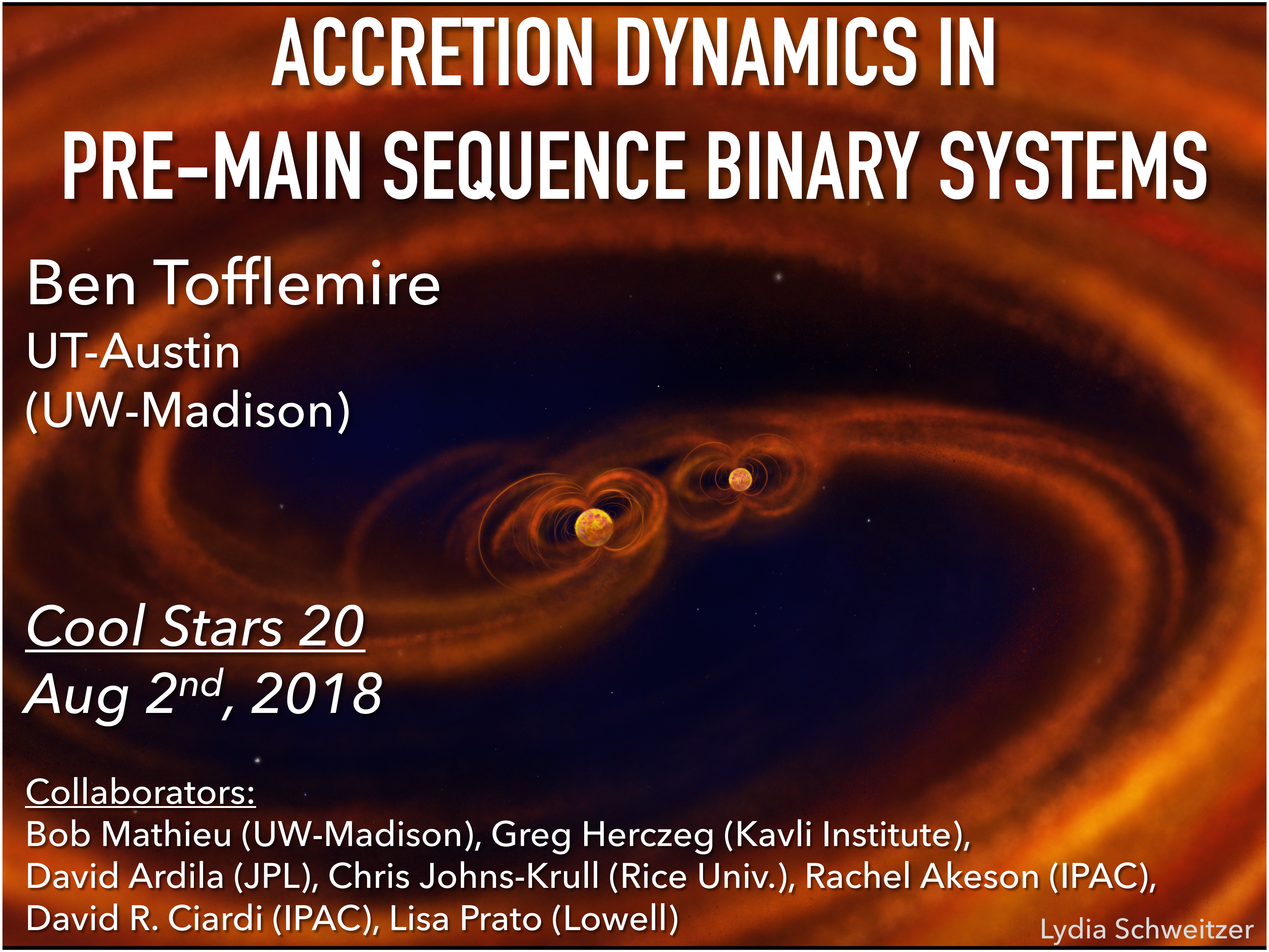


ACCRETION DYNAMICS IN PRE–MAIN SEQUENCE BINARY SYSTEMS

Ben Tofflemire

UT-Austin

(UW-Madison)

Cool Stars 20

Aug 2nd, 2018

Collaborators:

Bob Mathieu (UW-Madison), Greg Herczeg (Kavli Institute), David Ardila (JPL), Chris Johns-Krull (Rice Univ.), Rachel Akeson (IPAC), David R. Ciardi (IPAC), Lisa Prato (Lowell)

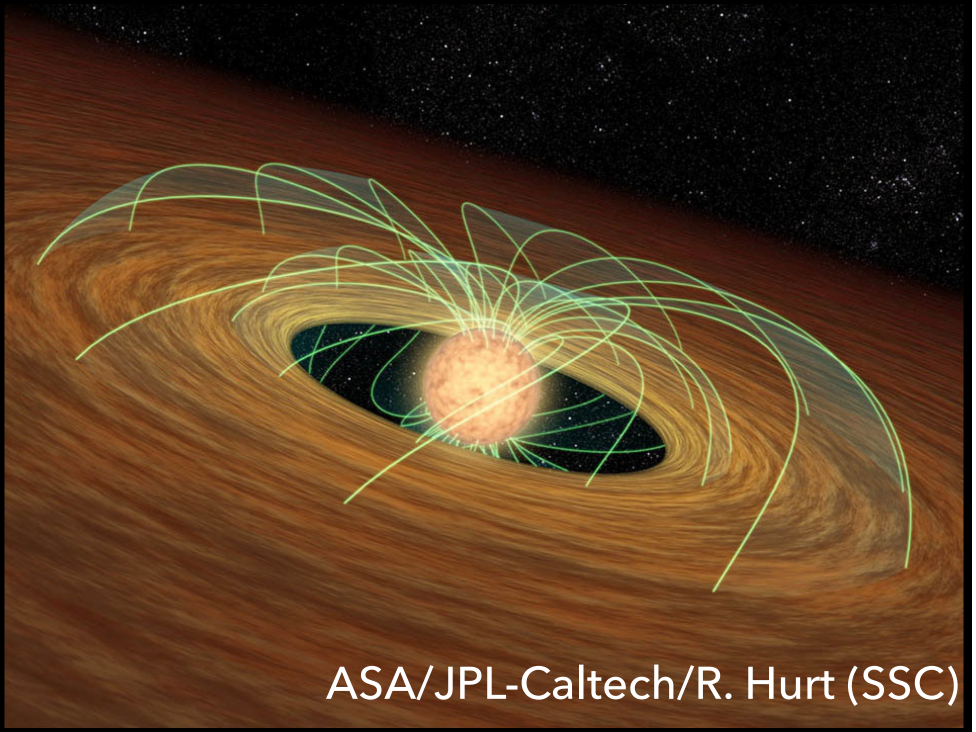
Lydia Schweitzer

The Star-Disk Interaction

Stellar Implications

- Gain ~10% of total mass

- Disk-locking determines angular momentum evolution



Disk & Planet Implications

- Disk evolution timescale & stability
  - Consumption rate: accretion & outflows (winds, jets)
  - Planet Formation & Migration

- Disk Chemistry/Photoevaporation
  - Hard radiation from accretion & magnetic activity (rotation)

The Star–Disk Interaction

Stellar Implications

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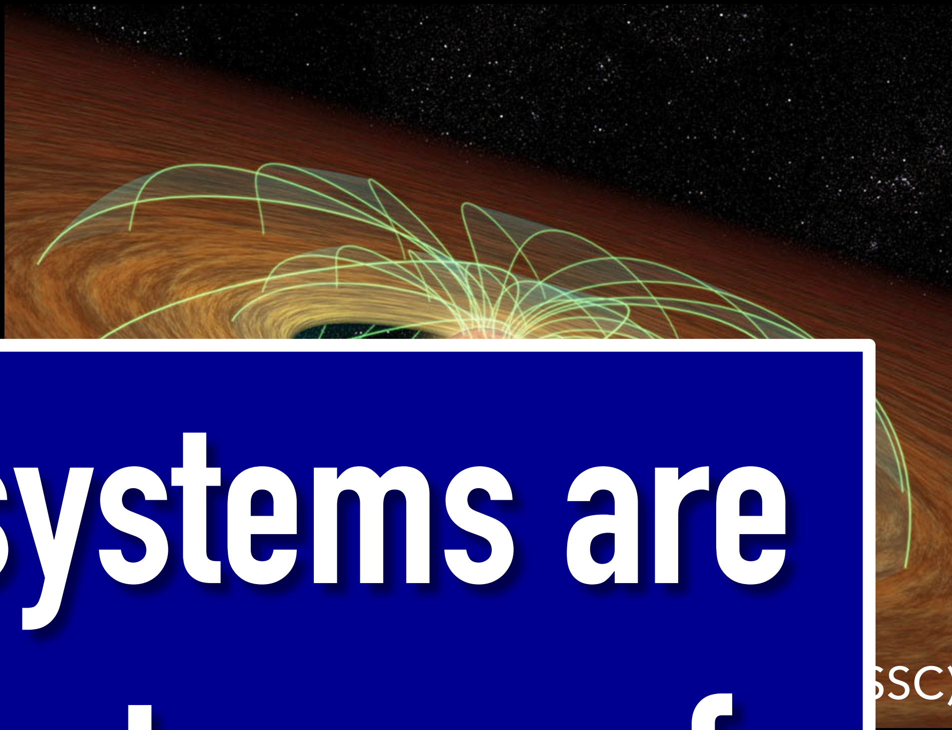


But! Binary systems are a common outcome of star formation!!!

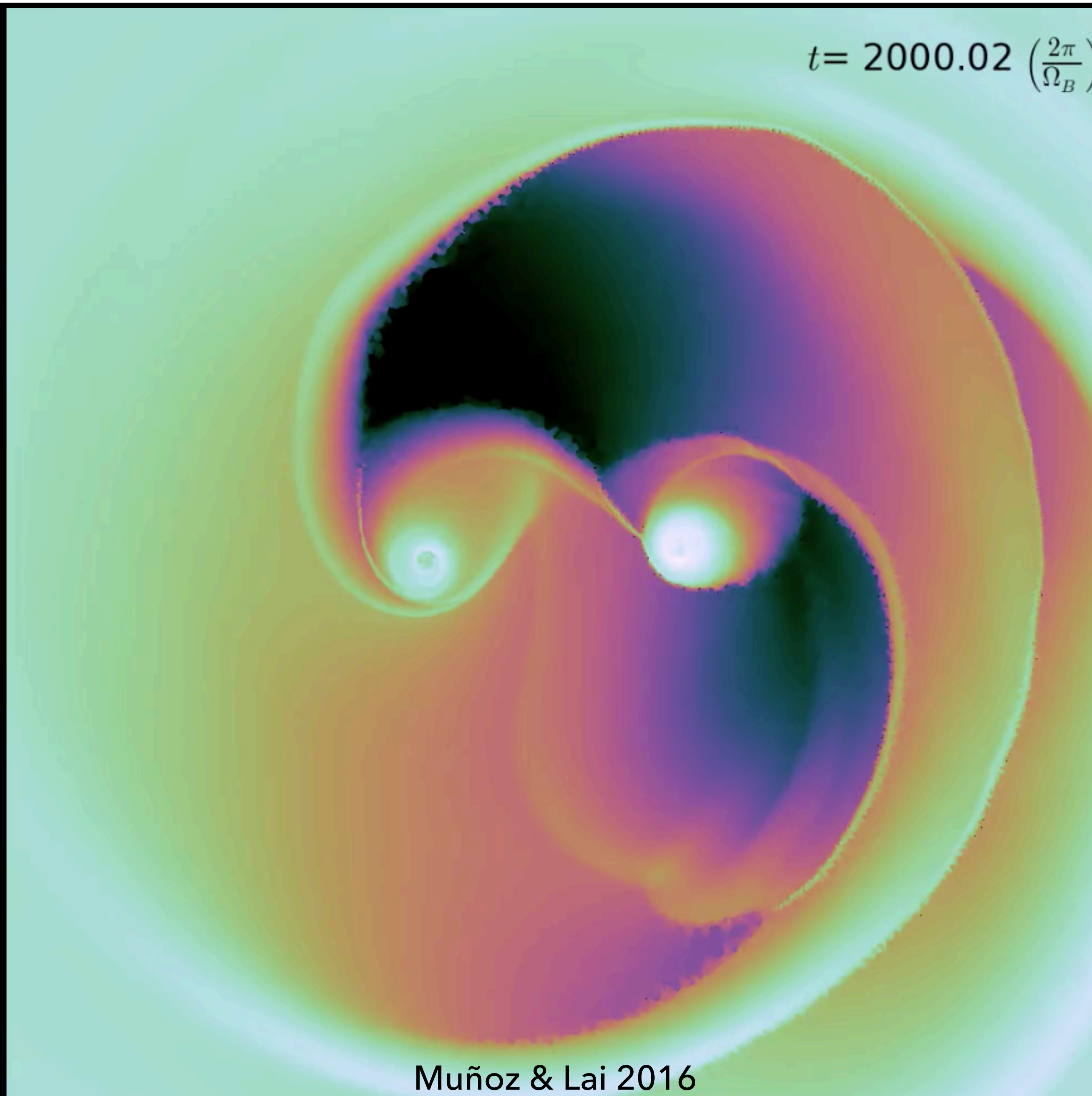
Eccentric Binary Accretion

Simulation:

- AREPO (Voronoi AMR)
- >2000 orbital periods simulated
- Scale free
- e = 0.5; q=1.0
- Includes gravity and gas physics only

Results:

- Accretion streams at every orbital period
- Periastron accretion bursts



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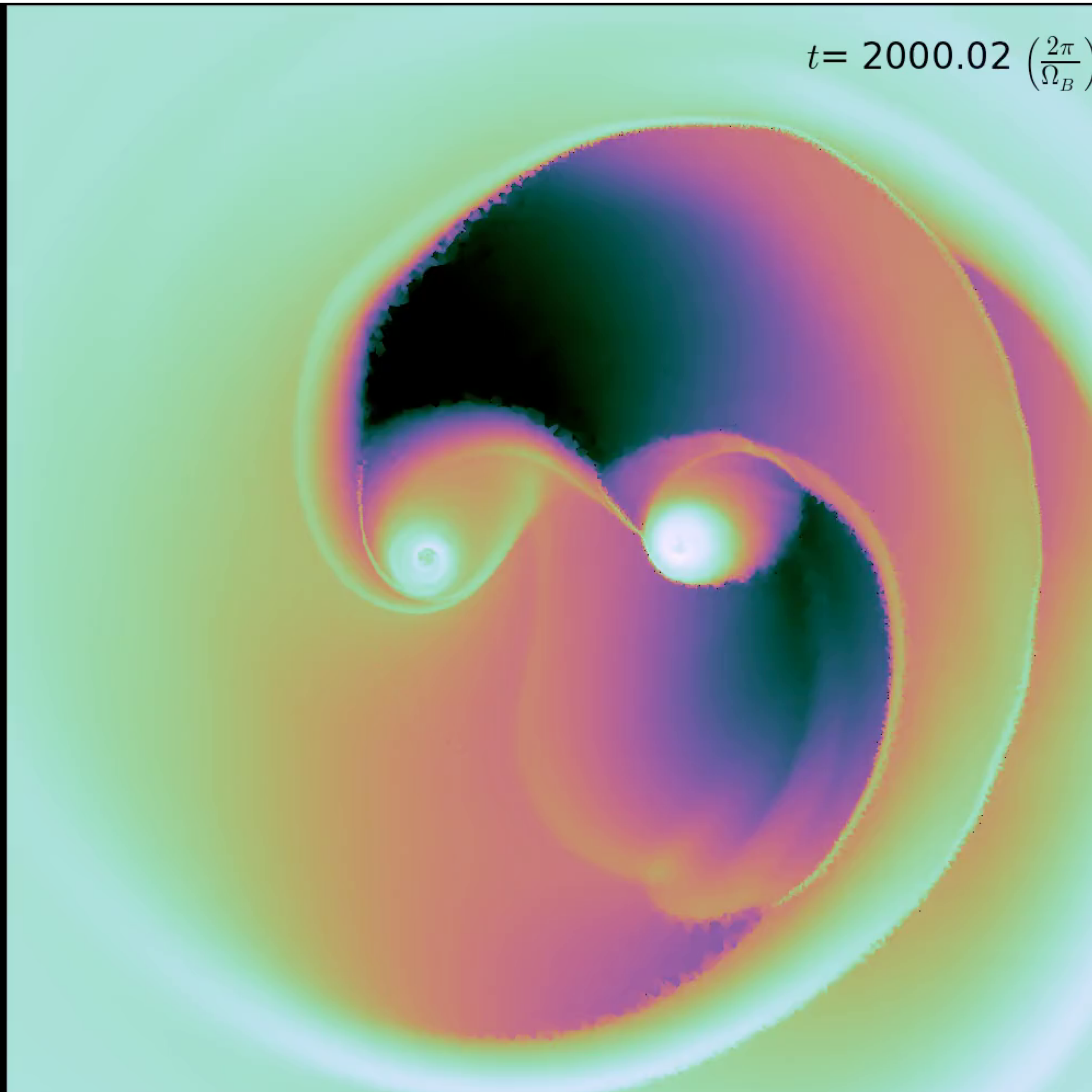
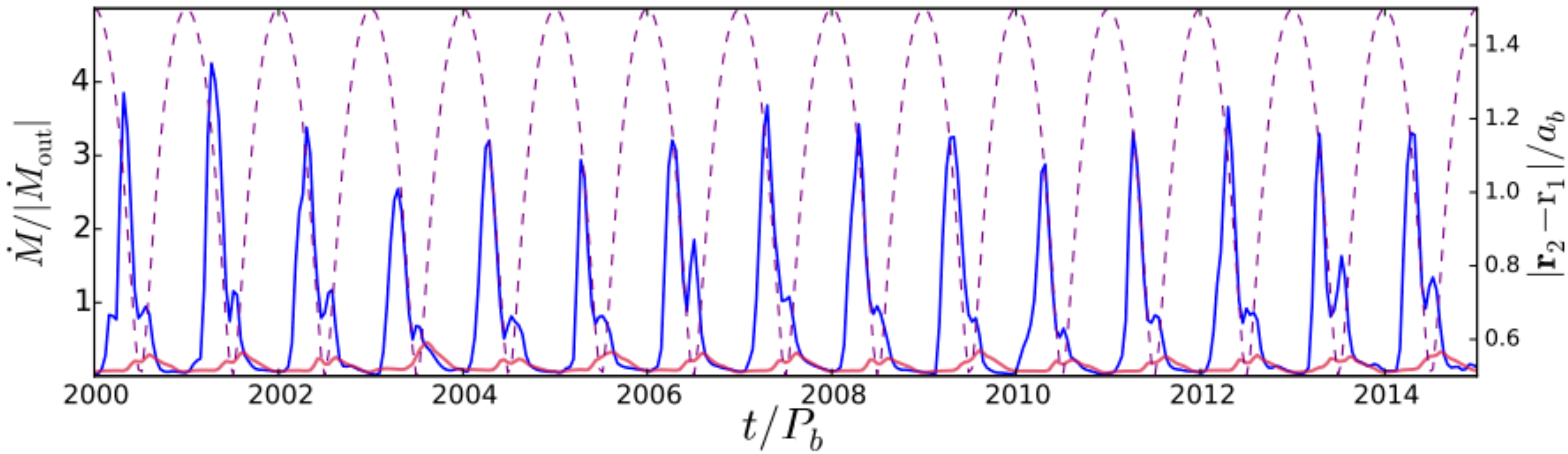


Eccentric Binary Accretion

Theory

Muñoz & Lai 2016



The Binary–Disk Interaction

Implications for Close Binaries:

- Disk Architecture
  - Central Gap
- Variable, Pulsed Accretion
- Dynamically Heat the Circumbinary Disk
  - Pushes snow-line out
- Reduced Star-Disk Locking Efficiency
  - Higher rotation rates

The Binary–Disk Interaction

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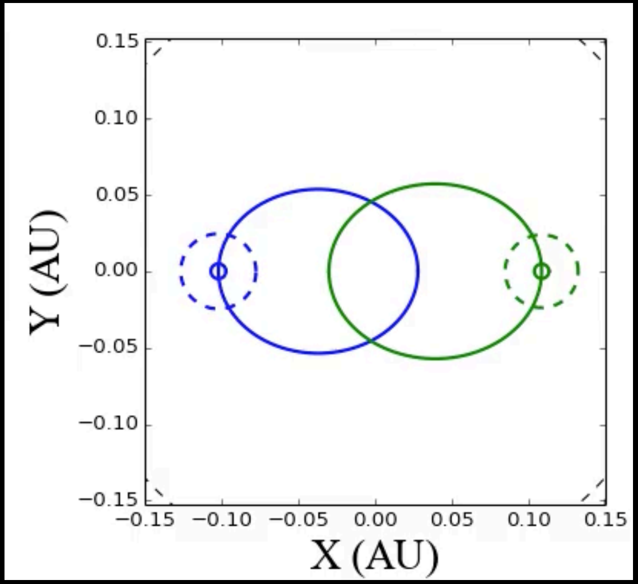
- Reduced Star-Disk Locking
  - Higher rotation rates
- *Period Regime of Eclipsing Binary Benchmarks*

Targets

DQ Tau

Orbital Parameters:

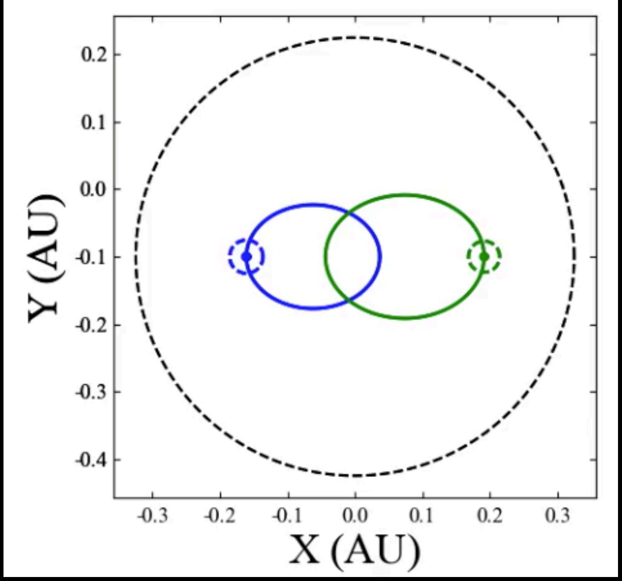
- P = 15.8 days
- e = 0.57
- a = 0.13 AU
- q = 0.94 ($M_1 \sim M_2 \sim 0.6 M_\odot$) (Czekala et al. 2016)



TWA 3A

Orbital Parameters:

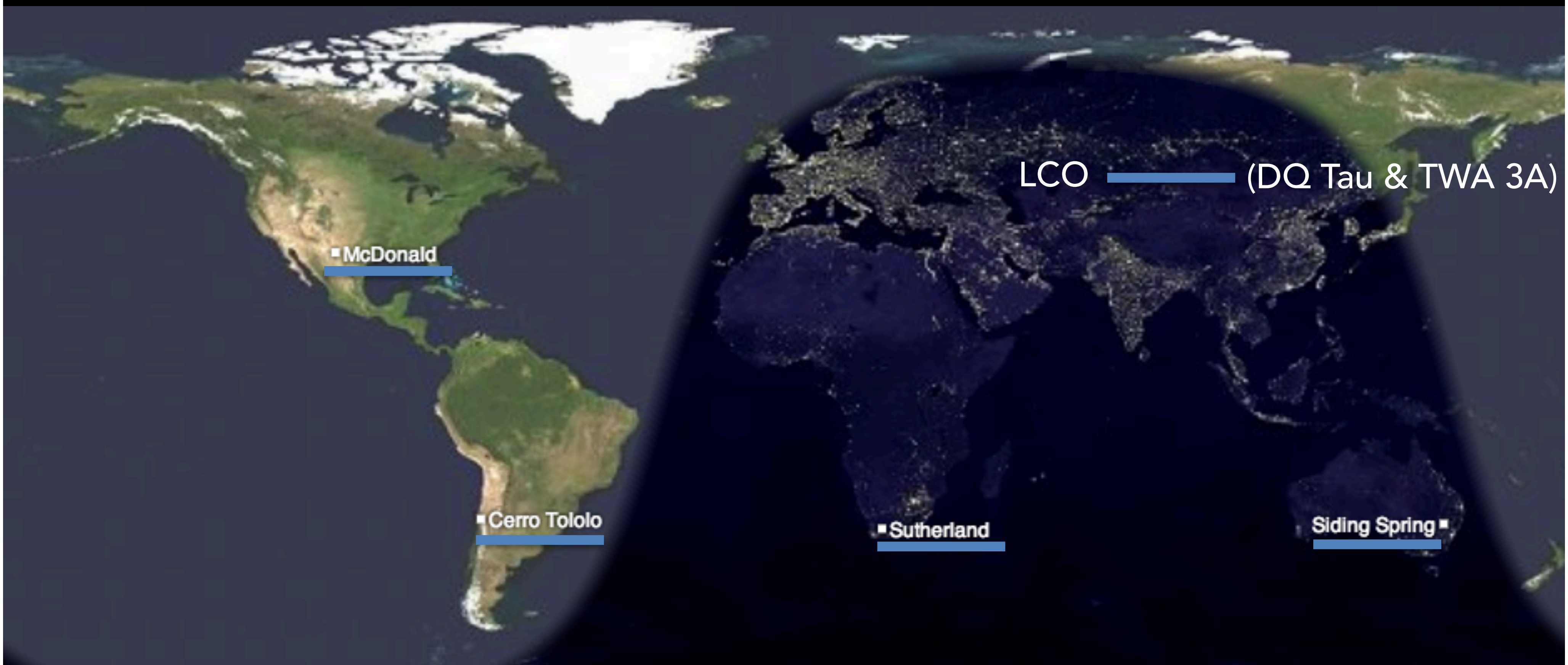
- P = 34.9 days
- e = 0.63
- a ~ 0.16 AU
- q = 0.84 ($M_1 \sim 0.3 M_\odot$) (Kellogg et al. 2017)



Observing Binary Accretion

LCO Observations (DQ Tau and TWA 3A)

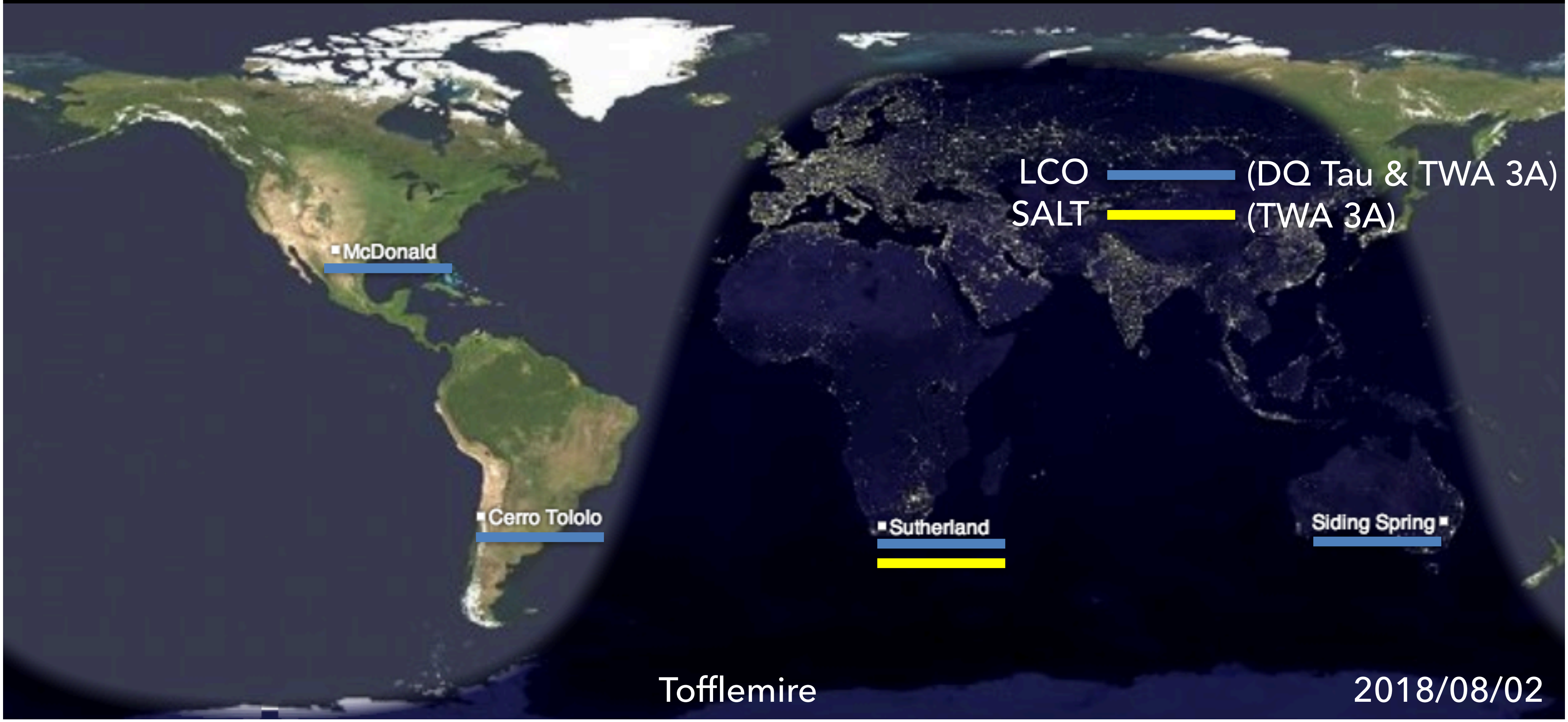
- 20 Visits per orbit
  - Visit = UBVRIY (Hα, Hβ)
- Coverage for ~10 orbital periods



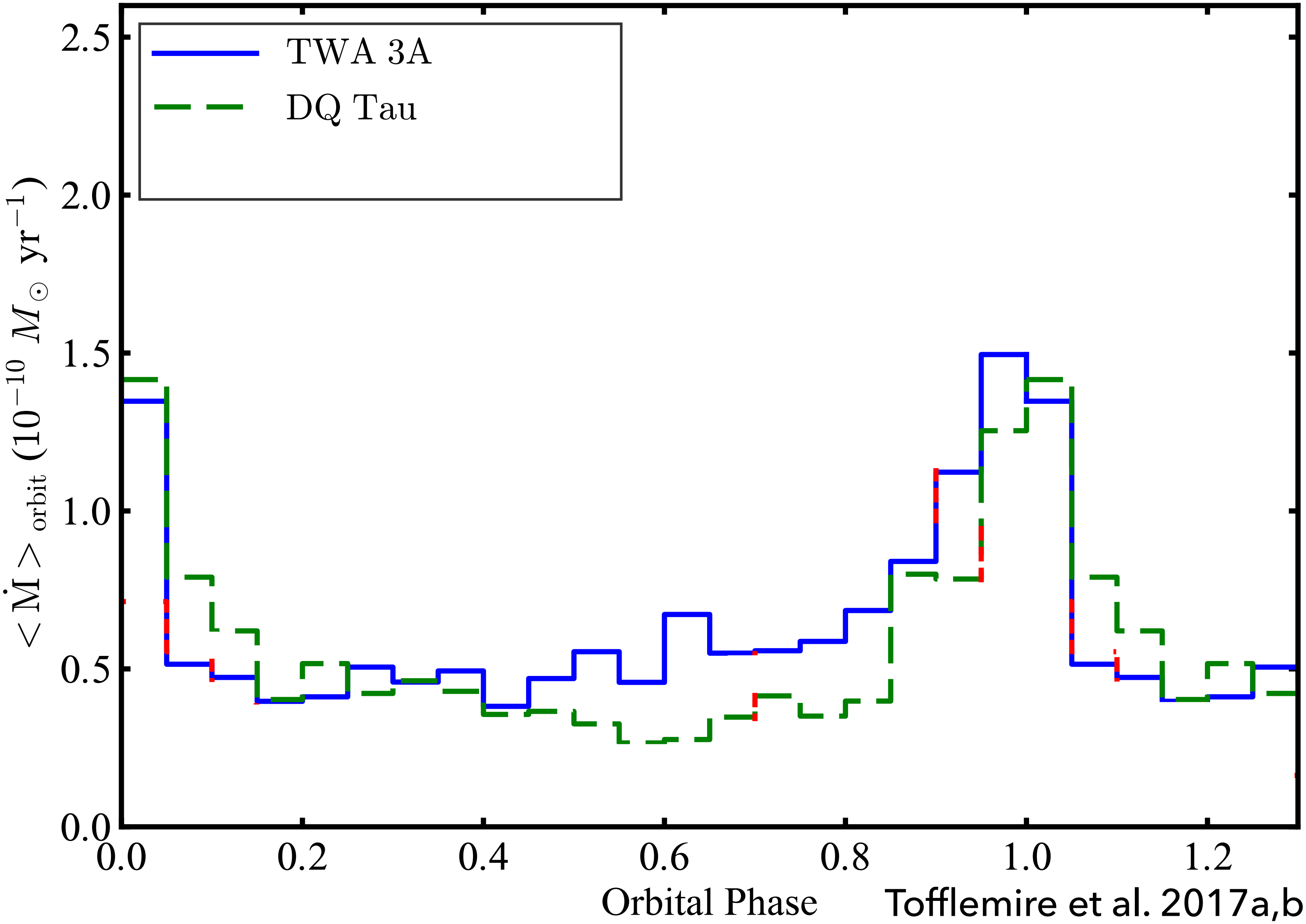
Observing Binary Accretion

SALT Observations (TWA 3A):

- 15 Epochs
  - HRS (R~35,000; 3800 - 8700Å)
- Spanning ~3 orbital periods

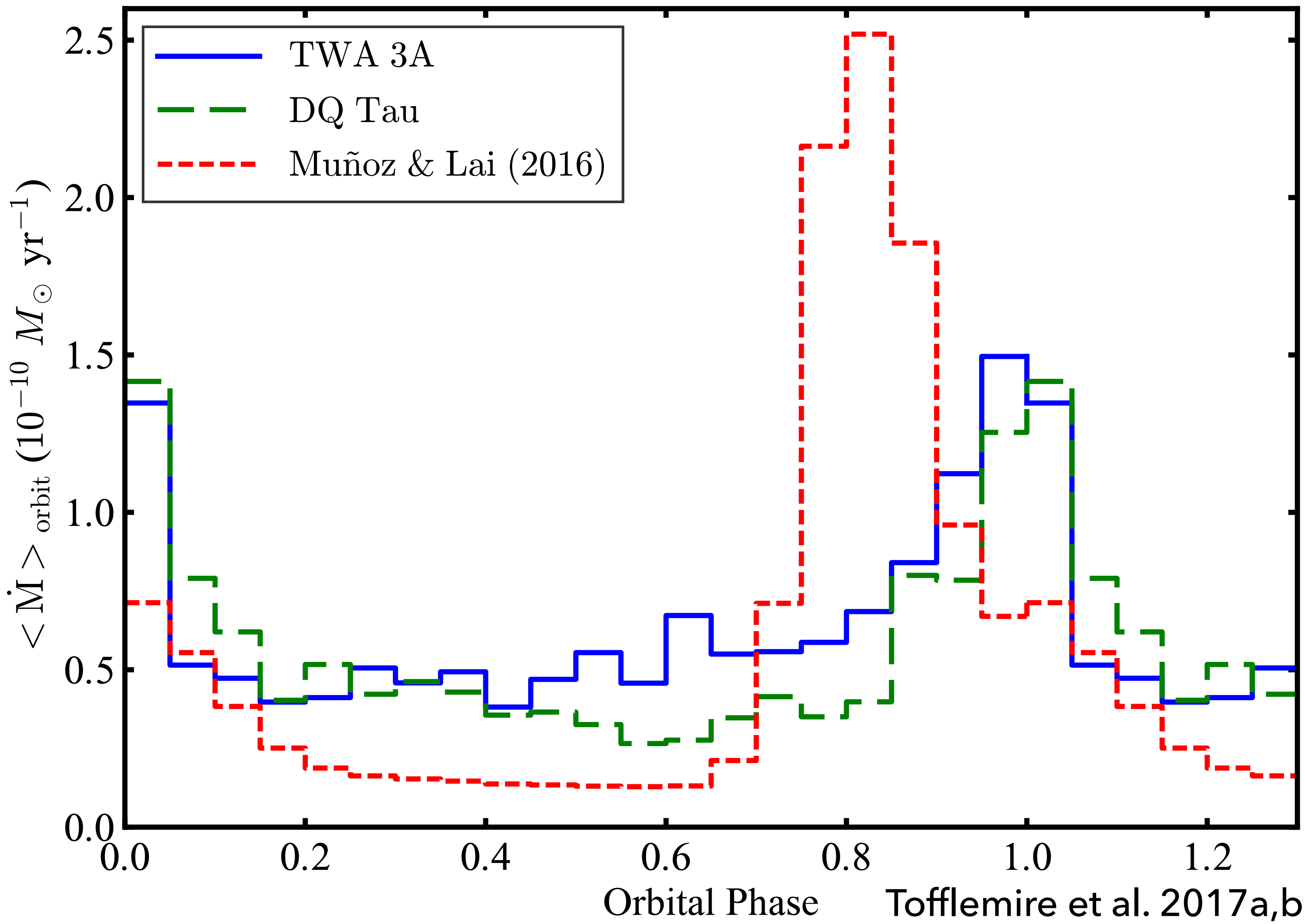


Binary Accretion



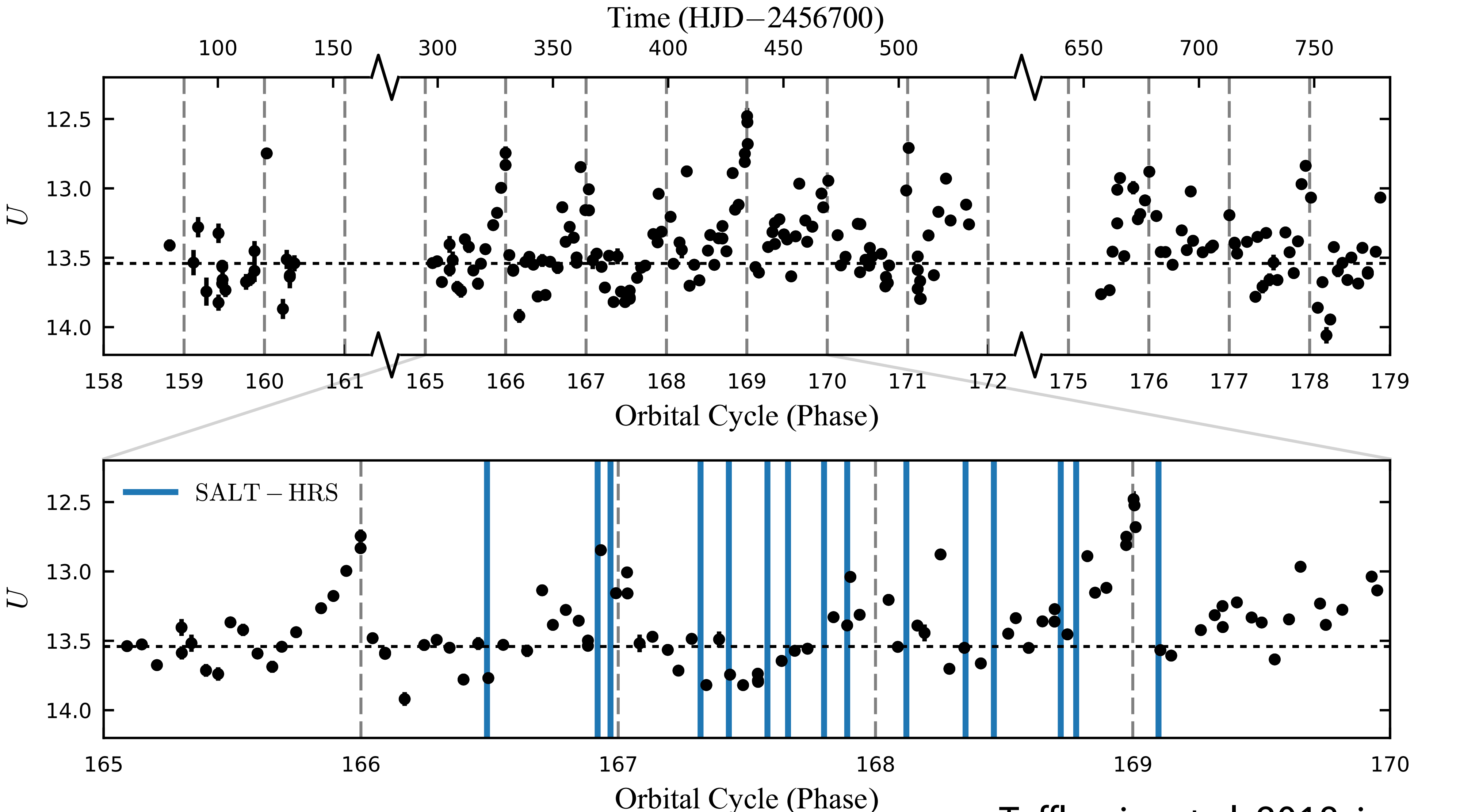
Tofflemire et al. 2017a,b

Binary Accretion



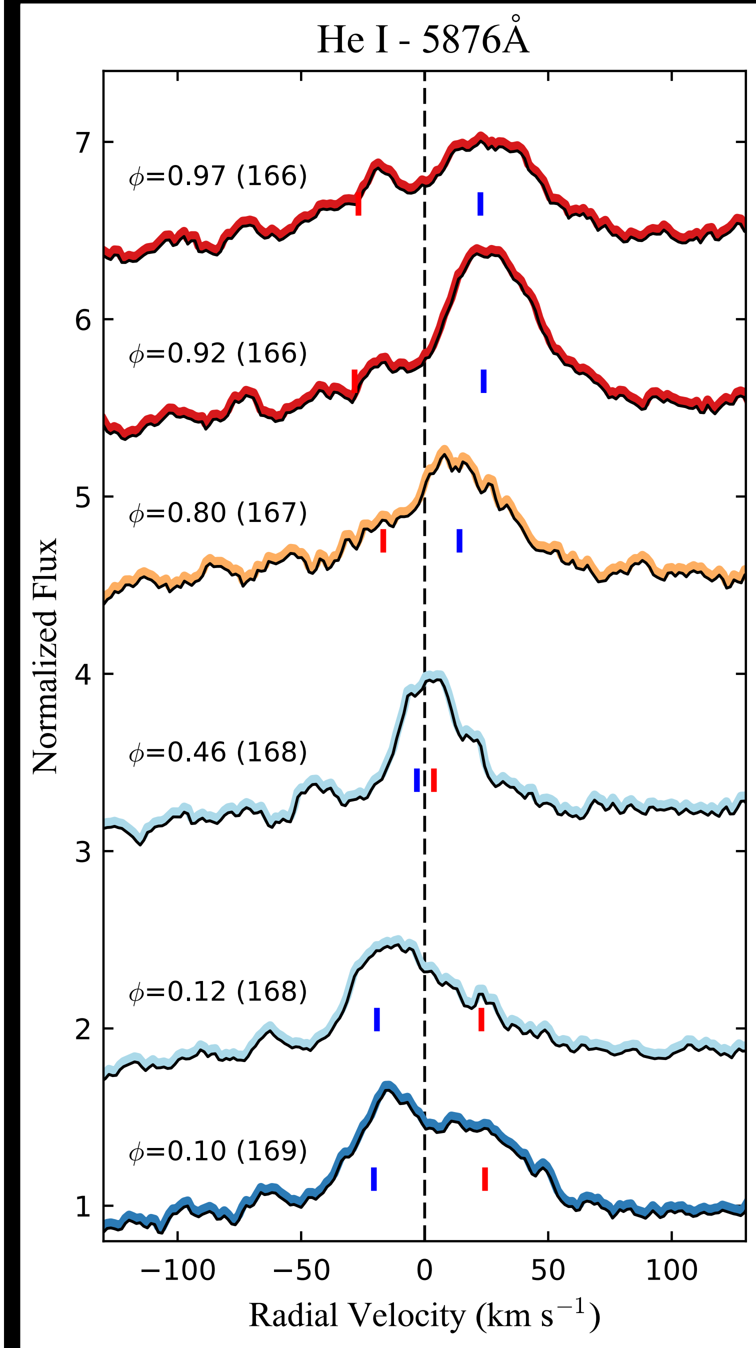
Tofflemire et al. 2017a,b

TWA 3A – Spectroscopic Campaign



Tofflemire et al. 2018, in prep

TWA 3A — He I 5876 Variability



Before
Periastron
(High Accretion)

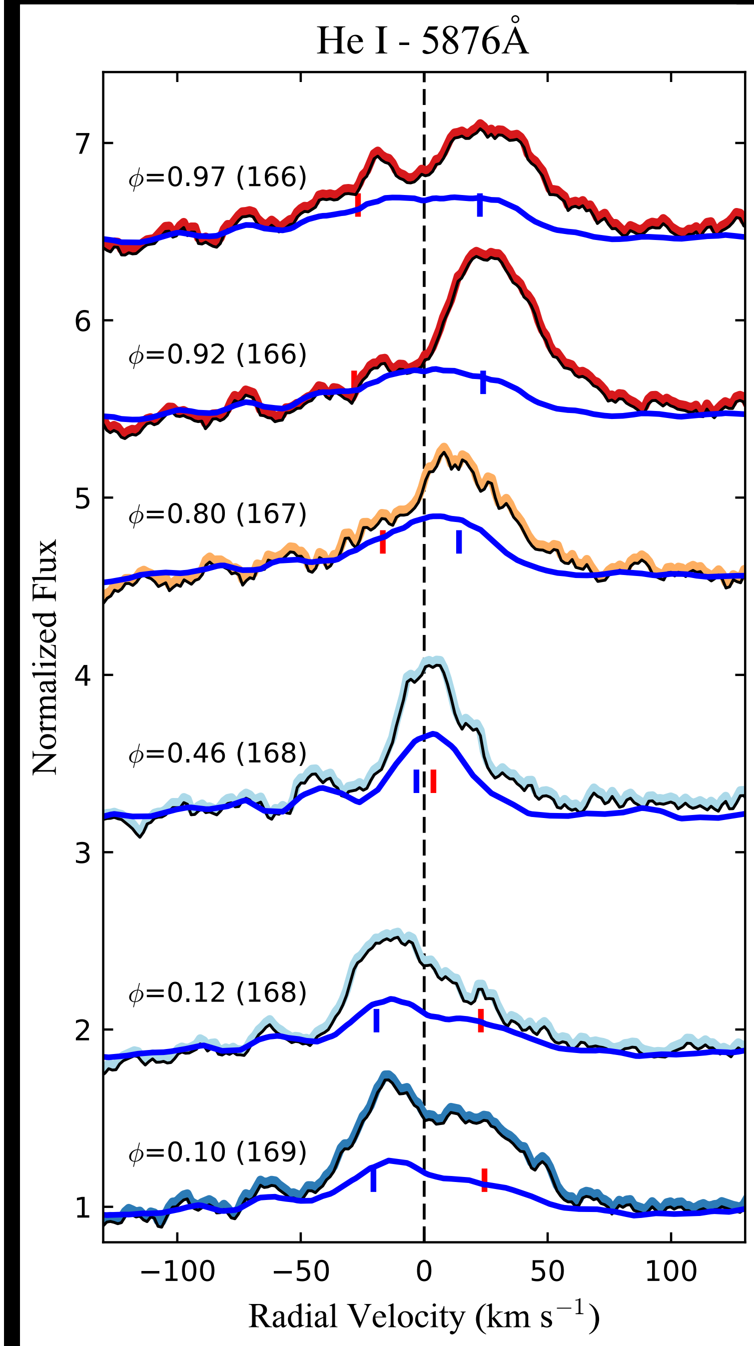
Apastron
(Little/No Accretion)

After
Periastron
(High Accretion)

Tofflemire

2018/08/02

TWA 3A – He I 5876 Variability



Before Periastron (High Accretion)

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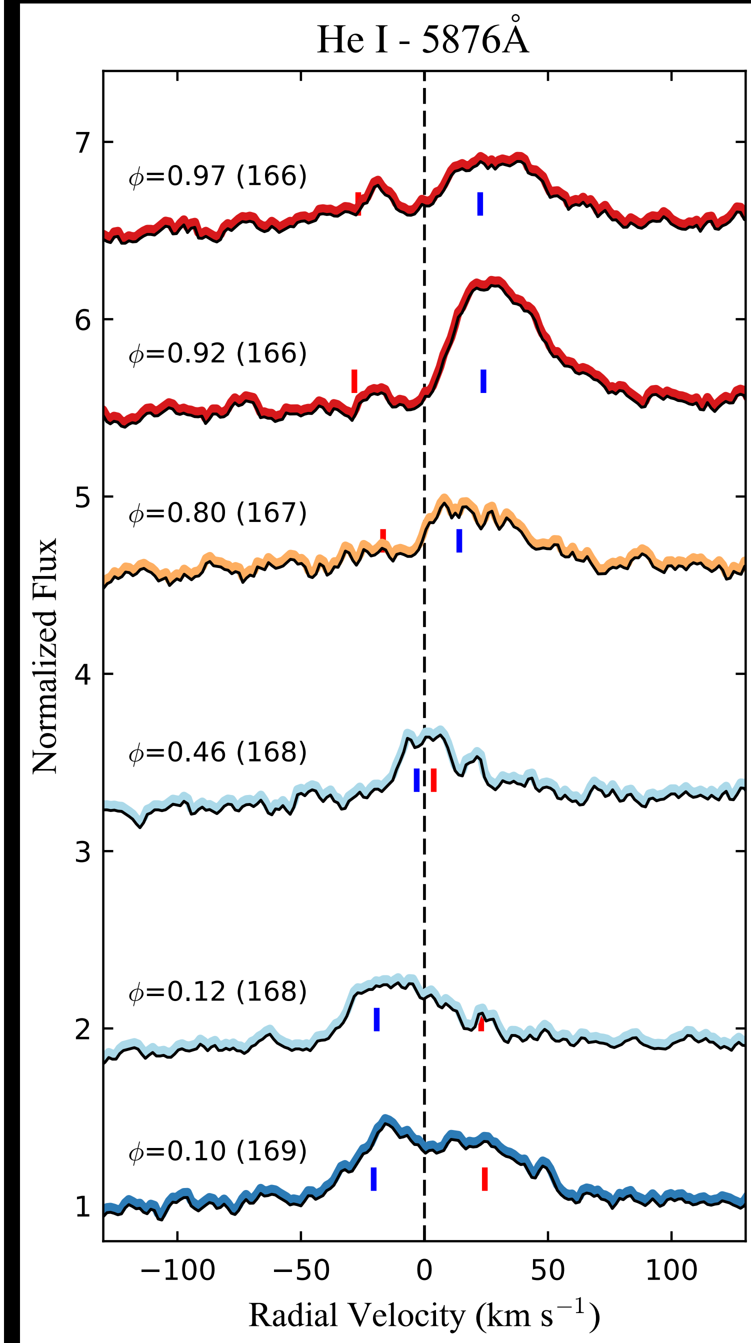

Before Periastron (High Accretion)

Apastron (Little/No Accretion)

After Periastron (High Accretion)

He I emission favors the primary's velocity, suggesting it is the primary accretor

Tofflemire

2018/08/02

Preferential Accretion

Secondary as Dominant Accretor:

- Prediction of *most* hydrodynamic simulations
  - Material at the circumbinary disk gap has specific angular momentum closer to the secondary
    (Artymowicz & Lubow 1996; Hayasaki et al. 2007, 2013; Cuadra et al. 2009; Roedig et al. 2011; Farris et al. 2014; Young et al. 2015; Young & Clarke 2015)

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Primary and Secondary Alternate:

- Munoz & Lai (2016) predict the dominant accretor varies based on the precession of a disk asymmetry

Preferential Accretion

Secon

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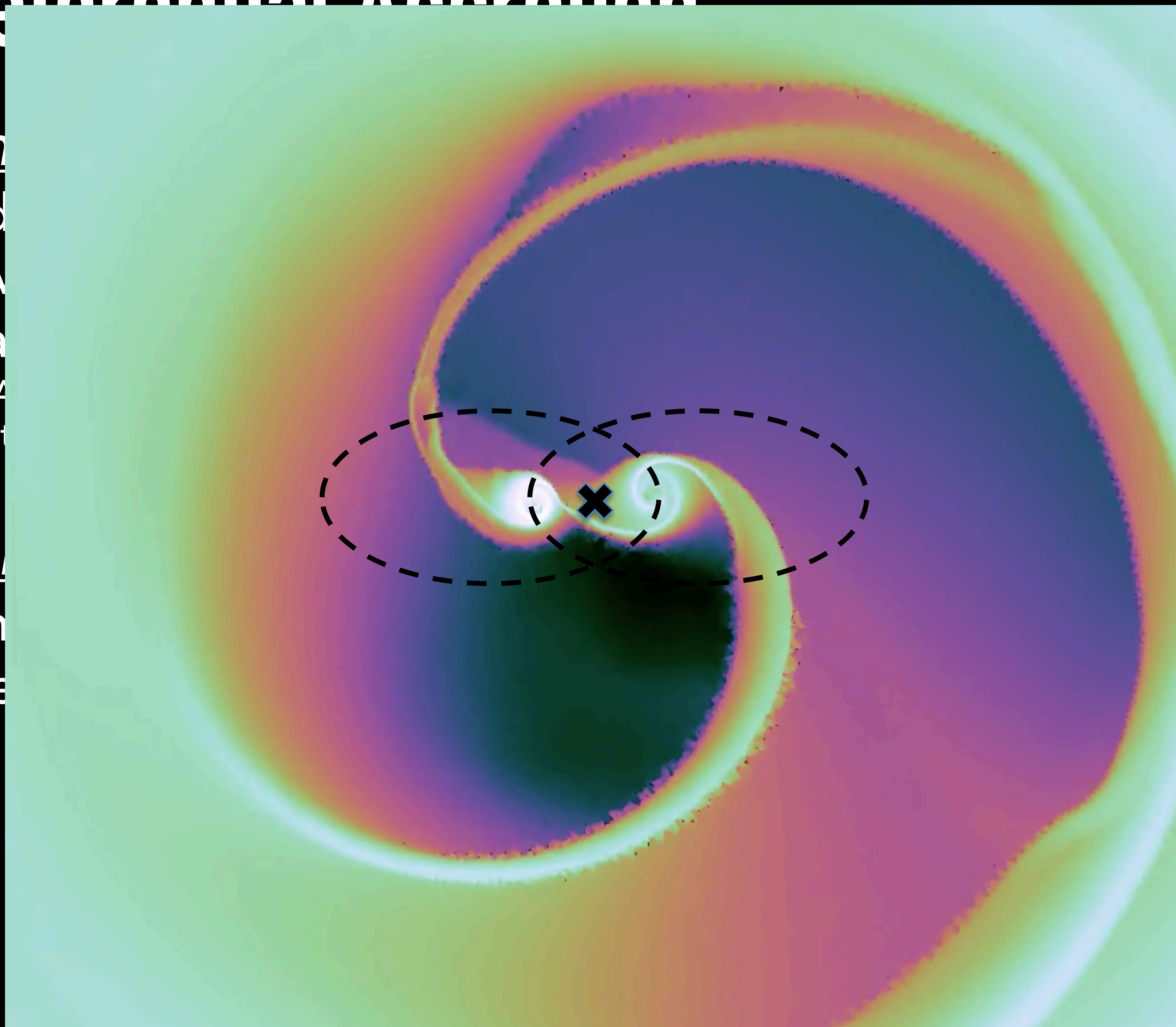
Roedig



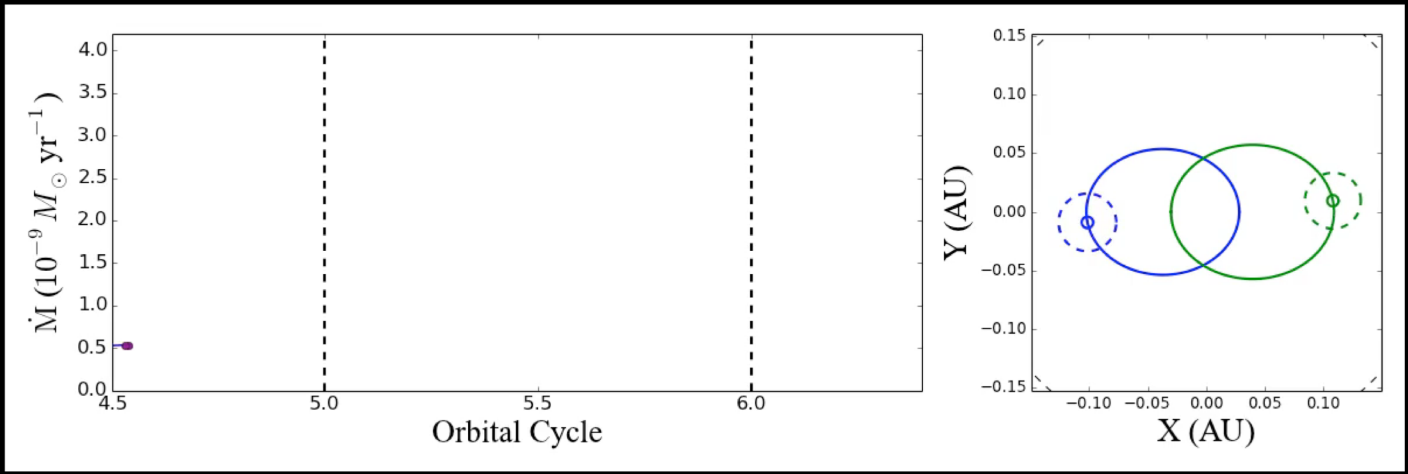
Primar

- Mun ries
  base

Summary

Eccentric, short-period binaries exhibit periodic, pulsed accretion events near periastron passage

- Results in fairly good agreement with numerical simulations



Accretion events favor the primary star in TWA 3A

- Trend holds in two widely separated epochs (~150 orbits)
- Favoring asymmetry, precessing circumbinary disk scenario