the inference methods, in this case, spectropolarimetric inversions. In this work we synthesize Stokes spectra of five infrared iron spectra lines from a state-of-the-art MHD simulation. Spectral and spatial smearing, and photon noise are then applied to the spectra, in order to mimic what a 4-m class telescope would observe. We then apply SNAPI spectropolarimetric inversion code to the synthetic observations and discuss the diagnostic potential of these spectral lines.

Poster 208

MUSCAT2 at the Teide Observatory

Pilar Montanes-Rodriguez[1]; Enric Palle[1]; Hannu Parviainen[1]; Norio Narita[2]; Akihiko Fukui[2]; Muscat2 Team

[1] Instituto de Astrofisica de Canarias, [2] Astrobiology Center and the University of Tokyo

MuSCAT2 is the new instrument offered at the Carlos Sanchez Telescope, the 1.52 m telescope located at the Teide Observatory. It has been developed by the Astrobiology Center and the University of Tokyo, in collaboration with the Instituto de Astrofísica de Canarias. MuSCAT2 allows for simultaneous photometry in four filters. The default filter set includes g, r, I, and z. MuSCAT2 is designed to be especially efficient for science related with transiting extrasolar planets and objects varying on short timescales. In particular, the search and confirmation of exoplanets around cool stellar types. However, the field-of-view of 7.4’x7.4’ of each of the four cameras and the simultaneous photometry make it an interesting instrument for many different science cases.

Poster 209

UA, Universidad de Alicante, Spain;

D. Montes[1]; R. González-Peinado[1]; H.M. Tabernero[2, 1]; J.A. Caballero[3]; E. Marfil[1]; F.J. Alonso-Floriano[4, 1]; M. Cortés-Contreras[3]; J.I. González Hernández[5, 6]; A. Klutsch[7,1]; C. Moreno-Jódar[8, 1]: et al.

UCM, Universidad Complutense de Madrid, Spain;

CAB, Centro de Astrobiología (INTA–CSIC), Spain; Leiden Observatory, Netherlands; IAC, Instituto de Astrofísica de Canarias, Spain; Universidad de La Laguna, Spain; INAF - Osservatorio Astrofisico di Catania, Italy; Escuela Técnica Superior de Ingeniería Aeronáutica y del Espacio, Spain Calibrating the metallicity of M dwarfs in wide physical binaries with F-, G-, and K- primaries: spectral indices and photometry of the M dwarfs secondaries In our previous work we have established a sample of 192 physically bound systems made of late-F, G-, or early-K primaries and late-K or M dwarf companion. For 173 primaries of these systems we have derived precise stellar atmospheric parameters: Teff, log g, Vmicro, and chemical abundances for 13 atomic species, including [Fe/H]. Using this information of the primaries and the spectral indices derived from CAFOS/2.2m (CAHA) low-resolution spectra and photometry in different bands of the M-dwarf companions we have derived several calibrations.

Long-term Photometric Variability in Kepler Full-frame Images: Magnetic Cycles of Sun-like Stars

Poster 210

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Stellar chromospheric activity is a significant hinderance to the characterization of planetary systems. Our knowledge of possible manifestations of magnetic activity is limited by observations: there are only a handful of stars with both known rotation periods (and thus ages) and observed photometric variations over a magnetic cycle. While this data collection historically requires expensive dedicated surveys, large space-based surveys for transiting planets are opening a window to observations of long-timescale stellar brightness variations. Here, I will present recent work to use the Kepler Full Frame Images to recover long-term stellar brightness variations in Sun-like stars in the Kepler field, identifying hundreds of Solar-type stars with non-constant brightness over the Kepler mission. We find that stars with rotation periods shorter than ≈ 23 days tend to have brightness variations dominated by starspots, while more slowly rotating stars have brightness variations dominated by faculae. I will also show recent efforts to identify trends between stellar parameters and observed stellar variability.

Stellar and Exoplanetary Atmospheres Bayesian Analysis Simultaneous Spectroscopy of Cool Stars

Poster 211

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The transit of an exoplanet in front of its host star offers unique access to the atmospheres of both objects. Multi-wavelength measurements of the ‘geometric’ transit depth are linked to chemical composition, clouds and hazes in the exoplanet atmospheres. The stellar limb-darkening effect, coupled with the orbital parameters, plays a major role in shaping the observed light-curves. The limb-darkening profile provides tighter constraints on stellar-atmosphere models than spatially-integrated quantities, such as the emergent stellar spectrum.

To date, empirical estimates of stellar limb-darkening profiles were mostly limited by the attainable photometric precision, because of low S/N and instrumental systematics. The few available estimates are likely to be biased by the use of ‘simple’ parameterisations, e.g. linear or two-coefficient limb-darkening laws.

Here we present novel results obtained with SEA BASS: Stellar and Exoplanetary Atmospheres Bayesian Analysis Simultaneous Spectroscopy. SEA BASS enables simultaneous derivation of four-coefficient stellar limb-darkening, transit depths and orbital parameters from multi-wavelength observations. In many cases, four limb-darkening coefficients are necessary to approximate the stellar intensity profile, but strong parameter degeneracies tend to hamper convergence of the light-curve fits with them as free parameters. Accurate modelling of stellar limb-darkening is paramount to achieve 10^{-5}-10^{-4} precision in transit depth, required for spectroscopic studies of the exoplanet atmosphere. In previous studies, the most common choices were (1) to fix the limb-darkening coefficients in light-curve fits to values obtained from stellar-atmosphere models, or (2) to adopt simpler parameterisations with up to two limb-darkening coefficients.

Here we present SEA BASS results on cool stars hosting a transiting exoplanet, for which the uncertainties on stellar-atmosphere models would not allow robust parameter estimates.

Poster 212

The First Mid-Infrared Spectra of the Coldest Brown Dwarf

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Planetary-mass, free-floating brown dwarfs are touchstone objects for understanding planetary atmospheres; they have the bulk compositions of stars but complex physics and chemistry that closely resembles that of giant planets. The coldest brown dwarf, WISE 0855, is unique amongst these objects, since its the closest known planetary-mass, free-floating object and has a temperature nearly as cold as the solar system gas giants (250 K). Like Jupiter, it is predicted to have an atmosphere rich in methane, water, and ammonia, with clouds of volatile ices. WISE 0855 is faint at near-infrared wavelengths and emits almost all its energy in the mid-infrared. Skemer et al. (2016) presented the first spectrum of WISE 0855, from 4.5-5.1 μm (M band), which revealed water vapor features. We present a new spectrum of WISE 0855 in L band, from 3.4-4.14 μm. Methane absorption is clearly present in the spectrum but the mid-infrared color can be better matched with a methane abundance that is somewhat depleted relative to solar abundance. There is evidence for water ice clouds in the M band spectrum. We find a lack of phosphine spectral features in both the L and M band spectra–distinct from Jupiter's atmosphere, which has strong phosphine features at these wavelengths, indicating that the mixing in WISE 0855 must be different. Lastly, we suggest that a deep continuum opacity source may be obscuring the near-infrared flux, possibly a phosphorous-bearing cloud predicted by equilibrium chemistry models. Observations of WISE 0855 provide critical constraints for cold planetary atmospheres, bridging the temperature range between the long-studied solar system planets and accessible exoplanets. JWST will soon revolutionize our understanding of cold brown dwarfs with high-precision spectroscopy across the infrared, allowing us to study their compositions and cloud properties, and to infer their atmospheric dynamics and formation processes.

Are M Dwarfs Under Luminous or Over Radius?

Poster 213

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There are troubling disagreements between model and observed parameters for M dwarf stars. These disagreements are evident in two of the most well understood open clusters in the sky; the Pleiades and Praesepe. Below about 4200K, the lower stellar sequence of both clusters diverges from theoretical isochrones (e.g. Bell et al. 2012). Using robust fitting methods, we have utilised optical to mid-infrared photometry to accurately measure the luminosity and effective temperature of a sample of M stars from these clusters, and hence determine their radii. We find that the radii are systematically inflated by at least 5 percent for a given age and luminosity when compared to the corresponding stellar model. We performed an independent check of the temperature using robust optical spectrophotometry of a sample from both clusters that spans the temperature range of the radius discrepancy. The cooler effective temperatures that result from fitting the optical/IR photometry alone match molecular and atomic features in optical spectra much more closely than the temperature provided by the isochrone. Despite this marked improvement, many molecular species still show considerable discrepancies.

Although there have been claims in the literature that M dwarfs are over radius, we show that our results, and those in the literature, could also be consistent with stars that are under luminous. This finding has important implications for stellar evolution and the radii of exoplanets.

Examining Stellar CME candidates: Does the solar flare-CME relation extend to other stars?

Poster 214

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A well established relation between solar CMEs and flares has been revealed due to decades of direct observations. Strong flares are associated with faster and more massive CMEs and their correlation increases with increasing respective energies. The continuously growing number of confirmed extrasolar systems, particularly around M-dwarfs, requires the evaluation of the impact that stellar CMEs might have on habitability. However, direct imaging of stellar CMEs is currently impossible, so indirect observational methods need be employed. The three main observational techniques for capturing stellar CME signatures are measuring a) Type II radio bursts, b) Doppler shifts in UV/optical lines, and c) continuous absorption in the X-ray spectrum. We examine the most probable CME candidates up to date together with their kinematics and energetics. Finally, we discuss the extension of the solar CME-flare relation towards the high-energy limit for active stars and assess the uncertainty levels of the different observational methods utilized.

Poster 215

Stellar dating using chemical abundances

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Some stellar chemical abundance ratios, such as [Y/Mg], have recently been singled out as potentially very good stellar clocks for solar twins. However, when these relations are tested on stars with other effective temperatures and/or metallicities, these relations almost disappear. Here, we present a new chemical clock which works better over a range of temperatures and compositions. It was discovered through the analysis of a homogenous sample of spectroscopic data on 923 stars, comprising abundances on 14 chemical species. The Random Forest model we have trained estimates stellar ages using the chemical abundances of the sample as input to an uncertainty of around 1Gyr. Only the ratios [Y/Mg], [Y/TiII], [Sr/TiII], [Y/Zn], [Sr/Mg], and [Y/Al] sum up to around the 70

Poster 216

A Catalog of Cool Dwarf Targets for the Transiting Exoplanet Survey Satellite

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We present a catalog of cool dwarf targets (V - J > 2.7, Teff < 4000 K) and their stellar properties for the upcoming Transiting Exoplanet Survey Satellite (TESS), for the purpose of determining which cool dwarfs should be observed using two minute observations. TESS has the opportunity to search tens of thousands of nearby, cool, late K- and M-type dwarfs for transiting exoplanets, an order of magnitude more than current or previous transiting exoplanet surveys, such as Kepler, K2, and ground-based programs. This necessitates a new approach to choosing cool dwarf targets. Cool dwarfs are chosen by collating parallax and proper motion catalogs from the literature and subjecting them to a variety of selection criteria. We calculate stellar parameters and TESS magnitudes using the best possible relations from the literature while maintaining uniformity of methods for the sake of reproducibility. We estimate the expected planet yield from TESS observations using statistical results from the Kepler mission, and use these results to choose the best targets for two minute observations, optimizing for small planets for which masses can conceivably be measured using follow-up Doppler spectroscopy by current and future Doppler spectrometers. The catalog is available in machine readable format and is incorporated into the TESS Input Catalog and TESS Candidate Target List. We also present preliminary results from cross-matching the catalog with Gaia Data Release 2.

A rare, young M+M eclipsing binary in the 32 Orionis moving group

Poster 217

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Although M dwarfs comprise the overwhelming majority of stars in the Galaxy, a detailed understanding of these objects remains elusive. For example, current modelling struggles to accurately predict mass and radius in M dwarfs and this is especially true of pre-main sequence systems, where evolutionary models are poorly constrained observationally. Double-lined eclipsing binaries are key yardsticks for fundamental stellar parameters. However, due to the intrinsic faintness of such systems, there are currently only two dozen or so M+M eclipsing binaries that can be used to robustly test models and an even smaller number of pre-main sequence systems. We have recently identified and fully characterised a young (25 Myr), nearby (103 pc) $0.5 + 0.2\ M_{\odot}$ eclipsing binary which is a member of the under-studied equatorial moving group 32 Orionis. At an age of 25 Myr and with component masses which straddle the fully-convective boundary for M dwarfs, the system is uniquely placed to test models of low-mass star formation, structure and evolution at intermediate epochs between the youngest star-forming regions such as Orion and the dispersed Gyr-old field population.

Interaction of stellar winds of cool star binaries embedded in a partially ionized ISM

Poster 218

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The stellar winds of α Centauri A (HD 128620: G2 V) and B (HD 128621: K1 V) collide and form a hot ionized collision disk between them, perpendicular to the axis of separation of the two stars. The two winds as well as the collision disk material combine to a stellar wind region that is terminated by the presence of a partially ionized, modestly dense ISM cloud, the G cloud. Proxima Cen is outside this so-called astrosphere. We present detailed numerical simulation of this system, and other cool star binaries, that among other ingredients account for the non-equilibrium behavior of interstellar neutral hydrogen that traverses the astrosphere. The results of this modeling are presented, characterizing the environment of binaries and the potential observational consequences, as well as environments of extrasolar planets harbored by binaries.

Poster 219

Lifetime, Emerging and Decay Rates of Starspots on Solar-type Stars Estimated by Kepler Data and Comparisons with Sunspots

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Recently, many superflares on solar-type stars were discovered by the Kepler Space Telescope (Maehara et al. 2012). Such active stars showing superflares are thought to have large starspots (Notsu et al. 2013). The emerging and decay process of such large starspots are not well understood, but important for the understanding of superflare events as well as underlying stellar dynamo. In this study, we have developed a simple method to measure temporal evolutions of starspot area with Kepler data by tracing local minima of the light curves (Maehara et al. 2017). In the analysis, a time-phase diagram (i.e., O-C diagram) of the local minima enables us to identify a temporal evolution of a single starspot group. We applied this method to a huge amount of active solar-type stars observed by Kepler, and calculated the lifetimes, emerging rates and decay rates of starspots from the obtained temporal evolution of starspot area. As a result, we found that lifetimes (T) of starspots are typically 50-300 days when spot area (A) is 0.1–2.0 percent of solar hemisphere. We also compared them with sunspots, and found that the lifetimes of starspots are much shorter than those extrapolated from the empirical relation of sunspots ($T_{\mathrm{sunspot}} \propto A_{\mathrm{sunspot}}$), while being consistent with other researches on starspots (e.g., Giles et al. 2017). The emerging and decay rates of starspots are surprisingly consistent with, or a little smaller than, those of sunspots, which may indicate the same underlying processes.

Poster 220

An abundance of slowly spinning M dwarfs: insights from ground-based measurements of their rotation periods

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Development of an age-rotation ("gyrochronology") relationship for M dwarfs has been inhibited by two factors. First, there has been a paucity of rotation period measurements for the lowest-mass stars. Second, much of the rotational evolution of very low-mass stars occurs at field ages, when precise ages for M dwarfs are challenging to determine. We use ground-based photometric data to measure new rotation periods for field-aged M dwarfs. Our high-cadence, long-baseline photometry derives from the MEarth Transiting Planet Survey. We present 241 rotation periods for M dwarfs in the Southern hemisphere, which join the 347 periods that we previously measured in the Northern hemisphere. The overall period distribution shows an increase in the longest periods at lower stellar masses and a persistent gap in the distribution at intermediate rotation periods. We will discuss the ages at which gyrochronology may be applicable to M dwarfs, and prospects for obtaining new measurements of rotation and age in M dwarfs.

Big planets, little stars: Directly imaged companions to young M-stars

Poster 221

Henry Ngo[1,2]; Dimitri Mawet[2,3]; Garreth Ruane[2]; Wenhao Xuan[2,4]; Brendan Bowler[5]; Therese Cook[6]; Zoe Zawol[7]

NRC Herzberg; Caltech; JPL; Pomona College; UT Austin; UCLA; Pasadena High School

We present new results from two recent searches for directly imaged planets and brown dwarfs around young M-stars. In our first study, we target 180 young (10-150 Myr) M-stars in the L-band (3.8 microns). The new vector vortex coronagraph on Keck/NIRC2 allows us to find companions as close as 80 milliarcsecond, which enables our survey to be sensitive to young planets with masses between 1-10 Jupiter masses and with projected separations between 1-10 au. The initial survey is complete and follow-up observations of 40 candidate companions are planned for 2018. While transit and radial velocity detection techniques have probed giant planet populations at close separations (within a few au), this survey will determine the occurrence rate of giant planets around small stars at larger separations. We will also be sensitive to brown dwarf companions, allowing us to identify new multiple systems of low mass stars. In our second study, we present deep M-band (4.7 microns) imaging of an intermediate-age M-star, also with the vortex coronagraph. These observations are sensitive to objects with masses as low as 1 Jupiter mass in the 1-2 au range. Our results demonstrates a new way to explore the planet occurrence rate and multiplicity of nearby low-mass objects at both young and intermediate-ages.

The Magnetic Fields of M-type T Tauri Stars

Poster 222

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The complex multipolar field of V2247 Oph, the coolest, lowest mass T Tauri star to be magnetically mapped presents a puzzle - it is fully convective yet displays a magnetic field that contrasts with the observed dipole fields of more massive and yet fully convective pre-main sequence stars. This discrepancy could indicate the type of bistable dynamo observed in the large scale fields of main sequence M dwarfs, where we see both complex, non-axisymmetric, multipolar fields and simple, axisymmetric dipolar fields within the same stellar demographic. To investigate further the magnetic fields of the coolest pre-main sequence stars, we present maps of the large scale surface field of an additional two M-type T Tauri stars to compare field topologies and interpret the results in terms of stellar dynamo theory.

Poster 223

Towards stellar butterfly diagrams

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An important indicator of the solar magnetic activity cycle is the change in emergence latitudes of sunspots, leading to the well-known butterfly diagram. The corresponding phenomenon in other stars is poorly understood since starspot latitudes are generally unknown. Rotation rates from star spots are, however, comparatively easy to measure. Here we study an ensemble of 3091 Kepler stars for variations in rotation rate over the course of their magnetic activity cycles, which has been measured previously using photometric variability. We find that the rotation rate is generally anti-correlated with the activity cycle, similar to what is seen in the latter part of the solar activity cycle. The degree of anti-correlation is greatest for stars with rotation periods close to that of the Sun, but is almost de-correlated for both fast and very slow rotators. For solar-like rotators the variation in rotation rate begins to show an asymmetry between the start and end of the activity cycle, similar to what is seen from the solar butterfly diagram.

Poster 224

Spectroscopic observations of Kepler/TESS solar-type superflare stars

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Recent Kepler-space-telescope observations found more than 1000 superflares on $\sim$ 300 solar-type stars (e.g., Maeahra et al. 2012 Nature). Many of the superflare stars show quasi-periodic brightness variations with the typical period of 1-30 days and the typical amplitude of 0.1-10 percent. We conducted spectroscopic observations of these superflare stars using Subaru/HDS and APO 3.5m telescope (Notsu et al. 2015a, 2015b, 2018 in prep). The projected rotation velocity ($v \sin i$) values are consistent with brightness variation period and there is a good correlation between Kepler brightness variation amplitude and the intensity of Ca II lines (Ca II H&K, Ca II 8542Å). These results support that the above brightness variations are caused by stellar rotation with large starspots, and existence of large starspots should be a key to understand superflares.

More detailed spectroscopic studies (e.g., activity cycle) of superflare stars are important, but Kepler target stars are faint and not appropriate for such detailed studies. TESS satellite, launched after April 2018, brings us a large sample of brighter (e.g., V <12 mag) superflare stars. We have started spectroscopic monitoring observations of nearby active solar-type stars (superflare candidate stars) in the TESS field. These results can have good collaborations with multi-wavelength project observations (e.g., X-ray, UV, polarimetry) of young solar-type stars.

The Relation Between Stellar Rotation and Magnetic Activity in Open Clusters

Poster 225

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In low-mass stars, the strength of the magnetic dynamo decreases over time as stars spin down through the loss of angular momentum via magnetized winds. Both coronal X-ray emission and chromospheric H-alpha emission trace the strength of the changing dynamo and, when combined with rotation periods in a single-aged population, can therefore be used to examine the dependence of magnetic activity on rotation across a range of masses. We observed two open clusters, the 60 Myr-old Alpha Persei and the 500 Myr-old M37 clusters, to obtain X-ray fluxes, Hα equivalent widths, and rotation periods of their stars. We calculated Rossby numbers, $R_o = P/\tau$, where P is the rotation period and τ is the convective turnover time. With these data we explore how X-ray and Hα luminosity depend on R_o, whether the behavior in the unsaturated regime (i.e., when the measured activity has a dependence on R_o) differ for these two tracers of magnetic activity, and how the different tracers of activity differ from each other in the same set of stars.

Center-to-limb Doppler diagnose of the solar granular and intergranular convective flow

Poster 226

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The solar surface is governed by the so-called granulation, composed of bright grain-feature called granule, surrounded by dark narrow lane called intergranular lane, which is a visible manifestation of convection. Solar observations can resolve the spatial distribution of the granulation, identifying blue-shifted profiles (upflows) in granules and red-shifted ones (downflow) in intergranular lanes. While stellar observations only have access to mean spectral profile averaged over the surface, solar observations provide a unique opportunity to characterize the properties of the stellar convection. However, in spite of having spatially-resolved observation, we have lack of knowledge about horizontal flows, because spectroscopic observations are only sensitive to the line-of-sight (LOS) component of the velocity field, i.e., the gas displacement perpendicular to the surface plane. In this study, we aim to characterize those horizontal flows, based on a fact that the LOS angle at the solar limb observation is aligned with the horizontal gas flow. In this regard, we analyzed spectral data observed from the solar disk center to limb. The dataset is made by the Hinode spacecraft, which can provide spectral profiles with the highest spatial resolution available from the space. Our findings show that the horizontal flow speed is 1.6-1.9 km/s in root-mean-squared (RMS) and that its maximum amplitude occurs in intergranular lanes, which is almost two times larger than vertical flow of 0.9 km/s. Thus, we have found that intergranular lanes are more filled with vigorous horizontal flows than granules, improving our traditional view that

conceives intergranular lanes as simply downflowing regions. Moreover, I would like to investigate in the future, whether there is any link between our results of the sun and the stellar granulation, helping to understand the spectral signature, found on stellar observation and their physical background.

Poster 227

Sample selection for the Infrared radial velocity survey of cool stars

Masashi Omiya[1,2]; the IRD team

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Low mass stars are attactvie targets to search for Earth-like planets (in their habitable zone) by infrared Doppler technique because of relatively large Doppler signals caused by the planets and their cloase-in orbits. However, many of low-mass stars are active and/or rapidly rotating stars, which are unsuitable for precise radaial velcoity measurments, and then avoide to detect small planets. Thus,, it is important to carefully select suitable sample to search for such small planets around low-mass stars. We selected 150 sample stars among nearby low-mass stars for a newly planed planet search by the infrared radial velocity survey with the Subaru telescope and the infraRed Doppler (IRD) instrument. The sample stars are M-type dwarf stars with low masses (0.1-0.25 $M_{\odot}$), slow rotational velocity and weak intrinsic surface activity. The stellar masses are determined using a empirical formula of absolute magnitude and stellar mass with directly measured parallaxes. The stellar activity and rotational velocity are investigated with equivalent widths of H-alpha emission lines by their optical medium-resolution spectra obtained our original observations using five telescopes and some literatures. Finaly, we will choose 60 stars among 150 stars for sample of extensive RV survey in the survey observations with IRD/Subaru.

Poster 228

The atmosphere of WASP-69b observed via high-resolution transmission spectroscopy

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Instituto de Astrofisica de Canarias

Transit spectroscopy is one of the most commonly used methods to characterize exoplanets' atmospheres. From the ground, these observations are very challenging due to the terrestrial atmosphere and its intrinsic variations, but high spectral resolution observations overcome this difficulty by resolving the spectral lines and taking advantage of the different Doppler velocities of the Earth, the host star, and the exoplanet. We analyze the transmission spectrum around the Na I doublet at 589 nm of the extrasolar planet WASP-69b, a hot Jupiter orbiting a K-type star with a period of 3.868 days, and compare the analysis to that of the well-known hot Jupiter HD 189733b. We present the analysis of the Rossiter-McLaughlin (RM) effect for WASP-69b, and find that only the contrast of the D2 line of the doublet can be measured ($5.8 \pm 0.3\%$). This corresponds to a detection at the 5σ-level of excess absorption of $0.5 \pm 0.1\%$ in a passband of 1.5 å. Even if sodium features are clearly detected in the WASP-69b transmission spectrum, more transits are needed to fully characterize the line profiles and retrieve accurate atmospheric properties.

What do starspots look like?

Poster 229

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We have performed the first-ever, realistic ab-initio simulations of the photospheric structure of starspots for a range of cool main-sequence stars, namely the spectral types M, K, G, and F. We use the radiative MHD code MURaM which includes radiative energy transfer and partial ionization. MURAM is so far the only radiative MHD code that has managed to compute complete sunspots with some semblance of realism.

We explore several fundamental properties like umbral intensity contrast, temperature, and magnetic field strength as functions of spectral type.

Dynamical evolution of spatio-kinematic groups in star-forming regions: are Friends of Friends worth knowing?

Poster 230

Richard Parker

University of Sheffield

Recently, a great deal of effort in star formation research has focused on quantifying coherent structures in either gas filaments, or groups of stars, by classifying together structures with similar spatial and kinematic properties using the 'friends of friends' technique. Most of these studies use observational data which is only one snapshot in time. In this talk I will show how groups identified by the friends-of-friends technique are both artificial, in the sense that they are found in a hierarchically self-similar distribution, and transient in that dynamical evolution of star-forming regions quickly erases the original groups. These findings call into question the physical motivation behind identifying spatio-kinematic groups in star-forming regions.

Photospheric parameters of CARMENES target stars from high-resolution spectroscopy

Poster 231

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Max-Planck-Institut für Astronomie, Heidelberg, Germany; Centro Astronómico Hispano-Alemán [CSIC-MPG], Observatorio Astronómico de Calar Alto, Almería, Spain; Institut de Ciències de l'Espai [CSIC-IEEC], Barcelona, Spain

CARMENES started a new planet survey on M dwarfs in January 2016. The high-resolution spectrographs are operating in the visible (VIS) and near-infrared (NIR) wavelength ranges at Calar Alto Observatory, Spain. They perform high-accuracy radial-velocity measurements (1 ms-1) with the aim to detect low-mass planets within the habitable zones of M dwarfs. We analyzed the CARMENES spectra and provide fundamental parameters for the target stars in order to constrain planetary properties and understand star-planet systems. Using state-of-the-art model atmospheres (PHOENIX-ACES) and chi2-minimization with a downhill-simplex method, we determined effective temperature, surface gravity and metallicity [Fe/H] of about 300 stars of spectral types M0.0-6.5V. We found good agreement between the models and our observed high-resolution spectra. We show the performance of the algorithm, results from VIS spectra, and parameter and spectral type distributions for the CARMENES target sample. We also present first preliminary results obtained from CARMENES NIR spectra as well as comparisons to results obtained from VIS and to literature values.

Poster 232

Leibniz-Institute for Astrophysics Potsdam (AIP), An der Sternwarte 16, 14482, Potsdam, Germany;

Rishi R. Paudel[1]; John E. Gizis[1]; D. J. Mullan[1]; Sarah J. Schmidt[2]; Adam J. Burgasser[3]; Peter K. G. Williams[4]; Edo Berger[4]

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Center for Astrophysics and Space Science, University of California San Diego, La Jolla, CA 92093, USA; Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138, USA. White light flare rates of M5-L5 dwarfs using *K2* data The *K2* mission's unique combination of wide area coverage and continuous time coverage over months has enabled us to study white light flare rates of cool stars of various spectral types. We have shown that the white light flares are ubiquitous in some late-M and early L dwarfs. Some early L dwarfs are even capable of producing superflares with bolometric flare energies greater than 10^{33} erg despite having lower effective temperatures. We update our results on the white light flare rates of very-low-mass stars with a wide range of spectral types: M5-L5, obtained by using both short cadence ($\sim$1 min) and long cadence ($\sim$30 min) *K2* data. We analyze the possible relation between flare rates of very-low-mass stars in our sample and different properties like spectral type, age, etc. Strong magnetic fields of order of 5-10 kilogauss are required to explain the most energetic flares. Using constraints on magnetic fields from the biggest flares, we discuss the nature and evolution of the magnetic dynamo on very-low-mass stars. Our results will be helpful in predicting the number of flares on the low-mass cool stars which will be observed by future photometric surveys like *TESS*.

Eclipsing binaries in the ASASSN and APOGEE surveys

Poster 233

Michal Pawlak

Charles University in Prague

The APOGEE project is a large spectroscopic survey covering over 260 000 sources. Most of this objects are also observed photometricly by the ASASSN survey, which provide an unique opportunity to study them photometricly and spectroscopicly at the same time. I would like to present the collection of about 370 eclipsing and ellipsoidal binary stars identified in the cross-matched data of the two surveys. The combination of photometric and spectroscopic data allows for an very accurate parametrisation of each of the objects, including deriving accurate periods and magnitudes from ASASSN photometry as well as logg, Teff, Vsini from APOGEE spectra. Additional information can also be derived from recently released Gaia DR2. The synergy between the different type of survey gives an opportunity to explore the properties of the objects in the sample in a broad context.

Predicting the Extreme Ultraviolet Exposure of Planets Orbiting M dwarfs

Poster 234

Sarah Peacock[1]; Travis Barman[1]; Evgenya Shkolnik[2]

University of Arizona; Arizona State University

The high-energy radiation environment around M dwarf stars strongly impacts the characteristics of close-in exoplanet atmospheres but is particularly difficult to observe. Correct estimates of stellar extreme ultraviolet (EUV) flux are important for studying the photochemistry and stability of exoplanet atmospheres, as EUV radiation ionizes hydrogen, leading to the heating, expansion, and potential escape of the planet's upper atmosphere. Due to a lack of instruments and the additional trouble of contamination from optically thick interstellar hydrogen, observing in the EUV is impossible for stars other than the sun. In place of direct measurements, methods to predict EUV flux from M dwarfs include empirical scaling relationships and semi-empirical models that extrapolate into the EUV from either X-ray or far-ultraviolet (FUV) observations. Here we present EUV-IR model spectra computed with the PHOENIX atmospheric code of three M dwarf planet hosts: GJ 176, GJ 436, and GJ 832. The models include prescriptions for the stellar upper atmosphere, including the chromosphere and transition region, where EUV, FUV and NUV fluxes originate. We compare our results to FUV, NUV, and optical spectroscopic observations and discuss the sensitivity of the model to changes in the temperature structure and the ability to constrain these models using FUV and NUV photometry. With the scarcity of observed EUV spectra, upper-atmosphere models such as these are important for advancing our understanding the effects of high-energy radiation on planets orbiting M dwarfs.

Poster 235

Atmosphere and Evolutionary Models for Cool Brown Dwarfs and Giant Exoplanets

Mark Phillips; Isabelle Baraffe; Pascal Tremblin; Gilles Chabrier; Eric Hebrard; Ben Drummond; Jayesh Goyal;

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The study of brown dwarfs and giant exoplanets is rapidly evolving as ever-improving instrumentation becomes sensitive to cooler objects. Accurate and reliable atmosphere and evolutionary models are important for placing mass and age constraints on newly discovered objects, and understanding the rich chemistry and physics taking place in their atmospheres. We are expanding on the widely used COND evolutionary models by developing a grid of model atmospheres (T_{eff}=200-2000K, log(g)=2.5-5.5) with our state-of-the-art 1D radiative-convective equilibrium code ATMO. ATMO includes the latest opacities for important molecular absorbers such as H_2O, CH_4 and NH_3, and takes into account the condensation of H_2O and NH_3 which are important for the coolest atmospheres (T_{eff}=200-350K). These model improvements allow us to follow the evolution of Jupiter mass objects down to the coolest temperatures (T_{eff}=200K). I will present comparisons of these new models to previous model grids and to observations in colour-magnitude diagrams. I will also highlight the uncertainty surrounding the highly pressure broadened potassium resonance doublet, the treatment of condensates through rainout, and the calculation of low temperature chemical equilibrium abundances. Our future work will involve expanding on this initial grid, to investigate the effects of metallicity, C/O ratio and non-equilibrium chemistry in cool brown dwarfs and giant exoplanets.

Poster 236

FUMES: The Far Ultraviolet M-dwarf Evolution Survey

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CU Boulder - LASP; NASA Goddard

The high-energy stellar radiation environment around M-dwarf stars from x-rays to ultraviolet wavelengths is driven by strong non-thermal magnetic heating of the upper atmosphere from the chromosphere into the corona. Understanding the strength and evolution of these heating processes and the resulting emissions is critical in light of the increasing population of known exoplanets around M-dwarf stars. Strong radiation at these energies can lead to atmospheric mass loss and is a strong driver of photochemistry in planetary atmospheres, with significant implications for habitability. Only recently, the results of the MUSCLES Treasury Survey provided the first comprehensive assessment of the high-energy radiation field around old, planet hosting M-dwarfs. However, the habitability and potential for such exoplanetary atmospheres to develop life also depends on the evolution of the atmosphere and hence the evolution of the incident radiation field. We thus present the results of the Far Ultraviolet M-dwarf Evolution Survey (FUMES), an HST-STIS observing campaign, with multi-wavelength follow-up in the optical and near infrared, targeting a small sample of young rapidly rotating early-to-mid M-dwarfs, to assess the evolution of the FUV radiation field, including Lyα, and how the strength of magnetic heating, as traced by transition region emission lines, decays with time. We further discuss the implications of our findings for the

entire high-energy radiation environment around M-dwarfs from youth to old-age and the potential impact on exoplanetary atmospheres.

A study of likeness: The solar twin 18 Sco and the Sun

Poster 237

Geisa Ponte; Gustavo Porto de Mello

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The detailed study of solar twins has direct applications both in the understanding of the chemical evolution of the Galaxy and the evolution of the solar properties over time, besides being a powerful tool in the study of exoplanetary systems. Due to its resemblance to the Sun, the differential spectroscopic analysis of solar twins becomes less dependent on theoretical assumptions, maximizing our capability of detecting minor differences in the atmospheric parameters space. Our main goal is to make a direct empirical comparison between the Sun, the well-known solar twin 18 Sco, and 5 bright solar twin candidates (Porto de Mello et al., 2014).

We used high resolution and high signal to noise ratio spectra (FEROS/ESO, R=48,000, and HARPS/ESO, R=115,000) to measure the FWHM (full width half maximum), line depth, equivalent widths of iron peak, s-process, and alpha elements lines: Ca I, Co I, Cr I, Cr II, Fe I, Fe II, Mn I, Ni I, Sc I, Sc II, Ti I, Ti II, Y I, and Y II. Also, a comparison was made between the resulting atmospheric parameters determination (i.e. effective temperature, surface gravity, metallicity) through our careful manual line measurements and those derived from automatic massive analysis tool iSpec (Blanco-Cuaresma et al., 2013), evaluating the impact of different sources of uncertainties present in the analysis (normalization errors, photonic noise, instruments stability and the use of different solar proxies). This multi-analysis approach allowed us to map some sources of uncertainties and degrees of subjectivity involved in determinations of spectroscopic solar similarity among twin stars.

Our results confirm that 18 Sco is statiscally identical to the Sun ($> 4\ \sigma$), remaining the best nearby solar twin known to the date. We also established a degree of similarity between the solar twins. These new bright solar twins should be considered as prime targets for asteroseismic studies, high cadence and high spectral resolution follow up.

Comparison of BT Settl Model Spectra in NIR to Brown Dwarfs and Massive Exoplanets

Poster 238

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Our understanding of giant exoplanets and brown dwarfs is hampered by the difficulty in observing them. Model spectra, such as the BT Settl model grid, can provide an opportunity to augment and validate our understanding of these faint objects by serving to contrast and complement our analysis of the observed spectra. The near infrared (NIR) K band wavelength region (1.97 - 2.40 microns) is favorable for analysis of low mass brown brown dwarfs and high mass gaseous companions due to its relatively high resolution and high signal-to-noise ratio wavelength range for spectra of planetary companions. We present a method to analyze the K band spectral structure and apply it to a sample of objects with field gravity, low gravity, and planetary mass as well as the BT Settl model grid for a similar range of effective temperatures and surface gravities. A correlation between spectral structure and effective temperature is found for the shorter wavelength region (2.03 - 2.10 microns), and there is evidence of gravity dependence for the longer wavelength range (2.215 - 2.290 microns). This work suggests that the K band has the potential to be an indicator for brown dwarf and exoplanet surface gravity and effective temperature. We also present analysis of the BT Settl Model grid examining equivalent width measurements of K I absorption lines in L Dwarfs.

Poster 239

Convective penetration in a pre-main sequence star

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To interpret the high-quality data produced from recent space-missions it is necessary to study convection under realistic stellar conditions. We describe the multi-dimensional, time implicit, fully compressible, hydrodynamic, implicit large eddy simulation code MUSIC. We use MUSIC to study convection during an early stage in the evolution of our sun where the convection zone covers approximately half of the solar radius. This model of the young sun possesses a realistic stratification in density, temperature, and luminosity. We approach convection in a stellar context using extreme value theory and derive a new model for convective penetration, targeted for one-dimensional stellar evolution calculations. This models provides a scenario that can explain the observed lithium abundance in the Sun and in solar-like stars at a range of ages. The motivation for this program of work is to derive new models based on realistic fluid simulations, to be implemented in stellar evolution codes and broadly used for stellar and galactic astrophysics.

Revealing the Complex Environment of Outbursting Protostars with Scattered Light Observations

Poster 240

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FU Ori (FUor) and EX Lup (EXor) objects represent a short-lived stage of protostellar evolution characterized by intense mass accretion events which cause extreme variability in the form of outbursts. It is likely such rapid accretion events constitute the means by which most newborn stars gain their initial mass. However, the mechanism(s) which cause such intense outbursts are poorly understood due in large part to their level of difficulty to observe in detail. We present optical and near-IR scattered light observations of several outbursting protostars which spatially resolve the circumstellar environment at radii $>$ 10 au. These images reveal complex morphological features in the dust surrounding these young stars which likely hint at their highly variable origins.

Synergy between VLBI and Gaia observations on evolved and young massive stars in the Galactic plane

Poster 241

L.H Quiroga-Nunez[1,2]; H. van Langevelde[2,1]; L. Sjouwerman[3]; Y. Pihlstrom[4], M. Reid[5]; A. Brown[1]; M. Rich[6]

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The Bar and Spiral Structure Legacy (BeSSeL) survey and the Bulge Asymmetries and Dynamical Evolution (BAaDE) project target maser stellar emission from young massive stars and evolved stars respectively. Follow-up radio-astrometric measurements are complementary to Gaia results, since the inner plane of the Galaxy is obscured at optical wavelengths. We are constructing a cross-match sample between Gaia sources and BAaDE targets. This resulting sample provides important clues on the intrinsic properties and population distribution of evolved stars in the Galactic plane, but specially at the Galactic Bulge. For the Bessel targets, which are heavily obscured we are investigating whether they can be associated with clusters of massive young stars detectable at optical wavelengths.

Poster 242

The CARMENES Survey

Andreas Quirrenbach[1]; CARMENES Consortium[2]

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M dwarfs are very interesting targets for searches for habitable planets. They are the most numerous type of star; therefore our closest cosmic neighbors may well live on a planet orbiting an M dwarf. It is also easier to look for Earth-like planets around low-mass stars, as they give rise to relatively large radial-velocity variations and deep transits. Third, planets of M dwarfs may be different from those of the Solar System as they experience stronger UV and X-ray irradiation. This provides opportunities for comparative studies of planetary atmospheres under varying conditions.

We are conducting a survey of 300 nearby M dwarfs (average distance only 13pc), with the goal of finding terrestrial planets in their habitable zones. We have built a pair of spectrographs that are optimized specifically for measuring precise radial velocities of cool stars. This CARMENES instrument is now operational at the 3.5m telescope of Calar Alto Observatory in Spain.

We have detected the signatures of several previously known planets as well as discovered new ones, with masses down to a few Earth masses. The CARMENES survey is also generating a unique data set for studies of M star atmospheres, rotation, and activity. The spectra cover important diagnostic lines for activity, as well as molecular lines sensitive to magnetic fields. Correlating the time series of these features with each other, and with wavelength-dependent radial velocities, provides excellent discrimination between planetary companions and stellar radial velocity ”noise”, and generates new insight into the physical properties of M dwarf atmospheres.

Poster 243

Constraining M-dwarf Photospheres through the Transit Light Source Effect

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Planet-hosting M dwarfs provide the exciting possibility of studying terrestrial exoplanets and their atmospheres with current and near-future instrumentation. Increasingly precise observations, however, are revealing that transmission spectra are subject to astrophysical signals introduced by activity in the host star photospheres. Viewed in another light, planet-hosting M dwarfs provide a synergistic opportunity to understand the properties of both exoplanet atmospheres and M-dwarf surface active regions, as transit observations provide spatial and spectral probes of resolved stellar surfaces. Here we summarize our work on investigating the impact of spots and faculae on transmission spectra using models of rotating M-dwarf photospheres, detailing implications for characterization efforts of both small exoplanet atmospheres and M-dwarf photospheres. We find that wide ranges of spot and faculae covering fractions are consistent with typical observed variabilities of M dwarfs. Molecular absorption features in photospheric active regions can imprint apparent features in transmission spectra comparable to or an order of magnitude larger than those of atmospheric features from rocky exoplanets, complicating searches for planetary atmospheric features but also enabling constraints on temperatures and filling factors of surface active regions. We compare model predictions to state-of-the-art observational data for the mid-M dwarf sub-Neptune host GJ 1214 and the ultracool terrestrial planet host TRAPPIST-1, examining the constraints provided for both the planetary atmosphere and stellar photosphere. We discuss the impact of M-dwarf photospheric activity on current HST and Spitzer observations and forthcoming TESS and JWST observations and detail current approaches and proposed ideas to further constrain the properties of M-dwarf photospheric active regions and fully exploit the M-dwarf transiting exoplanet opportunity.

Evidence for a Range of Cloud Depths in L/T Transition Atmospheres

Poster 244

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Utah Valley University

We present HST (Wide Field Camera 3, G141 grism) spectra (1.1 - 1.7 μm) for two highly variably L/T transition brown dwarfs. One target exhibits muted variability in the 1.4 μm water band, similar to other L/T transition brown dwarfs previously observed with WFC3. The other target exhibits a flat variability spectrum in and out of the water band, as is more commonly observed for earlier type L-dwarfs with higher altitude clouds. This target was followed up approximately 21 months later with simultaneous HST and Spitzer observations, and once again was found to have a flat variability spectrum. A simple Mie scattering model of a high altitude haze composed of micron sized grains can reproduce the observations. These findings suggest that different L/T transition brown dwarfs may have brightness-modulating clouds at different depths in their atmospheres, despite having similar spectral types and colors. Furthermore, for a given object, the inferred cloud depth is consistent over multi-year timescales, in contrast to the rapid evolution observed for the cloud features themselves.

The FunnelWeb Survey: Spectroscopic Stellar Parameters for All Southern Stars in the Gaia Era

Poster 245

A. D. Rains[1]; FunnelWeb Survey Collaboration[2]
Australian National University; Multiple

The FunnelWeb Survey, known simply as ‘FunnelWeb’, is a multi-object stellar survey of the Southern Hemisphere beginning in mid-2018. The FunnelWeb main survey will cover the entire southern sky, excluding only the most crowded regions, ($\delta \leq 0^o$, $|b| \geq 10^o$) and will obtain high-quality (S/N$\sim$100) optical spectra (370-870 nm, R $\geq$ 2000) for some $\sim$1.8 million stars down to a magnitude of G=14.5, aiming for 99

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Solar flares at high resolution: plans for observations with the Daniel K. Inouye Solar Telescope

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University of Colorado Boulder; LASP; National Solar Observatory; INAF

Solar flares have long been used as a template to understand (spatially unresolved) magnetically driven eruptions on solar-like stars. Recent solar results include the reproduction of UV line profiles and dynamics during episodes of chromospheric condensation and evaporation using RHD models (Kowalski et al. 2017 ApJ 836, 12), which have also been applied to understand heating processes in flares on solar-like stars. The realization that peculiar magnetic topologies of flaring active regions might suppress associated CMEs (Thalmann et al. 2015 ApJ 801, L23; Sun et al, 2015 ApJ 804, L28) has ”reverberated” in the stellar field due to the implications for stellar mass loss (Osten & Wolk 2015 ApJ 809, 79) and the habitability of exoplanets around low-mass stars (Alvarado Gomez et al 2018, in press).

Many of these advances have been brought about by novel facilities, exploring new spectral ranges (e.g. the near UV, IRIS), or diffraction limited spatial scales (SOT/Hinode, IBIS/DST, etc) combined with high cadence. The 4-m Daniel K. Inouye Solar Telescope (DKIST) will become operative in about 2 years, and it will provide observations of flares at an unprecedented resolution both in the lower solar atmosphere and the corona. We describe a set of flare science use cases that can be addressed with the DKIST, including investigations of the ”fundamental” scale of flare ribbons; changes of chromospheric magnetic fields leading to eruption; turbulence and electron pressure broadening in different portions of the flare ribbons. Many of these use cases originated during a workshop held in May at Rice University, as part of a community-led effort to define the Critical Science Plan for the DKIST.

Poster 247

Stability of Stellar Periods in the Hyades and Taurus

L. M. Rebull[1]; J. R. Stauffer[2]; K2 Clusters team
Caltech-IPAC/IRSA; Caltech-IPAC/SSC

K2 has opened to us the study of high-precision light curves from which we can derive stellar rotation periods. We have presented period distributions for the Pleiades, Praesepe, Upper Sco and Rho Oph. But, how stable are the periods we are deriving from them? Early ground-based work in Orion (Rebull 2001) suggested that, for the youngest stars, about half the stars had sufficiently different spot distributions in two consecutive years such that periods could not be recovered in the second year. However, now that we have K2, precision and diurnal windowing functions are no longer really much of a concern. For a handful of stars in Hyades and Taurus, the K2 spacecraft monitored them for two non-consecutive 70d windows (campaigns 4, 2015 Feb and 13, 2017 Mar). In this poster, we examine whether or not the light curves are similar in the two epochs, and how accurately the same period can be recovered.

Environmental impact on disc lifetimes

Poster 248

Jon Rees[1]; Tom Wilson[2]; Tim Naylor[2]; Cameron Bell[3]; David James[4]

UC San Diego; University of Exeter; Leibniz Institute for Astrophysics Potsdam; Harvard-Smithsonian Center for Astrophysics

Understanding circumstellar discs and their evolution is important for both young stars and planet formation. There have been suggestions that disc lifetimes may be impacted by the local environment, through tidal interactions or ionising radiation. It has also been suggested that stellar mass may be determined by the length of the accretion phase, and thus dependent on the longevity of the disc (Bate & Bonnell 2005). Long-lived discs in Taurus are thus a potential explanation for the observation that the mass function in Taurus peaks at higher masses than other regions (e.g. Bastian 2010).

We present evidence that circumstellar discs may survive longer in low-density, low-mass star formation environments. We show that both the Taurus-Auriga and Chamaeleon regions show an excess in disc fraction compared to the decline in disc fraction in denser clusters of similar age, suggesting that discs survive longer in their low-density, low-mass environments. To show this, we have carefully derived the age of two nearby low-density star-forming regions, Taurus and Chamaeleon. Our derived ages are significantly older than those typically quoted in the literature, but fully consistent with the new age scale derived in Bell et al. (2013).

Adding color to RVs: Revealing the signature of spots as a function of wavelength with CARMENES

Poster 249

Ansgar Reiners for the CARMENES team

Institut für Astrophysik Göttingen

The temperature contrast between spots and a star's quiet photosphere introduces distortions in atomic and molecular spectral lines. This effect can shift the apparent center of the lines and hereby affect the Doppler velocity measured in the spectrum of an active star. The effect depends on wavelength because the contrast between spot and photosphere does. The CARMENES spectrograph simultaneously covers the wavelength range 520-1710nm. In our M dwarf survey, we observed several active stars with significant RV excursions that are caused by stellar active regions. We can analyze the wavelength dependent signature of starspots and find that active stars can have very different faces. The color of RVs adds a new dimension to the analysis of Doppler velocities providing a fresh view into the properties of active stars.

Poster 250

Spot or faculae domination revealed by activity cycle phase differences

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We study the appearance of activity signatures in contemporaneous chromospheric emission data and photometric data to shed light on the underlying process that causes magnetic activity. Assuming a joint cycle period in both chromospheric and photometric time series data we show that the variability in active stars is usually in anti-phase, while the variability of inactive stars is in phase. This demonstrates that active stars are dominated by dark spots, whereas less active stars are dominated by bright faculae. The transition from faculae to spot domination occurs at the Vaughan-Preston gap. We further show that the shape of the chromospheric time series becomes strongly sinusoidal for inactive slowly rotating stars. This is accompanied by shallow photometric amplitudes. We speculate that for such slow rotators the dynamo is not able to generate a magnetic field strong enough to maintain long-lived large spots, while it is still powerful enough to generate an excellent chromospheric cycle.

Poster 251

Survivor: protoplanetary disk edition

Megan Reiter[1]; Aleksandra Kuznetsova[1]; Lee Hartmann[1]; Mario Mateo[1]; Nathan Smith[2]
University of Michigan; University of Arizona

Stellar feedback permeates high-mass star-forming regions, fundamentally shaping the cradle of star and planet formation. Photoionizing radiation from high-mass stars may destroy the disks around still-forming low-mass stars. At the same time, Solar System meteorites suggest that at least one supernova seeded the proto-Solar nebula with radioactive isotopes that play a central role in the evolution of terrestrial planet embryos. Whether feedback helps or hinders planet formation depends critically on the morphology and dynamics of the natal cluster (e.g., Lichtenberg et al. 2016). This is because star formation is a fundamentally dynamic process where the movement of individual objects (1 pc in 1 Myr for a velocity 1 km/s) results in significant changes in a given star's environment during formation (e.g., Kuznetsova et al. 2015). Here, we present first results from a new survey to measure radial velocities of low-mass stars in a truly high-mass star forming region, the Carina Nebula. Together with proper motions from GAIA, this provides the first comprehensive study of the 3D kinematics in a truly high-mass star-forming region, allowing us to:

- constrain the time that low-mass stars spend subject to disk-destroying radiation from nearby high-mass stars and the fraction polluted with supernova ejecta;
- measure kinematic substructure and model its evolution to test high-mass star-formation theories; and
- model the dynamical evolution of the cluster to determine how typical Sun-like birth conditions are.

Multi-Resolution Spectral Fitting of T dwarfs

Poster 252

Emily L. Rice; Paige A. Giorla Godfrey; Stephanie T. Douglas; Evan Morris; Sarah E. Logsdon; Emily C. Martin; Ian S. McLean; Jacqueline K. Faherty; Kelle L. Cruz

CUNY College of Staten Island; Slooh, LLC; Harvard-Smithsonian Center for Astrophysics; Columbia University; NASA Goddard Space Flight Center; University of California, Los Angeles; University of California, Los Angeles; American Museum of Natural History; CUNY Hunter College

T dwarfs are the coolest fully-populated spectral class and optimal analogs for the lowest mass directly-imaged exoplanets, like 51 Eridani b. The physical and atmospheric properties of these objects can be inferred via comparison to synthetic spectra from atmospheric models, which provide parameters like temperature, gravity, metallicity without relying on fraught measurements or estimates of distance, age, or radius. While more amenable to direct observations than exoplanets, T dwarfs are still intrinsically cool and faint and are thus challenging targets for high-resolution spectroscopy, even at infrared wavelengths where their emitted flux peaks. Therefore we are motivated to conduct multi-resolution spectral fits to determine how the precision, accuracy, and consistency of inferred parameters depend on the resolution of the observed spectra. The sample will span the T dwarf spectral class to test how dust, which is expected to be a larger contributor to opacity for earlier spectral types, may further complicate the results. This poster presents an overview of the sample, existing observations, atmosphere models, and preliminary results for selected objects.

The UV Evolution of K Stars: Assessing the Super-Habitability of Their Planets

Poster 253

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Compared to M dwarfs, K dwarfs (3,700 - 5,200 K; 0.6-0.9 $M_{\odot}$; conservative habitable zone 0.6 to 1.1 AU from the star) have lower ultraviolet (UV) flux levels at the habitable zone, emit fewer flares, contract faster onto the main-sequence in time for terrestrial planet formation, and have wider habitable zones. These critical factors suggest that perhaps the highest potential for finding a likely habitable planet may be around K dwarfs. The UV radiation across the system's evolution is one of the most important factors in determining if a planet is potentially habitable and if any biosignatures will be detectable with future space telescopes. We measured the evolution of the UV radiation of known K dwarf members of young moving groups and clusters ranging in age from 10 - 625 Myr and field stars using archived GALEX data to determine how the near-UV and far-UV radiation change over important planet formation and evolution timescales. This is the first comprehensive study of UV evolution of K dwarfs and characterizes the UV environment of their potentially habitable planets, an extension of our HAZMAT program to HAZKAT.

Poster 254

Investigating giant planet and brown dwarf formation and evolution through the detection and characterization of these sub-stellar companions

Emily Rickman; Damien Ségransan

The University of Geneva

Very little is known about giant planets and brown dwarfs at an orbital separation greater than 5 AU. And yet, both are important puzzle pieces needed for constraining the uncertainties that exist in giant planet formation and evolution models. With over 20 years' worth of radial velocity data from the CORALIE echelle spectrograph, we are now in a position to use the technique of radial velocity detection and direct imaging to complement one another. Using these techniques helps us understand how these wide-orbit giant companions form and evolve by investigating a mass and separation parameter space that is distinct from the one already occupied with exoplanets discovered through other methods. Here, we will present the detection and characterization of interesting wide-orbit giant planets and brown dwarfs from the CORALIE search for southern extra-solar planets which probes this new orbital parameter space and could signal whether different formation mechanisms are at play, adding to overall picture of planet formation and evolution.

Poster 255

Modeling Protoplanetary Disks Around Brown Dwarfs in Taurus

Anneliese M. Rilinger; Catherine C. Espaillat; Enrique Macias

Boston University

Understanding the properties of protoplanetary disks is central to understanding planet formation. The dust in these disks grows and forms planetesimals that become rocky planets or cores that accrete gas, creating giant planets. By measuring the masses of protoplanetary disks we can constrain the amount of material available to form planets. We present models of the spectral energy distributions (SEDs) for two brown dwarfs with protoplanetary disks in the Taurus Molecular Cloud. By combining SED models with ALMA data, we can obtain disk masses for these objects. We can thus determine whether an Earth-size or even Jupiter-size planet could form in these disks. We also present measurements of the disk sizes, which can help inform the origin of these systems. The disk properties measured here provide insights and constraints to theoretical models of planet formation around brown dwarfs and the formation of brown dwarfs themselves.

Accretion Variability in Young Low Mass Stars

Poster 256

C. Robinson

Boston University

Accretion onto the surface of the star informs us about the time-variable processes at work transferring angular momentum within protoplanetary disks. Moderate cadence observing campaigns of protoplantary disks indicate that short period (roughly 2 day) stochastic bursty accretion occurs in a large fraction of T Tauri stars. We have modeled the accretion columns connecting the disk to the star with a 1D hydrodynamic fluid model which is restricted to flow along a multipole magnetic field line geometry. We found that by smoothly varying the density at the footprint of the disk, traveling shocks form along the column and strike the star which leads to sudden bursts of accretion. We have also obtained multi-epoch coordinated observations of several young systems in the UV and the IR. We are currently working to connect these datasets to improve our understanding of the innermost regions of the disk.

The eROSITA all-sky survey - Stars in X-rays

Poster 257

J. Robrade

Hamburger Sternwarte

eROSITA (extended Roentgen Survey Imaging Telescope Array) is the prime instrument on the Russian SRG spacecraft to be launched in 2019. eROSITA will perform an 4 year all-sky survey (eRASS) at low to medium X-ray energies that is unprecedented, given its sensitivity, energy range, spectral and angular resolution as well as its eightfold sky coverage.

Stars constitute the majority of galactic X-ray sources in the eRASS and the detection of several hundreds of thousands of stellar systems down to fluxes of about $F_X = 1 \times 10^{-14}$ erg cm^{-2} s^{-1} at 0.3-10.0 keV energies is expected. The stellar X-ray sky is dominated by magnetically active stars and particularly for nearby stars, young stellar populations, YSOs and star formation regions the eRASS enables a systematic investigation of coronal properties, their evolution and activity-age-rotation relations. Furthermore, stellar variability is covered on multiple timescales, addressing flare statistics or activity cycles. I present the prospects of eROSITA for cool stars science as well as multi-wavelength aspects and identification schemes of the stellar X-ray sources.

Poster 258

Dynamical masses of M-dwarf binaries in young moving groups; I - The case of TWA 22 and GJ 2060

L. Rodet

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TWA 22 and GJ 2060 are two young (120-150 Myr) tight pairs of M dwarfs resolved through high-angular resolution techniques. Their short periods allow for dynamical mass determination within a few years, which make them precious benchmarks for the pre-main sequence (PMS) evolutionary models. We present new resolved images of both systems (VLT/SPHERE, VLT/NaCo, Keck/NIRC2, NTT/AstraLux), integral field spectra of GJ 2060 A and B, and radial velocity measurements of GJ 2060 AB (VLT/SINFONI, FEROS, ESO/HARPS). We used these new measurements to derive revised and robust constraints on the orbital parameters and dynamical masses of both binaries via dedicated MCMC orbital fitting. We used SINFONI data to study the spectrophotometric properties of GJ 2060 AB and derive luminosities and temperatures of the individual components. TWA 22, a member of the Beta Pictoris moving group whose age is particularly well constrained, displays a perfect agreement between dynamical mass determination and models predictions. Moreover, our orbital fit is fully consistent with previous estimates. On the other hand, GJ 2060 is a bona fide member of the ABDor moving group whose age constraint is loose. For the first time, we are able to derive a robust orbital determination that reveals a highly eccentric ($e \sim 0.9$) but clearly bound orbit. Models fail to give a total mass estimate consistent with the dynamical mass that we derive. In light of these case studies, we will discuss the precision of the models for PMS stars, and the possibility of hidden companions in those systems.

Poster 259

Occultations as a Window into Circumstellar Architecture: RW Aurigae

Joseph E. Rodriguez[1]; Ryan Loomis[1]; Stefano Facchini[2]; Thomas J. Haworth[3]; Sylvia Cabrit[4,5]; Richard A. Booth[6]; Catherine Dougados[5,7]; Eric Jensen[8]; Keivan G. Stassun[9,10]; Cathie J. Clarke[6]; William R. F. Dent[11]; Jerome Pety[12,4]

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It is known that planets form from the gas and dust in the protoplanetary disks surrounding young stellar objects (YSOs). What is not clear is what governs the large diversity of planet types and of planetary system architectures that are now being discovered by the thousands. The differences in the outcome of planet formation and the vast range in planetary system architectures are directly influenced by disk substructures and stellar companions. The archetype for the impact of binary interactions on disk evolution and possibly planet formation is the classical T Tauri star, RW Aurigae. With ongoing surveys like the AAVSO accumulating a century of photometric observations on RW Aurigae, we are now able to search for periodic phenomena on spatial scales of up to 20 AU. With recent ALMA observations of RW Aurigae, we are now able to resolve circumstellar features down to a few tens of AU,

with future observations being able to resolve down to a few AU. This overlap in spatial scale between photometry and interferometry allows a unique opportunity to link photometric occultation events to specific architectural features seen from ALMA. I will present our combined analysis of over a century of photometric observations and the new ALMA millimeter data for RW Aurigae, and discuss how we are beginning to link the observed occultations to specific architectural features.

The Time-Domain Spectroscopic Survey: Radial Velocity Variability in Dwarf Carbon Stars

Poster 260

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Dwarf carbon (dC) stars, main sequence stars showing carbon molecular bands, are an oxymoron. Only AGB stars can dredge carbon into their atmospheres from their cores. However, long-dead AGB stars may have enhanced (or polluted, depending on your mood) their companion stars via mass transfer. Indeed, this is known to be the case for several types of giants showing anomalous abundances, like the CH, Ba, and CEMP-s stars, all of which have a suspiciously high binary frequency. The dC stars may be the enhanced-abundance progenitors of most of these systems, but this requires a demonstrated high binary frequency for dCs. Our Time Domain Spectroscopic Survey, part of the Sloan Digital Sky Survey IV, targeted a large sample of dC stars for repeat spectroscopy to constrain the binary frequency and orbital properties. We analyzed radial velocity (RV) shifts between spectral epochs for a sample of 245 dC stars with a total of 547 spectra. We then compared this dC RV shift distribution to that of a control sample of objects with similar distributions of magnitude, color, and proper motion. Current results show a distinctly wider distribution in RV shifts in the dC stars compared to a well-chosen control sample.

Influence of Stellar UV Environment on Detecting Biosignatures and Pre-Biosignatures in the Atmospheres of Earth-like Planets Around Other Stars

Poster 261

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When we observe the first terrestrial exoplanet atmospheres, we expect to find planets around a wide range of stellar types, UV environments, and geological conditions. Since the first exoplanets available for characterization will be likely for M dwarf host stars, understanding the UV environment of these cool stars is a vital step in understanding the atmospheres of these planets (Rugheimer et al., 2015). Additionally the atmospheres of these planets will not been fixed in time. Earth itself offers many possible atmospheric states of a planet. We

set out to examine how an Earth-like planet at different geological epochs might look around other star types (Rugheimer & Kaltenegger, 2018). Additionally, we examine the plausibility of detecting prebiotically interesting molecules, such as HCN, NH_3, CH_4, and C_2H_6 in an early-Earth type atmosphere around stars with very different UV environments, an M dwarf and a solar analogue. We find that some of these molecules could be produced abiotically in a CO_2/CH_4/H_2 rich atmosphere with lighting and photochemistry. These molecules would be interesting to detect in an exoplanet atmosphere since they are known to be useful for key prebiotic chemical pathways. HCN, for example, is present at each of the initial photochemical reactions that produce lipids, amino acids and nucleosides, the three building blocks of life (Patel et al. 2015). We also look at the rise of oxygen and the detectability of combinations of biosignature gases throughout Earth history, modeling the great oxygenation event and Neoproterozoic oxygenation event around other star types. We show the VIS - IR spectral features, with a focus of the influence of the host star and UV stellar environment on the detectability of prebiotic and biosignatures in terrestrial exoplanet atmospheres.

Poster 262

A First Look At the Effect of Flares on Radial Velocity Observations in G Dwarfs: A Punch and a Splash?

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Sagan Fellow

We make an initial study of the radial velocity (RV) effects of flares in solar-like stars by turning to the nearest one: our Sun! This is part of a broader study of the RV effects of different magnetic region types using our own G2 star. We use SDO HMI to obtain radial velocities and AIA to collect FUV images (170 nm) across the solar disk every 4 hours throughout 2014, near a peak of the latest magnetic cycle. We use the 170 nm images to identify plage, network, and (apparent) flares. We defined flares as the brightest 170 nm pixels (at least 4x the quiet Sun average); inspection showed that many of these ”flicker” on and off, as expected for flares seen at a 4 hour cadence. The RV of the flare pixels were averaged in evenly stepped rings of constant limb angle μ to define the center-to-limb behavior. We find that flares are more strongly redshifted near disk center, and strongly blueshifted towards the limb. We interpret this as observing the flare impact (the ”punch”) in the chromosphere, compressing material away from the viewer, near disk center, and the horizontal ”splash” or expansion due to that impact towards the limb. Flare pixels show the largest scatter of any magnetic feature at fixed μ, consistent with seeing a variety of unevenly sampled events of different energy.

The flare RV(μ) curve is distinct form all other magnetic features and thus likely captures a distinct (flare) phemonenon. However the distribution of flaring pixels $N_{\rm flare}(\mu)$ shows an unexpected peak at disk center – there were almost no disk-center flares seen by the GOES satellite in 2014. We develop a plausible model for the $N_{\rm flare}$ distribution, and suggest a solution to this mystery.

SAINT-EX: Searching for exoplanets from the San Pedro Mártir Observatory

Poster 263

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In this contribution, we present the current status of the SAINT-EX (Searching And characterisINg Transiting EXoplanets) project that arises from the collaboration between the SAINT-EX Consortium and the Universidad Nacional Autónoma de México (UNAM). This venture has two main science objectives: i) To search for terrestrial planets orbiting ultra-cool stars, similar to the TRAPPIST-1 system, ii) To give ground-based support for the ESA CHEOPS space mission.

In order to achieve these goals, a fully robotic facility hosting a 1-m telescope is to be installed at the National Astronomical Observatory of México, in San Pedro Mártir. The facility's first light is foreseen in late Summer 2018 and will be used to perform a photometric follow-up of Northern Hemisphere stars in the search for signals of planetary transits. As a byproduct, it is expected the finding of rotational periods and long-term variability in the ultra-cool dwarfs monitored, that will help to significantly increase our understanding of the intrinsic activity of these fascinating stars.

Kinematics and dynamics of young star clusters with Gaia and Gaia-ESO

Poster 264

G.G. Sacco

INAF-Osservatorio Astrofisico di Arcetri

The mechanisms driving the formation and early evolution of star clusters are not well understood. To investigate this problem, our group started to study the structural and kinematical properties of young star clusters and star forming regions using high-resolution spectroscopy data of the Gaia-ESO Survey and, more recently, astrometry from Gaia. Here, I will show how these studies are challenging the current view on the dynamical evolution of star clusters.

Poster 265

Practical Gyrochronology: Lessons from Kepler in the Interpretation of Rotating Stellar Populations

Jennifer van Saders

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Kepler's high-precision, high-cadence, four-year-long lightcurves have enabled measurements of stellar surface rotation out to long periods and low amplitudes in a sample of many tens of thousands of stars. As such, this sample represents our first opportunity to face a challenge that will be common with future datasets: how do we interpret the information encoded in the rotation periods of a mixed and biased stellar population, particularly with respect to stellar ages? We present a forward modeling exercise in which we attempt to reproduce the observed distribution of rotation periods in the Kepler field stars by coupling rotational evolution models to a galactic stellar population model. We find that stars with Rossby number Ro > 2 are preferentially missing in the observed sample. We demonstrate that this threshold may correspond either to detection bias or to the onset of the weakened magnetic braking; in the latter case, it suggests that large samples of stars without detailed individual characterization can still be instrumental for refining our understanding of angular momentum evolution. We discuss future tests to robustly distinguish between these two scenarios. Second, subgiant ”contaminants” are common, with periods and colors entirely consistent with a dwarf population, but subject to markedly different period-age relationships. Evolutionary state information is therefore critical for the interpretation of the rotation periods, and fortunately now widely available with Gaia. Our exercise has shown that the naïve interpretation of rotational distributions can lead to severely biased age distributions, but that a more informed approach enables a rotating population to be a powerful tool both for inferring stellar parameters and testing our underlying rotational models.

Poster 266

An Open Source Injection and Recovery Tool and Measuring Transit Detection Efficiency in Ultracool Dwarfs Observed by K2

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We develop an extension to an open source Python framework called ”lightkurve” for high precision time series photometric signal injection and recovery with support for a range of astrophysical transients, including planetary transits, starspot rotation, stellar flares, and supernovae. These tools will provide support for measuring transit detection efficiency in ultracool dwarfs observed by K2. We are interested in our ability to recover various types of transits around dwarfs at the spectral type M/L transition; to investigate this, we inject transits that simulate planets from 0.5 to 3.5 Earth radii and of periods from 0.3 to 26 days and attempt to recover them. We find a threshold of detectability as a relation to orbital period and radius. These detection efficiencies allow us to calculate the probability of seeing planets around these stars as it relates to the planet occurrence rate for a certain type of planet. We can constrain the probability of seeing no planets around a given number of stars and put an upper limit on the planet occurrence rate. We have calculated an upper limit for planet occurrence for each type of planet around M/L dwarfs observed by K2.

Anelastic Models of Fully-Convective Stars: Differential Rotation, Meridional Circulation, and Residual Entropy

Poster 267

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University of Exeter; University of Colorado

Stars of sufficiently low mass are convective throughout their interiors; hence, they lack a "tachocline" akin to that found at the base of the Solar convection zone. They may, however, still possess internal differential rotation and meridional flows that can sculpt the magnetic fields built by convective dynamo action. Here, we present a series of 3D simulations of the interiors of fully convective stars, aiming partly to investigate how these internal flows vary in response to changes in the rotation rate or luminosity. Our models encompass the overall spherical geometry of the star, with the exception of a small excluded central region, and are conducted within the anelastic approximation (which retains the overall density stratification but filters out rapid acoustic waves). We consider both hydrodynamic and MHD cases: in the latter, a small seed magnetic field is introduced, amplified by dynamo action, and maintained by the flows against decay. We use these simulations to show that a theoretical model linking the differential rotation to the "residual entropy" can be used to provide reasonable estimates of the internal angular velocity profile given the flow at the surface (in some regimes). More generally, we examine the transition from solar-like to anti-solar differential rotation; the accompanying transition from multi-celled to single-celled meridional flows; the partial suppression of these flows by magnetic stresses and tensions; and the transport processes, and balances, that maintain the flows and fields.

Numerical simulation on the stellar wind from TRAPPIST-1.

Poster 268

T. Sakaue; K. Shibata
Kyoto University

We report the results of one-dimensional magnetohydrodynamic (MHD) simulation of the stellar wind from TRAPPIST-1. TRAPPIST-1 is a M8-type main sequence star with cooler temperature (2559K) and lower mass ($0.08 M_\odot$). The star is confirmed to have seven planets (Gillon et al. 2017) and thus greatly interested in not only by stellar astrophysics but also by astrobiology. The stellar wind or radiation from TRAPPIST-1 is the most important research subject to comprehend the interplanetary environment of TRAPPIST-1. Several solar wind theories, which have been examined observationally, are applied to the case of TRAPPIST-1. Among them, it is the plausible idea that the dissipation of the incompressible MHD wave leads to the heating and driving the stellar wind. For instance, Garraffo et al. 2017 succeeded in the three-dimensional MHD simulation of the stellar wind from TRAPPIST-1, by extending their solar wind model in which the incompressible MHD wave is exhausted by the turbulent dissipation. The incompressible MHD wave, on the other hand, is also affected not only by the turbulent dissipation but also by the nonlinear mode coupling, which leads to the formation of the shock wave and consequently contribute to heating the wind. This nonlinear process has been well investigated to account for the dynamics of the lower solar atmosphere (Kudoh & Shibata 1999) and driving the solar wind (Suzuki & Inutsuka 2005), but not discussed for the stellar wind from TRAPPIST-1. In this study, therefore, we performed the one-dimensional

MHD simulation to consider the nonlinear process of the incompressible MHD wave leading to the shock formation, and succeeded in reproducing the stellar wind from TRAPPIST-1.

Poster 269

A Homogeneous Study of Brown Dwarf Metallicities

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In this work we look at the metallicity of a large sample of Brown Dwarfs in a homogeneous way. Metallicity distributions for Brown Dwarfs remain largely unstudied due to the scarcity of publicly available models that include non-solar metallicities. We use the petitCODE atmospheric model grid computed for cold self-luminous cloudy objects (Samland et al. 2017, Mollière et al. 2015) which includes a wide range of metallicities and cloud sedimentation parameters together with the BACON (Bayesian Atmospheric CharacterizatiON, used in Samland et al. 2017) code for MCMC exploration of the parameter posterior distributions. We apply these tools on a large sample of publicly available spectral data of Brown Dwarfs including the SpeX Prism Library (Burgasser 2014).

Poster 270

Determination of surface rotation of Kepler solar-type stars

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Periodic modulations of stellar light curves may result from dark spots crossing the visible stellar disc. By studying spot-induced modulations, it is possible to learn about stellar surface rotation and magnetic activity. In this work, we analyze Kepler long-cadence data for a large sample of (~ 50000) solar-type stars ($T_{\text{eff}} < 5500$ K and $\log g > 3.5$), determining surface rotation periods for those with measurable spot modulation of the light curves. We use KADACS (Kepler Asteroseismic Data Analysis and Calibration Software; Garcìa et al. 2011) light curves obtained with three different filters (20-d, 55-d, and 80-d filters) and, for comparison, PDC-MAP (Presearch Data Conditioning - Maximum A Posteriori; e.g. Jenkins et al. 2010) light curves. The average surface rotation is obtained through the implementation of the methodology developed by Garcìa et al. (2014), which combines a time-frequency analysis based on wavelets and the auto-correlation function (e.g. McQuillan et al. 2014). Reliable rotation periods are finally determined by comparing the results for the three KADACS data sets and by comparing those with the results for the PDC-MAP light curves. We also take special care to identify possible classical pulsators and red giants which are polluting the target sample of solar-type stars.

UV Aurora on the Ultracool Dwarf LSR J1835+3259? Hubble Space Telescope Observations of its UV spectrum

Poster 271

Joachim Saur[1]; Christian Fischer[1]; Alexandre Wennmacher[1]; Paul D. Feldman[2]; Lorenz Roth[3]; Darrell F. Strobel[2]; Ansgar Reiners[4]

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An interesting question about ultracool dwarfs recently raised in the literature is whether their emission is purely internally driven or partially powered by external processes similar to planetary aurora known from the solar system. In this work we present Hubble Space Telescope observations of the energy fluxes of the M8.5 ultracool dwarf LSR J1835+3259 throughout the UV. The obtained spectra reveal that the object is generally UV-fainter compared to other earlier-type dwarfs. We detect the Mg II doublet at 2800 åand constrain an average flux throughout the Near-UV. In the Far-UV without Lyman alpha, the ultracool dwarf is extremely faint with an energy output at least a factor of 1000 smaller as expected from auroral emission physically similar to that on Jupiter. We also detect the red wing of the Lyman alpha emission. Our overall finding is that the observed UV spectrum of LSR J1835+3259 resembles the spectrum of mid/late-type M-dwarf stars relatively well, but it is distinct from a spectrum expected from Jupiter-like auroral processes.

The CT Cha system – reevaluation of the sub-stellar companion and the disk

Poster 272

T. Schmidt

Hamburg Observatory

CT Cha is with about 2 Myr of age one of the youngest systems in which a companion at the deuterium-burning limit was found. We combine new data taken from several observatories and instruments, including ESO SPHERE and HST, in addition to the original discovery data to reevaluate the nature of the sub-stellar companion based on longer wavelength coverage.

Among the properties of the co-moving companion, the different indications for accretion on the sub-stellar companion, ..., we focus on the disk around the star, now confirmed by several observatories and its properties as well as the SEDs of star and companion.

Poster 273

The Final BOSS Ultracool Dwarfs Sample

Sarah Jane Schmidt

Leibniz Institute for Astrophysics Potsdam [AIP]

We present the final BOSS Ultracool Dwarf (BUD) sample, which comprises 12,890 M7-L8 dwarfs photometrically selected from SDSS photometry and observed with SDSS low-resolution optical spectroscopy (from SDSS-I and -II as well as BOSS). Over 8000 of these dwarfs have parallaxes and proper motions from Gaia DR2. We use the updated distances from Gaia to recalculate color-magnitude relationships in SDSS and 2MASS colors, providing more precise distances for the entire BUD sample. Using these updated distances, we leverage the relationship between age and Galactic height to find that as expected, activity persists to very old ages in late- and early-L dwarfs. Unexpectedly, activity may be suppressed in the youngest (most nearby) dwarfs at the ML transition. We also combine proper motions, distances, and radial velocities measured from SDSS spectra to calculate three-dimensional kinematics for nearly 10,000 dwarfs. We find that there is a correlation between velocity dispersion and i-K, J-K, and J-W2 colors, confirming that these colors are not dependent on Teff alone, and are also affected by age-dependent quantities (likely surface gravity, cloud formation, and/or metallicity).

Poster 274

The stellar content of X-ray all-sky surveys

J. Schmitt; S. Freund; J. Robrade; P.C. Schneider

Hamburger Sternwarte

On March 29, 2019 the eROSITA-instrument will be launched onboard the SRG spacecraft. Upon arrival at L2, eROSITA will carry out an all-sky imaging X-ray survey in the energy band 0.2-10 keV lasting for four years, reaching an unprecedented sensitivity of 2×10^{-14} erg/cm^2/sec. The second most frequent source class among the expected more than three million X-ray sources, that eROSITA will detect, are magnetically active stars; thus eROSITA will produce the largest known sample of such objects. The identification of these active stars among the other X-ray source classes is a challenge, however, thanks to GAIA, an identification with a rather high degree of completeness and reliability is possible. We present our eROSITA stellar source identification strategy and our identification results when applied to the XMM-Newton slew survey and ROSAT all-sky X-ray survey.

Poster 275

Protoplanetary Accretion

P. C. Schneider

Hamburger Sternwarte

Accreting planets are thought to be bright Halpha sources and LkCa 15 is the first system where such accretion signatures have been claimed. I will present results from our HST campaign following-up these initial results. Our preliminary results indicate that our tailored observing strategy allows us reach very high contrast ratios that would allow us the detection of the claimed planetary signals.

Robustness of the recent solar g-mode detection

Poster 276

H. Schunker[1]; L. Gizon[1,2]

Max Planck Institute for Solar System Research; Georg-August-Universität Göttingen, Institut für Astrophysik

The most recent tentative detection of g-mode oscillations in the Sun has regenerated the field of helio- and astero-seismology to probe the cores of cool stars. I will show that the g-mode detection is fragile, and sensitive to the parameters in the analysis method. Moreover, I will show that the g-mode detection is extremely sensitive to the start time of the GOLF time series. I will also present preliminary tests to quantify the prospects for using this analysis method to detect g-modes on other cool Sun-like stars.

Spinning Worlds - The rotation of young gas giants and brown dwarf companions

Poster 277

H. Schwarz[1]; C. Ginski[2]; R. de Kok[3]; I. Snellen[2]; M. Brogi[4]; J. Birkby[5]; J. Fortney[1]; A. Skemer[1]

[1] UC Santa Cruz, [2] Leiden University, [3] Utrecht University, [4] University of Warwick, [5] University of Amsterdam

I present the first rotation measurements of directly imaged planets and brown dwarf companions, measured from the Doppler broadening of the spectral lines. The rotation influences weather and climate, temperature distribution, chemical mixing, and the magnetic field. More than that, the planetary spin is the result of accretion of angular momentum during the formation, and observing planetary spin rates may promote our understanding of the accretion process or even help differentiate between opposing formation scenarios.

The observed targets span a range of masses, ages and orbital distances, providing the first opportunity to compare the spin parameters of young exoplanets and brown dwarf companions. Although the observed sample is small, we do see a correlation of spin velocity with age, which we interpret as due to the youngest objects still accreting angular momentum and spinning up through subsequent cooling and contraction.

Activity and rotation effects on TiO and VO bands in M dwarf spectra

Poster 278

P. Schöfer

Institute for Astrophysics Göttingen

We present our measurements of activity indicators of M dwarfs in the CARMENES sample. In addition to chromospheric hydrogen, helium, sodium, and calcium lines in both the visual and the near-infrared arm of CARMENES, we monitor temperature-sensitive photospheric titanium oxide and vanadium oxide absorption bands. Besides discussing the connection between chromospheric activity and the strength of the photospheric absorption bands, we show that some stars exhibit periodic variations in these bands with the rotation period, providing evidence of a magnetic structure.

Poster 279

Do non-dipolar magnetic fields impact spin-down torques?

Victor See[1]; Moira Jardine[2]; Aline Vidotto[3]; Sean Matt[1]; Jean-Francois Donati[4]; Colin Folsom[4]; Sudeshna Boro Saikia[5]; Rim Fares[6]; Adam Finley[1]; Sandra Jeffers[7]; Stephen Marsden[8]; Matthew Mengel[8]; Julien Morin[9]; Pascal Petit[4]

University of Exeter; University of St Andrews; Trinity College Dublin; University of Toulouse; University of Vienna; Lebanese American University; University of Göttingen; University of Southern Queensland; University of Montpellier

Low-mass stars with outer convective zones are known to host strong magnetic fields at their surfaces. These fields drive angular momentum- & mass-loss leading to spin-down on the main sequence. One method by which stellar magnetic fields can be characterised is Zeeman-Doppler imaging. This is a powerful technique that can assess the strength and geometry of the large-scale magnetic fields of these stars. This is important because studies have shown that the open flux, which is geometry dependent, is the relevant magnetic property that determines the rate at which stars lose angular momentum.

In this poster, I estimate mass-loss rates and spin-down torques for a sample of stars that have been mapped with Zeeman-Doppler imaging. In total, this sample contains over 100 maps. Using the braking law of Finley & Matt (2018), I also determine whether non-dipolar magnetic field modes contribute to the spin-down torque of these stars. For the majority of the stars, only the dipolar field is important. However, there are regimes where the contribution of non-dipolar fields may be non-negligible.

Poster 280

Spectrophotometry of the DQ Her type Nova V5668 Sgr (2015)

Ilse Alejandra Aguilar Segoviano; Dennis Jack; Klaus Peter Schroder

Universidad de Guanajuato

For 9 months we were able to monitor the bright Nova V5668 Sgr (2015) with high-resolution spectroscopy, using the robotic 1.2m telescope TIGRE and its spectrograph HEROS (R=20.000). Interestingly, this nova turned out to be of the rare DQ Her type, which is characterized by curious, steep (within hours) dips in the lightcurve of 0.3 to 0.8 mag during the first 100 days, which do not coincide with any large changes in colour, followed by a recovery of the brightness within about a week. In this respect, with Nova V5668 Sgr, we compared of our spectra from the nights of 5 april (shortly before a maximum) with those of 11 april (shortly after the dip), and 28. april (a temporary maximum) with 1st May (the following dip).

To study the nature and origin of these sudden dips, we want to specify in absolute terms the respective contributions to the photometric changes by the emission line spectrum and by the continuum of the nova. Since TIGRE echelle spectra are only reduced to a relative flux scale, which changes from night to night, and in the case of emission lines it also depends on their strengths relative to the continuum, we needed to develop a strategy of spectrophotometric recalibration, which we present here, by means of a comparison star observed in the same nights.

The main result of this study is that the continuum, which originates in the WD photosphere, changes a lot more in these events, than the emission line spectrum.

Occurrence, mass distribution and orbital properties of Giant Planet, Brown Dwarfs and Very Low Mass Star companions to solar type stars.

Poster 281

Damien Segransan; Stéphane Udry

Observatoire de Genève

The historical CORALIE planet search program is on-going since 1998 and aims at monitoring solar type stars in the southern hemisphere within 50 pc of the Sun. Based on a sample of 1647 F-K dwarfs, the survey is able to detect any companions ranging form low mass stars to giant planets for periods up to 20 years. We present here a new statistical analysis of companions to solar type stars based on the unbiased CORALIE sample that allow us to update the occurence rate for giant planets, brown dwarfs and very low mass star companions. As expected, clear trends and differences emerge in the corresponding mass distributions and orbital elements comparison which brings additional constraints on the formation and evolutions of these objects.

Probing the High-Energy Radiation Environment of Exoplanets around Low-Mass Stars with SPARCS

Poster 282

E. L. Shkolnik[1]; D. Ardila[2]; T. Barman[3]; M. Beasley[4]; J. D. Bowman[1]; V. Gorjian[2]; D. Jacobs[1]; A. Jewell[2]; M. Knapp[5]; R. P. Loyd[1]; J. Llama[6]; V. Meadows[7]; S. Nikzad[2]; S. Peacock[3]; P. Scowen[1]; C. Spittler[1]; M. Swain[2]; R. Zellem[2]

Arizona State University; Jet Propulsion Laboratory; University of Arizona; Southwest Research Institute; Massachusetts Institute of Technology; Lowell Observatory; University of Washington

Roughly seventy-five billion M dwarfs in our galaxy host at least one small planet in the habitable zone (HZ). The stellar ultraviolet (UV) radiation from M dwarfs is strong and highly variable, and impacts planetary atmospheric loss, composition and habitability. These effects are amplified by the extreme proximity of their HZs (0.1-0.4 AU). Knowing the UV environments of M dwarf planets will be crucial to understanding their atmospheric composition and a key parameter in discriminating between biological and abiotic sources for observed biosignatures. The NASA-funded Star-Planet Activity Research CubeSat (SPARCS) will be a 6U CubeSat devoted to photometric monitoring of M stars in the far-UV and near-UV, measuring the time-dependent spectral slope, intensity and evolution of M dwarf stellar UV radiation. For each target, SPARCS will observe continuously over at least one complete stellar rotation (5 - 45 days). SPARCS will also advance UV detector technology by flying high quantum efficiency, UV-optimized detectors developed at JPL. These delta-doped detectors have a long history of deployment demonstrating greater than five times the quantum efficiency of the detectors used by GALEX. SPARCS will pave the way for their application in missions like LUVOIR or HabEx, including interim UV-capable missions. SPARCS may also be capable of 'target-of-opportunity' UV observations for the rocky planets in M dwarf HZs soon to be discovered by NASA's TESS mission, providing the needed UV context for the first habitable planets that JWST will characterize.

Poster 283

"Peter Pan" Disks: A New Type of Long-Lived Gas-Rich Circumstellar Disk

Steven M. Silverberg; Marc J. Kuchner; John P. Wisniewski

University of Oklahoma; NASA Goddard Space Flight Center

The Disk Detective project identified WISEA J080822.18-644357.3 (J0808-6443) as a disk-hosting member of the 45-Myr Carina association, making it the oldest M-type disk in a young known association identified to date. This system exhibits a much stronger infrared excess than is typically found around 45-Myr stars, suggesting a gas-rich system despite its age. Long lived gas-rich disks around dM stars suggest that the timefrare for planet formation around these stars is much longer than previously thought. However, these systems remain understudied; only three in total have been identified. We present new high-cadence photometry and near-infrared spectroscopy of J0808-6443, and discuss the mechanisms that could lead to long-lived gas disks.

Poster 284

Sizing Up Southern Red Dwarfs in the Solar Neighborhood

Michele L. Silverstein[1]; Todd J. Henry[2]; Wei-Chun Jao[1]; Sergio B. Dieterich[3]; Jennifer G. Winters[4]; Adric R. Riedel[5]; Kenneth J. Slatten[2]

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We present the first results from the Systematic Investigation of Radii and Environments of Nearby Stars (SIRENS) — the characterization of 512 nearby southern red dwarf primaries within 25 parsecs. We compare these stars with a control sample of roughly 60 PMS stars and 70 cool subdwarfs. Here we provide Johnson-Kron-Cousins VRI, 2MASS JHK, and WISE w1w2w3w4 photometry for 639 stars, including new/updated VRI photometry for 156 stars. Using parallax distances + optical, near-IR, and mid-IR photometry + spectral energy distribution (SED) model fitting as in Dieterich et al. 2014, we determine fundamental parameters (temperature, luminosity, radius, surface gravity, metallicity, and alpha enhancement) for the entire sample of southern dwarfs, young stars, and cool subdwarfs. We emphasize that this study determines these parameters for all southern red dwarfs with pre-GAIA parallaxes placing them within 25 parsecs, including the vastly under-studied late M dwarfs, currently difficult to resolve via optical or infrared interferometers such as the CHARA Array. We use a large/small radius as a marker of youth/age (pre-main sequence stars/subdwarfs), and compare our derived model radii to radii determined using interferometry to verify the accuracy of our technique. We identify roughly a dozen each of candidate PMS stars and previously unidentified subdwarfs within 25 parsecs.

IGRINS for the characterization of YSOs

Poster 285

K. R. Sokal[1]; G. N. Mace[1, 2]; L. Prato[3]; L. Nofi[3, 4]; D. T. Jaffe[1]

University of Texas at Austin; McDonald Observatory; Lowell Observatory; Institute for Astronomy, University of Hawaii

High-resolution, near-infrared spectra are optimal for characterizing YSOs and providing the foundation for our understanding of stellar evolution. We present an in-depth study of the star TW Hydra as an example of the characterization achievable with IGRINS, the Immersion GRating INfrared Spectrometer. By comparing the observed IGRINS spectra of TW Hydra to magnetic synthetic spectra from MoogStokes, we re-evaluate the stellar parameters of effective temperature, surface gravity, and magnetic field strength to identify an age of 8 Myr.

IGRINS has been obtaining high-quality spectra of YSOs in the Taurus star-forming region since its first light in 2014. Over 150 YSOs, including a substellar sample of 30 objects, in Taurus have been observed with IGRINS at the 2.7m Harlan J. Smith Telescope at McDonald Observatory and the 4.3m Discovery Channel Telescope of Lowell Observatory. The Taurus sample spans from K0 to M9 and includes Class I to Class III objects. With these observations, we have compiled a uniform dataset of a broad sample of YSOs of similar ages. In addition to this rich Taurus dataset, we have completed a complementary sample of targets in the younger Ophiuchus star-forming region, with IGRINS at McDonald Observatory and the 8.1m Gemini South telescope.

The influence of magnetic activity on the fundamental properties of cool stars

Poster 286

Garrett Somers

Vanderbilt University

Precise measurements of eclipsing binary (EB) parameters have revealed a consistent discrepancy between the predictions of stellar evolution models and the radii of young, low-mass stars. In short, active stars are often measured to be 10-20 percent larger and 5-10 percent cooler than model predictions for their mass, age, and composition. This so-called “radius inflation” problem has now been convincingly demonstrated on the pre-main sequence thanks in part to new EBs discovered in young clusters by the K2 mission. By altering the luminosity and effective temperature of young stars, radius inflation distorts the relationship between stellar observables and fundamental properties, dramatically biasing derived masses and ages of pre-main sequence objects. The underlying cause of radius inflation remains debated but must be understood if we are ever to accurately model early stellar evolution and derive correct ages for pre-main sequence clusters.

In this talk, I will argue that strong magnetic activity is the most likely physical mechanism driving this puzzling phenomenon. Magnetic activity is ubiquitous in young cool stars, and results from theoretical models of magnetic stars show that magnetic fields can alter the underlying mass-radius relation of cool stars through their influence on convective efficiency, and can produce color abnormalities driven by cooling their surfaces. I will discuss my efforts to model the impact of magnetic fields on stellar structure using a 1-D evolution code, and

detail some new results in reconciling stellar theory with observations of active stars. The inclusion of magnetic fields into theoretical isochrones hold the potential to radically improve the measured fundamental properties of pre-main sequence stars, better predict the age scale of young clusters, and more fully understand the chaotic H-R diagrams of pre-main sequence associations.

Poster 287

University of Arizona, Tucson, AZ 85719, USA ;

D. Souto[1]; K. Cunha[1,2]; V. Smith[3]; D. A. Garcia-Hernandez[4,5]; O. Zamora[4,5]; C. Allende Prieto[4,5]; S. R. Majewski[6]; J. Teske[7]

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National Optical Astronomy Observatory, 950 North Cherry Avenue, Tucson, AZ 85719; Instituto de Astrofísica de Canarias (IAC), Vía Lactea S/N, E-38205, La Laguna, Tenerife, Spain; Departamento de Astrofísica, Universidad de La Laguna (ULL), E-38206, La; Department of Astronomy, University of Virginia, Charlottesville, VA 22904-4325, USA ; Department of Terrestrial Magnetism, Carnegie Institution for Science, Washington, DC 20015; Chemical Abundances of M-dwarfs from the APOGEE Survey. I. The Exoplanet Hosting Stars Kepler-138 and Kepler-186 In this work, we present the first results of a detailed chemical study of M-dwarf star where we demonstrate that it is possible to obtain elemental abundances of up to thirteen elements (C, O, Na, Mg, Al, Si, K, Ca, Ti, V, Cr, Mn and Fe) from an LTE analysis of high-resolution near-infrared spectra, between 1.5 - 1.7 microns obtained by the APOGEE survey. Two M-dwarfs with exoplanets detected by the Kepler mission, Kepler-138 and Kepler-186 were analyzed. Our results indicate that both stars have near-solar metallicities, [Fe/H] = -0.09 and -0.08 dex, for Kepler-138 and Kepler-186, respectively. One interesting result obtained was that the star Kepler-186 exhibits an enrichment of silicon ([Si/Fe] = +0.18), and this element is important in controlling the internal structure of rocky planets.

Poster 288

Substellar companion in the Orion Nebula Cluster

Giovanni Maria Strampelli[1,2]; Jonathan Aguilar[3]; Antonio Aparicio[2,4]; Laurent Pueyo[3]; Massimo Robberto[1,3]

Space Telescope Science Institute, USA; Universidad de La Laguna, Spain; Johns Hopkins University, USA; Instituto de Astrofisica de Canarias, Spain;

Young binary stars provide us with coeval pairs of stars born in the same environment and with the same metallicity. Comparing their properties may provide key information on the early stages of stellar evolution, and constrain theoretical models developed to predict isochrones and evolutionary tracks during the Pre-Main- Sequence. We present new results relative to the population of substellar binaries in the Orion Nebula Cluster. We reprocessed HST data using an analysis technique recently developed to detect close companions in the wings of the stellar PSFs based on the PyKLIP implementation of the KLIP PSF subtraction algorithm. Starting from a sample of 4500 unique stars selected over a range of 10-22 mag (apparent magnitude, J-band), using the presence of the 1.4 micron H2O absorption feature in atmosphere, we were able to uncover 24 candidate companions for which we derive an estimate of their mass assuming a 2Myr isochrone and the reddening of their primary. With 3 stellar companions, 14 brown dwarfs and 7 planetary mass objects, these data provide us with an unbiased look at the low-mass end of the IMF and the transition from binary to planetary systems.

Feel the taste. First results from the recently commissioned PEPSI high-resolution spectrograph and polarimeter for the 2x8.4m Large Binocular Telescope

Poster 289

K. G. Strassmeier[1]; I. Ilyin[1]; S. Järvinen[1]; M. Steffen[1]; M. Mallonn[1]; E. Keles[1]; T. A. Carroll[1]; M. Weber[1]; E. Dineva[1]; C. Denker[1]; D. Sablowski[1]; M. Flores-Soriano[1]; C. E. Mack III[1]; A. Järvinen[1]; M. Woche[1]; M. C. Johnson[2]; C. Bender[3]; R. M. Wagner[4]; C. Woodward[5]; R. Gredel[6]

Leibniz-Institute for Astrophysics Potsdam [AIP], Germany; Department of Astronomy, Ohio State University, USA; Steward Observatory, University of Arizona, USA; Large Binocular Telescope Observatory [LBTO], Tucson, USA; Institute for Astrophysics, University of Minnesota, USA; Max-Planck-Institute for Astronomy, Germany

PEPSI is the new fiber-fed and stabilized "Potsdam Echelle Polarimetric and Spectroscopic Instrument" for the Large Binocular Telescope (LBT). It covers the entire optical wavelength range from 384 to 913 nm in three exposures at resolutions of either $R=\lambda/\Delta\lambda$=50,000, 130,000 or 250,000. The R=130,000 mode can also be used with two dual-beam Stokes IQUV polarimeters. The 50,000-mode with its 12-pix sampling per resolution element is our "bad seeing" or "faint-object" mode. A robotic solar-disk-integration (SDI) telescope feeds solar light to PEPSI during day time and a 450-m fiber feed from the 1.8m VATT can be used when the LBT is busy otherwise. CCD characterization and a removal procedure for the spatial fixed-pattern noise were the main tasks left from the commissioning phase. Several SDI spectral time series with up to 300 individual spectra per day recovered the well-known solar 5-minute oscillation at a peak of 3 mHz (5.5min) with a disk-integrated radial-velocity amplitude of only 47 cm/s. Spectral atlases for 50 bright benchmark stars including the Sun were recently released to the scientific community, among them the ancient planet-system host Kepler-444. These data combine PEPSI's high spectral resolution of R=250,000 with signal-to-noise ratio (S/N) of many hundreds to even thousands covering the entire optical to near-infrared wavelength range from 384 to 913 nm. Other early science cases were exoplanet transits including TRAPPIST-1, a spectrum of Boyajian's star that revealed strong and structured but stable ISM Na D lines, a spectrum of zeta Oph allowing a redetermination of the ISM Li line doublet, and a first Doppler image of the young solar analog EK Dra that revealed starspots with solar-like penumbrae. Home https://pepsi.aip.de

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Poster 290

Learning about cool stars with the BAaDE project

M. C. Stroh[1]; Y. M. Pihlström[1]; L. O. Sjouwerman[2]; M. J. Claussen[2]; M. R. Morris[3]; M. R. Rich[3]

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The circumstellar envelopes (CSEs) of evolved stars offer a method to construct a sample of point-masses along the full Galactic plane, which can be used to test models of the gravitational potential. In the CSEs of red giants, SiO maser emission is frequently observed at 43 and 86 GHz, providing line-of-sight velocities. The Bulge Asymmetries and Dynamical Evolution (BAaDE) project aims to explore the complex structure of the inner Galaxy and Galactic Bulge, by observing 43 GHz SiO at the Very Large Array and 86 GHz SiO at the Atacama Large Millimeter/submillimeter Array, with an expected final sample of about 20,000 line-of-sight velocities and positions. We will give an overview of the BAaDE survey, focusing on the comparison of the SiO 43 GHz and 86 GHz transitions. In particular, we observed 43 GHz and 86 GHz transition near-simultaneously in a subsample of the sources using the Australia Telescope Compact Array and found that on average the 43 GHz v=1 line is 1.3 times stronger than the 86 GHz v=1 line. The presence of a detectable 43 GHz v=3 line alters the statistics, consistent with the SiO masers displaying 43 GHz v=3 emission arising in a denser regime in the circumstellar shell compared to those without. Comparing our results with radiative models implies that the 43 GHz v=3 line is a tracer of density variations caused by stellar pulsations. We will discuss these results in the context of the BAaDE project.

Poster 291

Early Evolution of Infrared Sources of Protostellar Objects

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Korea Astronomy and Space Science Institute

We have studied early evolution of protostellar object in the star forming regions using IR survey data taken by space telescopes and ground-based telescopes. The time evolution of protostar, disk, and envelope in the protostellar object are explained. Especially, the quantitative variations in the physical parameters - such as brightness, temperature, radius, mass, and density - are estimated. We used virtual observatory to obtain the Spectral Energy Distributions (SEDs) of protostellar object. The SEDs of the protostellar object were classified according to the spectral class of protostar, and the relationship between physical parameters and age was studied. The physical parameters of central objects, disk and envelope were calculated by SED model fitting method. From these results, we found that 1) the SED spectral index of the protostellar object are ranges from 1.5 to -1.0, 2) the spectral class of the objects are 'Class I and Class II', and 3) the objects are hundreds of years old. As the time goes by, the density and temperature of the central protostar increase with decreasing size. The total mass and volume density of disk and envelope are decrease at the same time while the objects are expanding.

System IMF of the 25 Orionis Stellar Group

Poster 292

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The stellar initial mass function (IMF) has a great importance in astrophysics as it is vital for many studies but its behavior is still under discussion, specially in the low mass domain. We present the photometric determination of the system IMF of the 25 Orionis stellar group (25 Ori) from the planetary mass domain to the intermediate-mass regime. Working with optical and near-infrared photometry from DECam and the CIDA Deep Survey of Orion, as well as public data from Hipparcos, UCAC4, VISTA and 2MASS, we selected more than 1500 photometric member candidates of 25 Ori according to their positions in color-magnitude and color-color diagrams. This sample has an I_c range from 5.1 to 24.9 mag and covers a field of view of 2.2° in diameter encompassing the 25 Ori overdensity. We worked with a control field at the same galactic latitude of 25 Ori to estimate the contamination in the sample by field stars and extragalactic sources. To estimate the masses of the candidates we used the M_{I_c}-mass relations from the stellar models by Baraffe et al. (2015) and Marigo et al. (2017), resulting in a mass range from 12.9 $M_\odot$ down to 9 M_{Jup}. We estimated the uncertainties in the derived IMF due to the distances and visual extinctions generated for the member candidates without Gaia parallaxes or reported extinctions. We fitted a segmented power law, a log-normal and a tapered power law functions to the resulting IMF to compare their parameters with those in other star forming regions. Finally, we present the progress in the follow-up spectroscopy to assign the membership of the candidates in order to determine the IMF with a statistically complete sample of confirmed members. So far, this spectroscopic survey is $\sim$85% complete using data from GTC/Osiris (Downes et al. 2015), MMT/Hectospec, SDSS-III/APOGEE-2, SDSS-III/BOSS (Suárez et al. 2017) and OAN-SPM/Echelle.

An effective temperature scale for red supergiants in the Magellanic clouds

Poster 293

H. M. Tabernero[1]; R. Dorda[1]; I. Negueruela[1]; C. González-Fernández[2]

Universidad de Alicante; Institute of Astronomy, University of Cambridge

We present a self-consistent study of cool supergiants (CSGs) belonging to the Magellanic clouds. We derived stellar atmospheric parameters (Teff and [M/H]) using KURUCZ and MARCS atmospheric models for more than 400 stars by fitting a careful selection of weak metallic lines. We explore the significance of the temperature scale in two different metallicity environments (each Magellanic cloud). Critical and in-depth tests have been performed to assess the reliability of our calculated stellar parameters (i.e. internal error budget, any tentative systematic offset, ...). In addition, several robust statistical tests have been carried out to infer the significance of the Teff scale found. Our results point towards a unique Temperature scale that does not depend on the environment.

Poster 294

A Near-Infrared Search for Transiting Exoplanets around Brown Dwarfs with the 1.8-m Perkins Telescope

Patrick Tamburo; Philip S. Muirhead

Boston University

The characterization of atmospheres of Earth-sized exoplanets in the JWST era will require planetary targets around very small host objects, such ultra-cool dwarf stars and brown dwarfs. While the recent discovery of the TRAPPIST-1 system points to a wealth of planets around ultra-cool dwarfs, a planet transiting a brown dwarf has yet to be discovered. In this work, we discuss plans for a multi-year search for transiting exoplanets around brown dwarfs using the Mimir instrument on the 1.8-m Perkins Telescope in Anderson Mesa, AZ. By performing detailed simulations of this survey, we predict the discovery of about three planets over the course of five years. We also measure our planet recovery completeness for different planet radii and orbital periods using actual Mimir data. Finally, we estimate the fraction of habitable planets that will be discovered by the survey.

Poster 295

Radio detection of ultracool dwarfs with FAST

Jing Tang

NAOC

Ultracool dwarfs (UCDs) are a new class of radio emitters. In the past two decades, more than 20 UCDs have been detected GHz radio emissions, indicating they have kG magnetic fields. How such strong fields generate and sustain in fully convective objects is a big challenge to current dynamo theory. The physical conditions associated with these radio-active objects have been investigated, but the understanding is still limited due to the small sample. As the world's largest single dish radio telescope, the Five-hundred-meter Aperture Spherical Telescope (FAST) has high sensitivity. It can observe from 70MHz to 3GHz, with full polarization measurement, very suitable to detect highly circularly polarized radio emission from UCDs, and even giant exoplanets. Here we will estimate possible radio emissions from UCDs and check if they can be detected by FAST.

Poster 296

Weather on Other Worlds: The Three Most Rapidly Rotating Ultra-Cool Dwarfs

M. Tannock[1]; S. Metchev[1]; A Heinze; P[2]. Miles-Páez[1]; A. Burgasser[3]

University of Western Ontario; Institute for Astronomy, University of Hawaii; University of California, San Diego

We present the discovery of rapid photometric variability in three ultra-cool dwarfs from long-duration monitoring with the Spitzer Space Telescope. The T7, L3.5, and L8 dwarfs have the shortest photometric periods known to date: 1.08, 1.14, and 1.23 hours respectively. We investigate the effects of this fast rotation and constrain the physical parameters of the T7 dwarf, the fastest of the three rotators, using R=6000 near-infrared spectroscopy. While the three objects spin at likely < 50

The measurement of M dwarf Fe and TI abundances with Habitable Zone Planet Finder spectra

Poster 297

Ryan Terrien[1]; Suvrath Mahadevan[2]; Chad Bender[3]; Sam Halverson[4]; Joe Ninan[2]; Larry Ramsey[2]; Paul Robertson[5]; Arpita Roy[6]; Gudmundur Kari Stefansson[2]

Carleton College; Penn State; University of Arizona; MIT; UC-Irvine; Caltech

The measurement of M dwarf abundances is foundational for the study of these stars, the conditions and histories of their planets, and their place in the formation and evolution of the Galaxy. The complexity of M dwarf stellar spectra has historically precluded the spectroscopic modeling that would enable direct and precise abundance determinations. However, recent work has demonstrated that state-of-the-art model predictions of Fe and Ti line strength variations in R$\sim$25,000 Y-band spectra of M dwarfs can be empirically calibrated to construct a generally-applicable technique for measuring Fe and Ti abundances in M dwarfs. We explore the applicability of this technique in M dwarf spectra obtained with the Habitable Zone Planet Finder, a precision radial velocity spectrograph (R$\sim$55,000 over 820-1300nm) that is designed to detect exoplanets orbiting nearby M dwarfs. We consider the effects of telluric contamination and correction on this abundance-determination technique, as well as advantages offered by the high resolution of the Habitable Zone Planet Finder. This technique will be a powerful tool for HPF, complementing and extending the scientific value of spectra obtained through its primary mission of surveying M dwarfs for exoplanet companions.

Probing Accretion and Inner Disk of Very Low Accretors

Poster 298

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The current paradigm of the evolution in low mass pre-main sequence stars (T Tauri Stars; TTS) is magnetospheric accretion, according to which gas from the inner region of their protoplanetary disks falls onto the stars along the stellar magnetic field lines that truncate the disk at a few stellar radii. Although studies have shown that the accretion termination timescale and the primordial dust disk evolution timescale may be similar, the connection is less clear for gas disks around stars with very low accretion rates, and in particular, it is unclear how accretion stops. Here we report FUV, Optical, and NIR observations of three TTS in the Orion OB1b subassociation with an age of 5 Myr, the critical age in disk evolution in which 80 percent of disks have dissipated. The presence of the inner gas disk is inferred from FUV observations of H_2 λ1600 excess emission; magnetospheric accretion is probed by Hα and the He I λ10830 line, which suggest that our targets have low or no accretion. One of the accreting TTS (Classical TTS; CTTS) has a primordial disk based on the SED but shows only a marginal detection of FUV H_2 emission. Another CTTS has a transitional disk but shows

a conspicuous excess of FUV H_2. The last target is a non-accretor with no primordial disk, in agreement with non-detection of FUV H_2. Different accretion and disk evolution stages found at the same age suggests that accretion ends in diverse ways.

Poster 299

Filling in for *Gaia*: Parallaxes of Ultracool Objects with *WISE*

Christopher A. Theissen
UC San Diego

This project uses the multi-epoch astrometry from the *Wide-field Infrared Survey Explorer* (*WISE*) to demonstrate a method to measure proper motions and trigonometric parallaxes with precisions of $\sim$4 mas yr^{-1} and $\sim$7 mas, respectively, for low-mass stars and brown dwarfs. This method relies on *WISE* single exposures (Level 1b frames) and a Markov Chain Monte Carlo method. This method can be applied to objects outside the limits of *Gaia* for observing very low-mass stars and brown dwarfs (L, T, and Y dwarfs fainter than $G \approx 19$). This method is applied to *WISE* data of 43 nearby ($<$ 20 pc) dwarfs with spectral types between M6 and Y2, some with previously measured trigonometric parallaxes.

Poster 300

Computing Models of M-type Host Stars and their Panchromatic Spectral Output

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We have begun a program of computing state-of-the-art model atmospheres from the photospheres to the coronae of M stars that are the host stars of known exoplanets. For each model we are computing the emergent radiation at all wavelengths that are critical for assessing photochemistry and mass-loss from exoplanet atmospheres. In particular, we are computing the stellar extreme ultraviolet radiation that drives hydrodynamic mass loss from exoplanet atmospheres and is essential for determing whether an exoplanet is habitable. The model atmospheres are computed with the SSRPM radiative transfer/statistical equilibrium code developed by Dr. Juan Fontenla. The code solves for the non-LTE statistical equilibrium populations of 18,538 levels of 52 atomic and ion species and computes the radiation from all species (435,986 spectral lines) and about 20,000,000 spectral lines of 20 diatomic species.

The first model computed in this program was for the modestly active M1.5 V star GJ 832 by Fontenla et al. (ApJ 830, 152 (2016)). We will report on a preliminary model for the more active M5 V star GJ 876 and compare this model and its emergent spectrum with GJ 832. In the future, we will compute and intercompare semi-empirical models and spectra for all of the stars observed with the HST MUSCLES Treasury Survey, the Mega-MUSCLES Treasury Survey, and additional stars including Proxima Cen and Trappist-1.

The Luminosities of Y-Type Brown Dwarfs

Poster 301

Chris Tinney; Jacqueline Faherty; J. Davy Kirkpatrick

UNSW Sydney; American Museum of Natural History; IPAC Caltech

Gaia is ushering in a new era of astrometry-led fundamental properties for astronomy in general, and cool stars and brown dwarfs in particular. Sadly Gaia will tell us next to nothing about a critical class of objects - the coldest Y- and T-type brown dwarfs. They have to be targeted one at a time in the infrared from the space or the ground. We will present updated and improved luminosities for our sample of late-T and Y dwarfs being observed with the Magellan Baade telescope, and looking at what the colour-magnitude diagrams of these objects tell us about the atmospheres of these poorly understood objects. PLUS, we'll also show our latest binary orbit for Luhman16AB, now based on 5 years of resolved data taken with a single instrument.

TIGRE in pursue of a relation between the rotation velocity of stars and the physical properties of their exoplanets

Poster 302

L. Flor Torres; R. Coziol; K.P. Schröeder; D. Jack

Universidad de Guanajuato

A sample of 29 stars with exoplanets was observed with the TIGRE telescope at the observatorio La Luz in Guanajuato, using the HEROS Echelle spectrograph. The data were analysed in a semi-empirical way using iSpec, to deduce the basic physical characteristics of the stars: their effective temperature, surface gravity and metallicity. The relatively high resolution and good signal to noise of the spectra also allow constraining the micro and macro turbulence velocities to deduce with more precision the rotational velocity of the stars, v sin i. Comparing the stars with planets, we find a clear trend for the angular momentum of the orbit of the planets classified as Hot Jupiter to increase with the rotational velocity of its host star. However, for the more massive exoplanets, classified as Self Gravitating (SGE), no such trend is observed. The SGEs also seem to have higher ellipticities on than the hot Jupiters. These differences could be explain assuming different compositions for the Hot Jupiter and SGEs.

Poster 303

Predicting the Asteroseismic Surface Effect from 3D Convection Simulations

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Observed p modes of stars (including our Sun) have systematically lower frequencies than predicted by models, traced to inadequacies in our modeling of the surface layers. This is where convection deviates substantially from the mixing-length (MLT) formulation, and where convection both dampens and stochastically excites p modes. All these phenomena affect p-mode frequencies, producing the asteroseismic surface effect. We show the asteroseismic surface effect has a contribution from the convective expansion of stellar atmospheres (structural part), as well as from direct interactions between convection and modes (modal part). We present new results for the modal part computed directly from realistic 3D simulations of deep, convective atmospheres and combine it with our previous work on the structural part.

Poster 304

Exoplanet-induced Radio Emission from M Dwarfs

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University of Leicester

We consider the magnetic interaction of exoplanets orbiting M-dwarfs, calculating the expected Poynting flux carried upstream along Alfvén wings to the central star. A region of emission analogous to the Io footprint observed in Jupiter's aurora is produced, and we calculate the radio flux density generated near the surface of the star via the electron-cyclotron maser instability. We apply the model to produce individual case studies for the TRAPPIST-1, Proxima Centauri, and the dwarf NGTS-1 systems. We predict steady-state flux densities of up to ~ 10 μJy and sporadic bursts of emission of up to ~ 1 mJy from each case study, suggesting these systems may be detectable with the Very Large Array (VLA) and the Giant Metrewave Radio Telescope (GMRT), and in future with the Square Kilometre Array (SKA). Finally, we present a survey of 85 exoplanets orbiting M-dwarfs, identifying 11 such objects capable of generating radio emission above 10 μJy.

Jets in T Tauri stars

Poster 305

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Young stars are surrounded by a inflating and outflowing matter in the form of disks, winds and possibly jets. Using archival long-slit data taken by Hubble Space Telescope for binary T Tauri stars, which has previously been analyzed to study the properties of these stars themselves, we searched for the extended emission, which indicated presence of a jet. By looking at the data in the vicinity of [O I] lines, which are typical for jets but cannot be formed in the dense environment of the stellar photosphere, we identified three candidate stars - UY Aur, DF Tau, FV Tau C. By analyzing the extended emission for each of these stars more closely we were able to determine the speed and the flux for the jets.

Superflares and their biological effects on the habitability of planets

Poster 306

Adriana Valio; Raissa Estrela; Luisa Cabral

Center for Radio Astronomy and Astrophysics Mackenzie, Mackenzie University

Young stars and fully convective stars are very active and frequently produce superflares. We present the study of two active stars, Kepler-96 and TRAPPIST-1. The first star harbors a Super-Earth planet orbiting very close to it. With an age of 2.2 Gyr, this star is at the same stage of the Sun when the first multicellular organisms appeared on Earth. TRAPPIST-1 is a red dwarf with 7 terrestrial planets in orbit, three of them within the stellar Habitable Zone (HZ). Here we analyze the flares observed from the stars, inferring their physical properties such as duration (few minutes) and energy released by each flare. The biggest flare observed was found to have an energy of 1.810^{35} ergs, that corresponds to the energy range of the superflares found in literature. In addition, we analyze the biological impact of these superflares on a hypothetical Earth around Kepler-96 and the three TRAPPIST-1 planets within the HZ. Several atmospheric scenarios were tested: an Archean atmosphere and Present-day atmospheres with and without oxygen. The presence of an ocean was also included in our study. We estimated the UV flux produced by the superflare and concluded that life would only survive on the surface of Kepler-96b if there were already an ozone layer present on the planet atmosphere, or in an ocean of a few meters deep.

Poster 307

Observations of Disks Around RV Tau Variables with the Submillimeter Array

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Vanderbilt University; NASA Goddard Space Flight Center; Smithsonian Astrophysical Observatory; Fisk University; Harvard-Smithsonian Center for Astrophysics; Massachusetts Institute of Technology

RV Tau stars are variable supergiants that may be a crucial step in the evolution of low to intermediate mass stars with binary companions. The presence of a circumbinary disk may have an important impact on the orbital evolution of these systems. The association between disks, binarity, and the RV Tau long-term variability (i.e. RVb signature) had remained elusive until the Kepler spacecraft's observation of the RV Tau star, DF Cyg (Vega et al. 2017). Based on modeling of the Kepler light curve, radial-velocity data, and the spectral energy distribution for DF Cyg, we argued that the RVb phenomenon is likely to be fundamentally connected to a circumbinary disk revealed by infrared excess. However, as with most RV Tau stars, the lack of flux measurements longward of 20 microns restricts modeling of the SED and disk parameters. It is only at long wavelengths such as 800–1000 microns that the optically thin emission of the disk can be sampled and used to constrain key properties such as overall disk mass and total size for these systems. We have obtained flux measurements at 230 GHz for an RVb variable, U Mon, with the Smithsonian Submillimeter Array (SMA). Our SMA measurements provide a crucial lynchpin in the SED for determining the parameters of the disk surrounding these stars, while the images provide direct measurements of its size. The measurement for U Mon and a future sample of RV Tau variables will test the disk obscuration scenario that we put forward in Vega et al. (2017).

Poster 308

Magnetic activity cycles in open cluster NGC 6811

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The sun shows a magnetic activity cycle related to the occurrence of spots on its surface with a strong periodicity of 11 years. With the advent of space missions like CoRoT and Kepler, astronomers began to try and find ways to associate the photometric variability of the star with its intrinsic magnetic activity. Photometric proxies for activity appear to be correlated with the chromospheric S index and p-modes from asteroseismology. In order to investigate the existence and properties of magnetic cycles in a narrow range of fundamental parameters, we studied solar-type stars in the intermediate-age open cluster NGC 6811.

We tested cluster membership using astrometric solutions from Gaia DR2 for Kepler stars, using known members from previous studies and PARSEC isochrones as guides for our analysis. Then we restricted our sample to stars with $0.95 \leq M/M_{\odot} \leq 1.05$, with masses retrieved from the revised KSPC DR25. We determined rotation periods for all these stars using both a generalized Lomb-Scargle periodogram and the Auto-Correlation Function (ACF).

Taking into consideration the individual subtleties of each photometric activity index, we searched our sample for cycle-like periodicities, and in each case classified the variability as

either cyclic, flat, or acyclic. Some appear to present two distinct cycle patterns, which raises a question about how common it is to have a second cycle such as the solar 3-year cycle. We checked the usual correlations between P_{cyc}, P_{rot} and Rossby number and find a high degree of dispersion among them, which casts doubt on the existence of the Active branch.

We introduce theoretical questions about what determines the activity cycle period and whether there is some sort of fundamental difference between cyclic and acyclic stars. The comparison between stars with the same mass, age and chemistry suggests that neither of these properties is truly decisive.

Chemo-kinematic Ages of Low-Mass Stars

Poster 309

Mark J. Veyette

Boston University

The age of a star is one of its most fundamental properties, and one of the most difficult to measure accurately. Once on the main-sequence, M dwarf stars change imperceptibly in their temperature and luminosity, necessitating novel statistical techniques for estimating their ages. We introduce a new method to infer ages of M dwarfs using a combination of kinematics and alpha element enrichment, both shown to correlate with age for Sun-like FGK stars. We leverage the chemical and kinematic evolution of the Galaxy to develop a semi-empirical, probabilistic age-dating method. Utilizing new methods to directly measure titanium and iron abundances of M dwarfs from their high-resolution NIR spectra, we estimate the ages of several eccentric-planet-hosting M dwarfs. Tidal effects are expected to circularize the orbits of short-period planets around M dwarfs on short timescales. However, we find a number of mildly eccentric, close-in planets orbiting old stars. For these systems, we use our ages to constrain the tidal dissipation parameter, Q, of the planets. For two mini-Neptune planets, GJ 176 b and GJ 536 b, we find they have tidal Q values more similar to the ice giants than the terrestrial planets in our Solar System. We measure relatively old ages and high tidal Q values for GJ 436 b and GJ 876 d, suggesting they either have undergone significant tidal evolution or are influenced by an unseen companion. Ages of planet-hosting M dwarfs now allow us to investigate exoplanet evolution in the regime of low host-star mass.

Poster 310

Radio emission from a young exoplanet and its host star wind

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Magnetised exoplanets are expected to emit at radio frequencies, analogously to the radio auroral emission of Earth and Jupiter. Here, we predict the radio emission from V830 Tau b, the youngest (2 Myr) detected exoplanet to date. We model the wind of its host star using three-dimensional magnetohydrodynamics simulations that take into account the reconstructed stellar surface magnetic field. Our simulations allow us to constrain the local conditions of the environment surrounding V830 Tau b that we use to then compute its radio emission. We also estimate the thermal radio emission from the stellar wind itself and compare it with VLA and VLBA observations of the system, constraining therefore the stellar mass-loss rate. We estimate that the frequency-dependent extension of the radio-emitting wind is around 3 to 30 stellar radii for frequencies in the range of 275 to 50 MHz, implying that V830 Tau b, at an orbital distance of 6 stellar radii, could be embedded in the regions of the host-star's wind that are optically thick to radio wavelengths, but not deeply so. The V830 Tau system is a very interesting system for conducting radio observations from both the perspective of radio emission from the planet as well as from the host-star's wind.

Poster 311

The Importance of Cool Stars in Stellar Population Synthesis Models

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University of California Santa Cruz

The physical structure, past history, and current properties of a galaxy all go into shaping its observed integrated light spectrum. Stellar population synthesis (SPS) models work to infer the physical properties of galaxies – star formation rate, metallicity, total mass in stars – by matching observed spectra to synthetic spectra created by the sum of the spectra of stars potentially hosted by the galaxies. The foundational element to any SPS model is the underlying stellar library. To trust the results from SPS models, stellar libraries must have extensive stellar parameter space coverage, large wavelength coverage, and the stars included in the library must have accurate stellar parameters. The inclusion of cool stars in stellar libraries are of particular interest and particular difficulties mainly due to their paucity at low-metallicity. We have recently released a new optical to near-infrared stellar library, the Extended IRTF Library, and spectral interpolator that uses the library to create data driven stellar spectra as a function of stellar parameters. We will discuss how the new library and interpolator enable us to better characterize the cool dwarf regime in our SPS models and the effect that has on our ability to infer galactic properties.

Lyman-alpha transit observations of the warm rocky exoplanet GJ1132b

Poster 312

W. Waalkes[1]; Z. Berta-Thompson[1]; D. Charbonneau[2]; J. Irwin[3]; E. Newton[4]; J. Dittmann[4]; V. Bourrier[5]; D. Ehrenreich[5]; Eliza Kempton[6]

[1] University of Colorado, Boulder; [2] Harvard University; [3] Smithsonian Astrophysical Observatory; [4] Massachusetts Institute of Technology; [5] Observatoire de Geneve; [6] Grinnell College

GJ1132b is one of the few known Earth-sized planets, and at 12pc away it is also one of the closest known transiting planets. With an equilibrium temperature of 500 K, this planet is too hot to be habitable but we can use it to learn about the presence and volatile content of rocky planet atmospheres around M dwarf stars. Using Hubble STIS spectra obtained during primary transit, we search for a Lyman-α transit. If we were to observe a deep Lyman-α transit, that would indicate the presence of a neutral hydrogen envelope flowing from GJ1132b. On the other hand, ruling out deep absorption from neutral hydrogen may indicate that this planet has either retained its volatiles or lost them very early in the star's life. We carry out this analysis by extracting 1D spectra from the STIS pipeline, splitting the time-tagged spectra into higher resolution samples, and producing light curves of the red and blue wings of the Lyman-α line. We fit for the baseline stellar flux and transit depths in order to constrain the characteristics of the cloud of neutral hydrogen gas that may surround the planet. We do not conclusively detect a transit but the results provide an upper limit for the transit depth. We also analyze the stellar variability and Lyman-α spectrum of GJ1132, a slowly-rotating 0.18 solar mass M dwarf with previously uncharacterized UV activity. Understanding the role that UV variability plays in planetary atmospheres and volatile retention is crucial to assess atmospheric evolution and the habitability of cooler rocky planets.

A Young Quadruple System in Upper Sco Cen

Poster 313

Ji Wang; Trevor David; Lynne Hillenbrand; Dimitri Mawet

Caltech

We will talk about the discovery and characterization of EPIC 203868608

Poster 314

Gemini Planet Imager Spectroscopy of the Extremely Red Brown Dwarf Companion HD206893 B

Kimberly Ward-Duong[1,2]; Jennifer Patience[3]; Robert De Rosa[4]; Abhijith Rajan[5]; Julien Rameau[6]; Kate Follette[1]; and the GPIES Team

Amherst College; Five College Astronomy Department; Arizona State University; UC Berkeley; Space Telescope Science Institute; U. de Montreal

From the Gemini Planet Imager Exoplanet Survey, we present new near-infrared spectroscopy of the brown dwarf HD206893 B, a substellar companion orbiting within the debris disk of an F5V star. New H, K1, and K2 spectra with GPI demonstrate the extraordinary red color of the object, presenting a challenging atmosphere to model with existing model grids. Multi-epoch astrometric monitoring of the system suggests a probable semimajor axis of 10 au, well within the estimated disk inner radius of 50 au. As the second brown dwarf imaged within the innermost region of a debris disk, the properties of this system offer important dynamical constraints for companion-disk interaction and a useful benchmark for brown dwarf and giant planet atmospheric study.

Poster 315

Latest Results on Proxima Cen's Stellar Cycle

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Harvard-Smithsonian Center for Astrophysics

Until very recently, it was generally assumed that fully convective stars can not support magnetic activity cycles, an assumption challenged by some theoretical work and then overturned by the discovery of multi-year stellar cycles in at least seven stars of type M4 or later (Suarez-Mascareno et al. 2016). The best studied example is Proxima Cen (dM5.5e) with a 7-year cycle revealed by 15 years of ASAS optical monitoring and intermittent X-ray and UV observations (Wargelin et al. 2017). We present an update on Proxima that includes new data from ASAS-SN, Swift, XMM-Newton, and Chandra.

Poster 316

PEPSI radial velocity accuracy

M. Weber; K. Strassmeier; I. Ilyin

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PEPSI is the new bench-mounted fiber-fed and stabilized "Potsdam Echelle Polarimetric and Spectroscopic Instrument" for the Large Binocular Telescope (LBT). It covers the entire optical wavelength range from 383 to 914 nm in three exposures at resolutions of either $R = \lambda/\Delta\lambda = 43,000$, 120,000 or 250,000. A robotic solar-disk-integration telescope feeds solar light to PEPSI during day time and a 450-m fiber feed from the VATT can be used to feed PEPSI. We demonstrate the radial velocity accuracy of spectra taken with both the LBT and the VATT, and the mid and long term stability of the spectrograph. Furthermore we show first results from our automatic parameter determination pipline derived from the PARSES pipeline working at the STELLA echelle spectrograph.

A primer on reliable rotation period determination

Poster 317

J. Weingrill

Leibniz-Institut für Astrophysik Potsdam [AIP]

The applicability and usage of gyrochronology hinges on the determination of the true rotation period of the star, overwhelmingly from time series photometry. A proper photometric period determination of light-curves is crucial for scientific interpretation like gyrochronology. Such photometry may be via ground-based observations, or increasingly, space-based (e. g. CoRoT, Kepler, K2, TESS, PLATO2.0, ...). Each of these has merits, and has its place in the variability/rotation period landscape. Using examples from both, I plan to present ways to plan observing strategies where possible, to prepare the time-series data for analysis, and then to extract the rotation period itself. Space-based data are essentially unfiltered, and permit no real control over the observing cadence, but provide great precision. These high-cadence data allow well-known mathematical methods for period determination like Fourier analysis, the commonly-used autocorrelation technique and the powerful Wavelet analysis. And different observation time scales and cadences do have an impact on interpretability on periods as well as the signal-to-noise-ratio that can be achieved. Ground-based data, on the other hand, allow filtered and targeted observations over long (even multi-year) baselines, with precise control over the cadence (which could potentially even be randomized, although subject to the weather and the day-night cycle). Even robotic observatories like e.g. OGLE and STELLA suffer from daily observational gaps that require different tools to overcome the problems introduced by the observational window namely Generalized Lomb Scargle (GLS), Clean and Phase Dispersion Minimization (PDM).

Great care must be taken for the preparation of the ensemble of light-curves to mitigate instrumental or observational artifacts. And in most cases, the application of multiple methods is necessary. Even the correct selection of these ensembles might turn out to be crucial.

The reciprocal detection of transiting exoplanets around cool stars

Poster 318

R. Wells[1]; K. Poppenhaeger[1]; C.A. Watson[1]; R. Heller[2]

Queen's University Belfast; Max Planck Institute for Solar System Research

The detection of thousands of extrasolar planets by the transit method naturally raises the question of whether potential extrasolar observers could detect the transits of the Solar system planets, and in particular those of the Earth. In this talk I will present an analysis of the regions in the sky from where transit events of the Solar system planets can be detected - named "transit zones". I will discuss how probable it is to detect one or more Solar system planet, the timescales over which they are valid, plus the current list of known exoplanets in these zones and the prospects of finding temperate extrasolar planets which could observe transits of Earth. I will also report on a habitable zone candidate situated in one of the transit zones - a super-Earth near the inner-edge of the HZ of an early M-dwarf. We hope to find more systems with the ongoing Kepler-K2 mission.

Poster 319

Moderate Resolution Spectroscopy of Substellar Companion Kappa Andromeda b

Kielan Wilcomb[1]; Quinn Konopacky[1]; Travis Barman[2]; Jessie Brown[2]; Laci Brock[2]; Bruce Macintosh[3]; Jean-Baptiste Ruffio[3]; Christian Marois[4]

UC San Diego; University of Arizona; Stanford University; NRC-Herzberg

Recent direct imaging of exoplanets has revealed a population of Jupiter-like objects that orbit their host stars at wide separations (10-100 AU). These objects have masses between 2-14 M_{Jup} and effective temperatures between 500-2000 K, posing major problems for planet formation models. OSIRIS observations of directly imaged planets have expanded our understanding of their atmospheres, shed light on their formation, and revealed individual molecular lines. Here, we present OSIRIS K band spectra of the "Super-Jupiter," Kappa Andromeda b. Kappa Andromeda b has a lower mass limit at the deuterium burning limit, but also has an uncertain age, which may indicate the source is a higher mass brown dwarf. The spectra reveal resolved molecular lines from H_2O and CO. We measure abundances for H_2O, CH_4, and NH_3 that were consistent with previous measurements done by Todorov et. al (2016). We also measure the abundance of CO for the first time for this object. The spectra were modeled using PHOENIX atmospheric modeling to calculate a log(g) 3.5 which may indicate a young source with a 30 Myr age, rather than 200 Myr age previously found by Hinkley et. al (2013). We derive the C/O ratio for the source to provide insight into possible formation pathways. We also compare our results to atmospheric properties of other brown dwarfs and gas giant planets in an effort to improve our knowledge of intricate atmospheres of young, substellar objects.

Poster 320

Spot activity of V889 Herculis

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V889 Herculis is a young solar analog, with an estimated age of 30-50 million years. The star shows evidence of strong magnetic activity. This is seen as large starspots, which we resolve through Doppler imaging. We present Doppler imaging temperature maps based on spectral observations collected from 1999 to 2007, along with photometric data from 1994 to 2017. In the photometric record, an approximately 10 year long activity cycle is seen, as well as a trend of decreasing mean magnitude, lasting from cycle to cycle. This suggests a gradually increasing activity level. We study how this photometric trend is related to the spottedness and mean surface temperature retrieved from the Doppler images.

Measurements of M dwarf stellar wind mass-loss rates

Poster 321

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University of Warwick; UT Austin; Smithsonian Astrophysical Observatory

M dwarfs have emerged as prime targets in the search for habitable planets beyond the Solar system. However, the increased stellar activity that such planets will undergo, relative to Solar system planets, may have detrimental effects on their evolution and habitability. In particular, little is known about the effects of stellar wind due to the paucity of stellar wind rate measurements.

Here we present ultraviolet spectroscopy of a sample of close M dwarf-white dwarf binaries obtained using the Cosmic Origin Spectrograph onboard the Hubble Space Telescope. Accretion of material from the M-dwarf wind results in the contamination of the pure hydrogen atmosphere of the white dwarfs with traces of C, O, Si and other metals. Modelling the photospheric abundances allows us to measure the accretion rate onto the white dwarf and the composition of the M dwarf wind. From these measurements, we derive the stellar wind rate as a function of M dwarf type and spin period, and discuss the potential implications for planetary systems.

Information theoretic approach to discovering causalities in solar cycle

Poster 322

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The causal parameters and response lag times of the solar cycle dynamics are investigated with transfer entropy, which can determine the amount of information transfer from one variable to another. The causal dependency of the solar cycle parameters is bidirectional. The transfer of information from the solar polar field to the sunspot number (SSN) peaks at lag time (τ) $\sim$ 30-40 months, but thereafter it remains at a persistent low level for at least 400 months ($\sim$ 3 solar cycles) for the period 1906-2014. The latter may indicate the persistency of the polar fields from cycle to cycle. It may also lend support to the idea that the polar fields from the last 3 or more solar cycles can affect the production of SSN of the subsequent cycle. There is also a similarly long term information transfer from the SSN to the polar field. Both the meridional flow speed and flux emergence (proxied by the SSN) transfer information to the polar field, but one transfers more information than the other, depending on the lag times. The meridional flow speed transfers more information to the polar field than SSN at $\tau \sim$ 28-30 months and at $\tau \sim$ 90-110 months, which may be consistent with some flux transfer dynamo models and some surface flux transport models. However, the flux emergence transfers more information to the polar field than the meridional flow at $\tau \sim$ 60-80 months, which may be consistent with a recently developed surface flux transport model. The transfer of information from the meridional flow to SSN peaks at $\tau \sim$ 110-120 months ($\sim$ 1 solar cycle), suggesting that the meridional flow can be used to predict SSN about one cycle ahead. Work is being undertaken to perform similar analysis with stellar cycles. Preliminary results and comparisons with solar cycle are presented.

Poster 323

A Study Star Formation in the Outer Galaxy

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The wealth of infrared data provided by recent infrared missions such as Spitzer, Herschel, and WISE has yet to be fully mined in the study of star formation in the outer galaxy. The nearby galaxy and massive star forming regions towards the galactic center have been extensively studied. However the outer regions of the Milky Way, where the metallicity is intermediate in value between the inner galactic disk and the Magellanic Clouds, has not been systematically studied.

We use Spitzer/IRAC's GLIMPSE (Galactic Legacy Infrared Mid-plane Survey Extraordinaire) observations of the galactic plane at 3.6, 4.5, 5.8, and 8.0 microns to identify young stellar objects (YSOs) via their disk emission in the mid-infrared. A tiered clustering analysis is then performed: preliminary large scale clustering is identified across the field using a Density-Based Spatial Clustering of Applications with Noise (DBSCAN) technique. Smaller scale sub clustering within these regions is performed using an implementation of the Minimum Spanning Tree (MST) technique. The YSOs are then compared to known objects in the SIMBAD catalogue and their photometry and cluster membership is augmented using available Herschel and WISE photometry. The Robitaille models are applied to the YSOs to obtain best fit stellar and disk masses to their SEDs. We then compare our results to those in the inner galaxy to determine how dynamical processes and environmental factors affect the star formation efficiency. These results will have applications to the study of star formation in other galaxies, where only global properties can be determined.

We will present here the results of our initial investigation into star formation in the outer galaxy using the Spitzer observations of the SMOG field.

Poster 324

A Spectroscopic Census of All Mid-to-late M Dwarfs Within 15 Parsecs

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Within 15 pc, there are 456 stars with masses 0.1 - 0.3 the solar value. This sample represents a tremendous opportunity to study these fully convective stars near the bottom of the main sequence; these are also the only viable targets for the study of terrestrial exoplanet atmospheres. Yet, our knowledge of this population is woefully incomplete: thirty percent have no published spectrum, while forty percent have only low-resolution spectroscopic measurements available from the literature.

We are conducting a multi-epoch, high-resolution spectroscopic survey of these stars that lie within 15 pc via acurate trigonometric parallaxes. In the northern hemipshere, observations with the Tillinghast Reflector Echelle Spectrograph (TRES) on the 1.5m telescope at the Fred Lawrence Whipple Observatory (FLWO) on Mt. Hopkins, AZ, are complete. The southern part of this survey is underway using CHIRON at the Cerro Tololo Inter-American Observatory / Small and Moderate Aperture Research Telescope System (CTIO/SMARTS) 1.5m. We present here results from our TRES survey. We report systemic radial velocities,

rotational broadening, and H-alpha equivalent widths for 305 stars, as well as preliminary orbits for eight new spectroscopic binaries that we have discovered. In addition, our photometric monitoring of these objects with the MEarth Observatory provides rotation periods and constraints on large flares.

Our survey will more than triple the number of these stars with complete high-resolution spectroscopic and trigonometric characterization. We will provide a legacy dataset for the use of future generations of astronomers.

This work is being supported by grants from the National Science Foundation and the John Templeton Foundation.

XOcube: Smallsat Exploration of the Exospheres of nearby Hot Jupiters Orbiting X-ray Bright Stars

Poster 325

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We describe a science mission concept for XOcube, a series of smallsats which will monitor X-ray bright exoplanet hosts during exoplanet transit using miniature focusing X-ray optics (MIXO) telescopes. The depth and duration of the of the flux change will allow us to characterize the exopspheres of multiple hot Jupiters in a single year. In addition, the long baselines of the out of transit data will allow us to characterize the temperature, flux and flare rates of the exoplanet hosts at an unprecedented level.

Characterizing the Coronal Properties of Main Sequence Stars with Chandra/LETGS Spectra

Poster 326

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We analyze the X-ray spectra of 19 main sequence stars observed by Chandra/LETGS. Emission measure (EM) distributions and coronal abundances are measured from emission lines in the spectra. We find that the EM distributions correlate with surface X-ray flux (F_X) in a predictable way, regardless of spectral type. Thus, we provide EM distributions as a function of F_X that can be used to estimate the EM distribution of any main sequence star with a measured broadband X-ray luminosity. Unlike the EM distributions, coronal abundances are very spectral-type dependent. Surprisingly tight correlations with surface temperature are seen for both relative and absolute abundances. The fractionation of elements during coronal heating is a crucial diagnostic for the coronal heating process, so exploring the spectral type dependence of this fractionation is potentially a fruitful avenue for testing different heating mechanisms. Finally, we note that the exoplanet host star τ Boo has anomalous coronal abundance characteristics, suggesting that the presence of a close-in massive exoplanet may be affecting the star's coronal abundances.

Poster 327

Lyman Alpha Reconstructions of Young, Active M Dwarfs with the FUMES Dataset

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UV stellar radiation can control chemistry and mass-loss in planetary atmospheres due to the large, wavelength-dependent photoionization cross sections of common atmospheric molecules. Thus, characterizing the UV spectral energy distribution of an exoplanet host star is critical for evaluating the origin of any atoms or molecules detected in planets. H I Lyman alpha (1215.67 å) dominates the far-UV spectrum of M dwarfs, but strong absorption from neutral hydrogen in the interstellar medium makes direct observations of the intrinsic Lyman alpha emission from even the closest stars challenging. The Far-Ultraviolet M-dwarf Evolution Survey (FUMES) has observed 10 early-to-mid M dwarfs with ages ranging from 10 Myr to several Gyr's to evaluate how the incident UV radiation evolves throughout the lifetime of exoplanetary systems. We have reconstructed the intrinsic Lyman alpha profiles of the targets and report the detection of broad >1000 km s^{-1} wings of the Lyman alpha line profile, resulting from Doppler diffusion out of the highly optically thick line core. We show how the intensity of Lyman alpha and its broad wings evolves with stellar age and activity.

Poster 328

Atmospheric Retrieveal of Cool Y Dwarfs

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Brown dwarfs' near-infrared spectra contain a wealth of information which can reveal the physical and chemical processes that occur in their atmospheres. Using a recently developed atmospheric retrieval model, we are able to constrain various molecular abundances, along with photometric radius, gravity, cloud optical depths, and temperature profiles for a set of ultra-cool (T8-Y1) dwarfs observed with the Hubble Space Telescope Wide Field Camera 3. From these spectra, we are able to constrain the abundances of water, methane, ammonia, CO, CO_2, H_2S, and Na+K. Using the retrieved abundances of water and methane, we are able to determine the atmospheric carbon-to-oxygen ratios and metallicities for these objects. We also identify a continuing trend of alkali metal depletion towards cooler effective temperatures likely due to the formation of optically thin Na_2S and KCl clouds. Finally, we make predictions for how such constraints will be improved by the James Webb Space Telescope's NIRSpec and MIRI instruments.

Survival Function Analysis of Planet Size and Orbital Distributions

Poster 329

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Survival Function Analysis, when applied to Planet Size and Orbital Distributions, identify breaks in planet properties @ 2, 4, 10 Earth radii, and reveal that small planets (<4 Earth radii) are distributed log-uniform in semi-major axis a or orbital period P up to an inner threshold of 0.05 AU. The difference in the slopes of survival function of small versus large exoplanets could be interpreted as a result of different planet migration mechanisms.

Properties of metal-poor very low-mass stars and brown dwarfs

Poster 330

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L subdwarfs are composed of metal-poor very low-mass stars and brown dwarfs. We used the UKIDSS and SDSS to search for L subdwarf candidates. Spectroscopic follow ups were carried out with the GTC/OSIRIS and the VLT/X-shooter. We have identified 34 new L subdwarfs verified by spectroscopy. We classified L subdwarfs into sdL, esdL and usdL subclasses based on a new classification scheme (Zhang et al. 2017a, MNRAS, 464, 3040). We developed a procedure to assess the substellar status of metal-poor objects based on their effective temperatures and metallicities, and identified the most metal-poor substellar object (Zhang et al. 2017b, MNRAS,468, 261). There are nine halo transition brown dwarfs whose luminosities are partially generated from unsteady hydrogen fusion in their cores. They lie in a 'substellar subdwarf gap' which covers a narrow mass range but a wide temperature range from mid L to early T types (Zhang et al. 2018a, MNRAS, arXiv:1805.08033). Based on the sample of 65 known L subdwarfs, we studied the population properties of L subdwarfs by comparing their spectral type, subclass and colours to those of L dwarfs and main sequence stars. The sdL, esdL and usdL subclass sequences are well separated on some optical to near-infrared colour-colour plots. We found that about one third of these 65 known L subdwarfs are likely substellar objects and two thirds of them are very low-mass stars (Zhang et al. 2018b, submitted). We will also present Gaia observations of L subdwarfs.

Poster 331

A Pan-STARRS1 Proper-Motion Survey for Young Brown Dwarfs in the Nearest Star-Forming Regions and a Reddening-Free Classification Method for Ultracool Dwarfs

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Constructing complete samples of young brown dwarfs in the solar neighborhood is of prime importance to investigate the universality of the low-mass initial mass function (IMF). Based on photometry and proper motions from the Pan-STARRS1 (PS1) 3π Survey, we are conducting the widest and deepest brown dwarf search in the nearby star-forming regions, Taurus–Auriga (Taurus) and Upper Scorpius (USco). Our work is the first to measure proper motions for brown dwarf candidates in Taurus and USco over such a large area and long time baseline (≈15 yr) with such high precision (≈4 mas yr^{-1}). Since extinction complicates spectral classification, we have developed a new approach to quantitatively determine reddening-free spectral types, extinctions, and gravity classifications for mid-M to late-L ultracool dwarfs ($\approx 100-5$ M$_{\rm Jup}$) using low-resolution near-infrared spectra. So far, our spectroscopic follow-up has increased the substellar census of Taurus by $\approx 50\%$ and almost doubled the substellar census of USco, constituting the largest single increases of brown dwarfs and free-floating planets found in both regions to date. Most notably, our new discoveries reveal an older ($>$10 Myr) low-mass population in Taurus, in accord with recent studies of the higher-mass stellar members. The mass function appears to differ between the younger and older Taurus populations, possibly due to incompleteness of the older stellar members or different star formation processes. Upon completion, our survey will establish the most complete substellar and planetary-mass census in both Taurus and USco associations.

Poster 332

Systematic search for young active stars in large spectroscopic surveys

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Stellar activity is one of the crucial parameters in exoplanetary research. It does not only directly affect planetary environments but can also mimic their signals and introduce radial velocity jitter. It manifests itself in a wide range of emission intensities in the strongest spectral lines and makes a systematic search for such stars in large stellar surveys straightforward. Here we present systematic data-driven and model-independent search of field active single stars in large stellar surveys. It is based on direct comparison of inactive and active stars with the same atmospheric parameters, both drawn from large databases of stellar surveys. Such approach proved successful in the RAVE survey (calcium infrared triplet - Ca II IRT) and resulted in 38,000 candidates for active stars. Similar results from the Galah survey (H alpha and Lithium line) will be presented. Starting this year and aiming at observing two million stars with Gaia G<12.5, FunnelWeb survey will observe and characterise every star that TESS will find a planet around. It will cover all optical wavelengths and enable a direct calibration between traditionally studied Ca II HK and Ca II IRT. This is especially important for M dwarfs as their signal is stronger in infrared wavelengths.

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