HIGH-ENERGY RADIATION AT THE SUBSTELLAR BOUNDARY

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Cool Stars 20: Very Low Mass Objects

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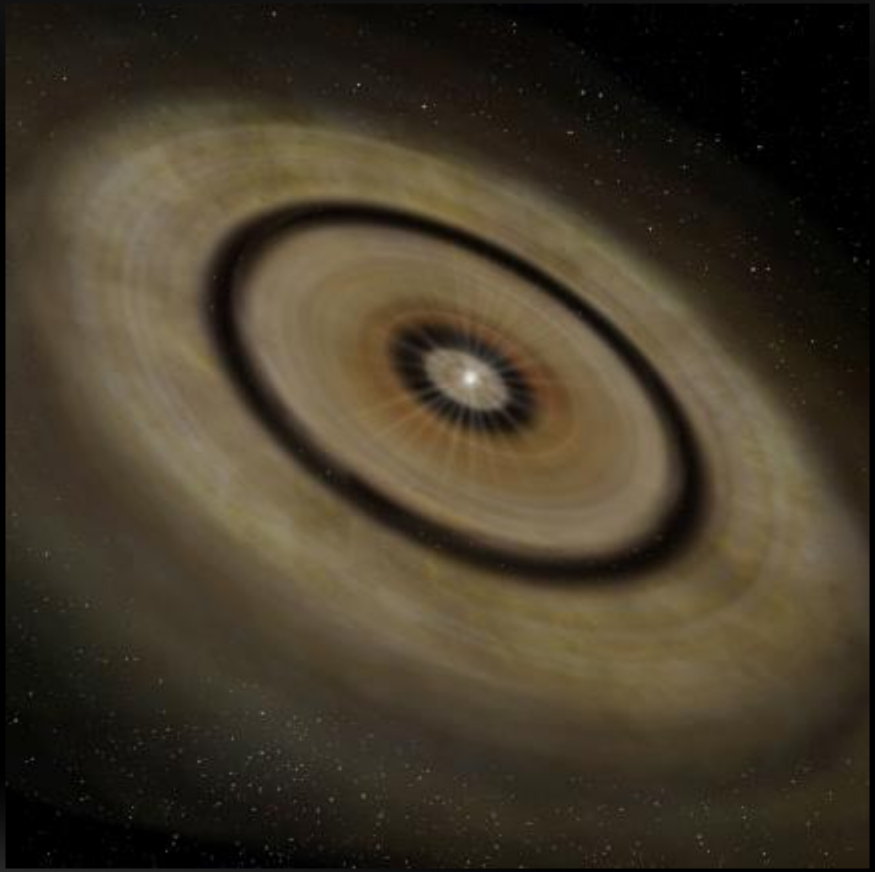
MOTIVATION

- Characterize X-rays from young, low mass stars to understand the timescale and conditions for exoplanet formation
- Resulting X-ray source spectral & temporal parameters can be incorporated into stellar irradiation models for disk evolution models
- Low mass (M type) stars are the best targets for the discovery of potentially* habitable exoplanets
    - **Caveat: high levels of activity may constitute a potential hazard for habitability*
    - ~75% of stars within 10 pc (Henry et al. 2006)
    - low luminosity
        - close-in habitable zones
        - direct imaging of planets is “easy” (proximity of NYMGs)

TW HYDRA ASSOCIATION

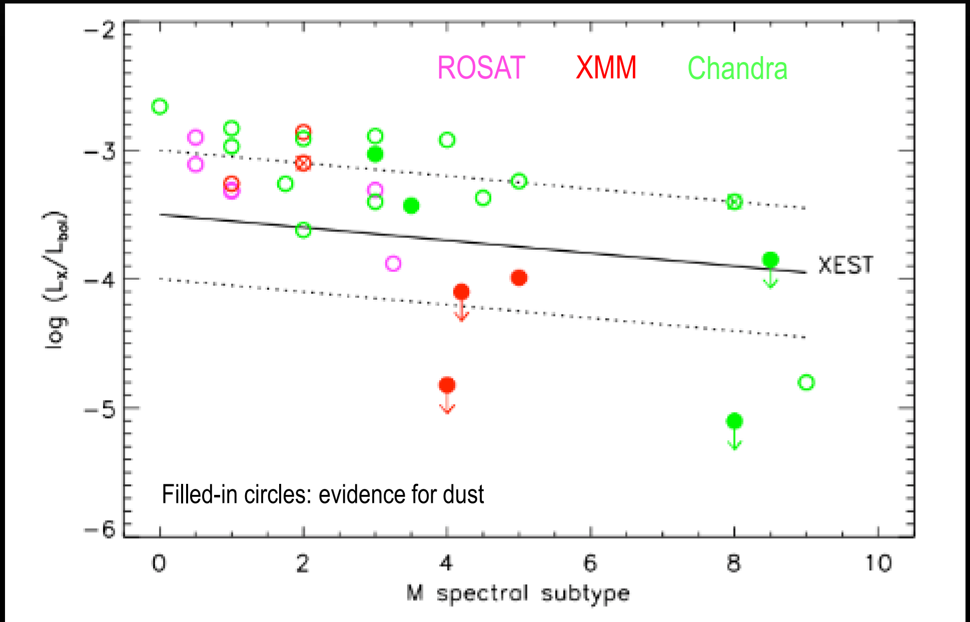
- D ~ 50 pc, age ~ 8 Myr
- Age is similar to timescale for giant planet formation (via core accretion mechanism)
- Only young cluster close enough to Earth that all its M stars can be well measured by both ALMA for disk masses (Rodriguez et al. 2015) and by Chandra for L_X/L_{bol} (Cycle 18; this work).
- Most members (earlier than M3) lack disks
  - Have already formed planets?
  - Will never form planets?



Credit: NOAJ

KASTNER ET AL. 2016:
M STARS IN THE TW HYA ASSOCIATION: STELLAR X-RAYS AND DISK DISSIPATION

- L_X of all M stars in TWA with available ROSAT, Chandra, or XMM data
- Early-M overluminous
- Late-M underluminous
- Does L_X decline more rapidly for late M?
- Suppression of coronal X-ray emission by accretion?
- Fundamental difference in internal structure? (Star vs. Brown Dwarf)



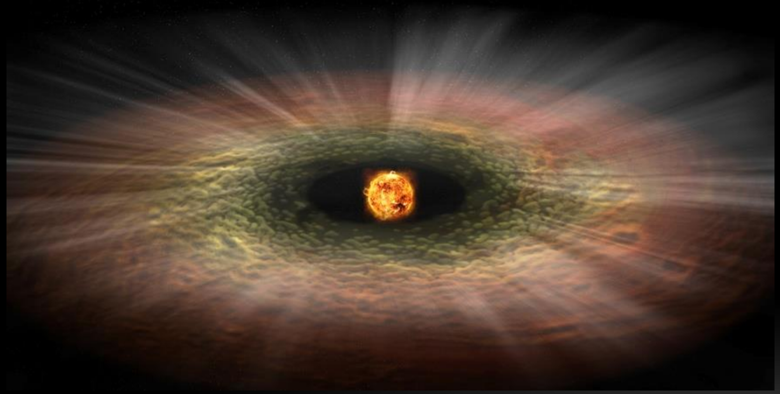
XEST: XMM-Newton Extended Survey of Taurus (Gudel et al. 2007)

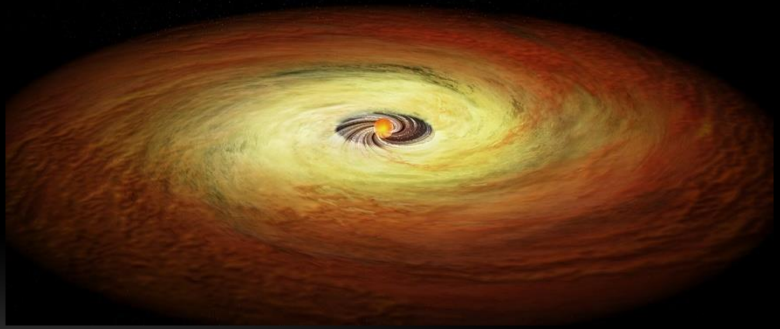
KASTNER ET AL. 2016

- X-ray + infrared/submm data suggest:
  - ***anticorrelation*** between pre-MS X-ray luminosity & disk lifetime

- Evidence for residual primordial disk material increases for later subtypes (Rodriguez et al. 2015)

- Disk survival times may be longer for ultra-low-mass stars
  - *disk evolution models generally predict that any dependence on stellar mass should be very weak*

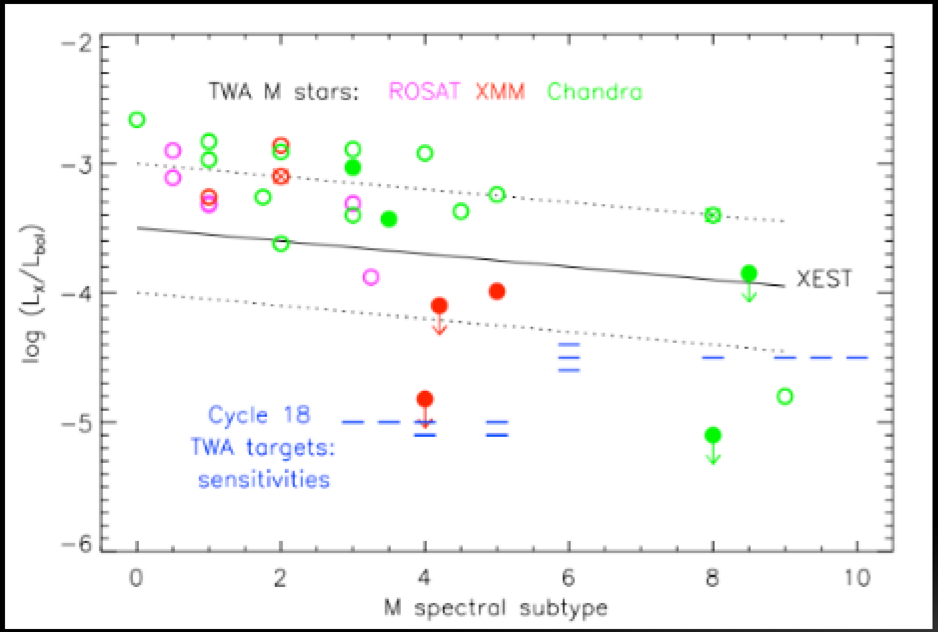




Credit: NASA/CXC/M.Weiss

CHANDRA CYCLE 18 LARGE PROGRAM

- Expand TWA sample to the extreme low end of stellar initial mass function
  - 10 mid- to late-M stars
- K+16 study: lacking in spectral types later than M3



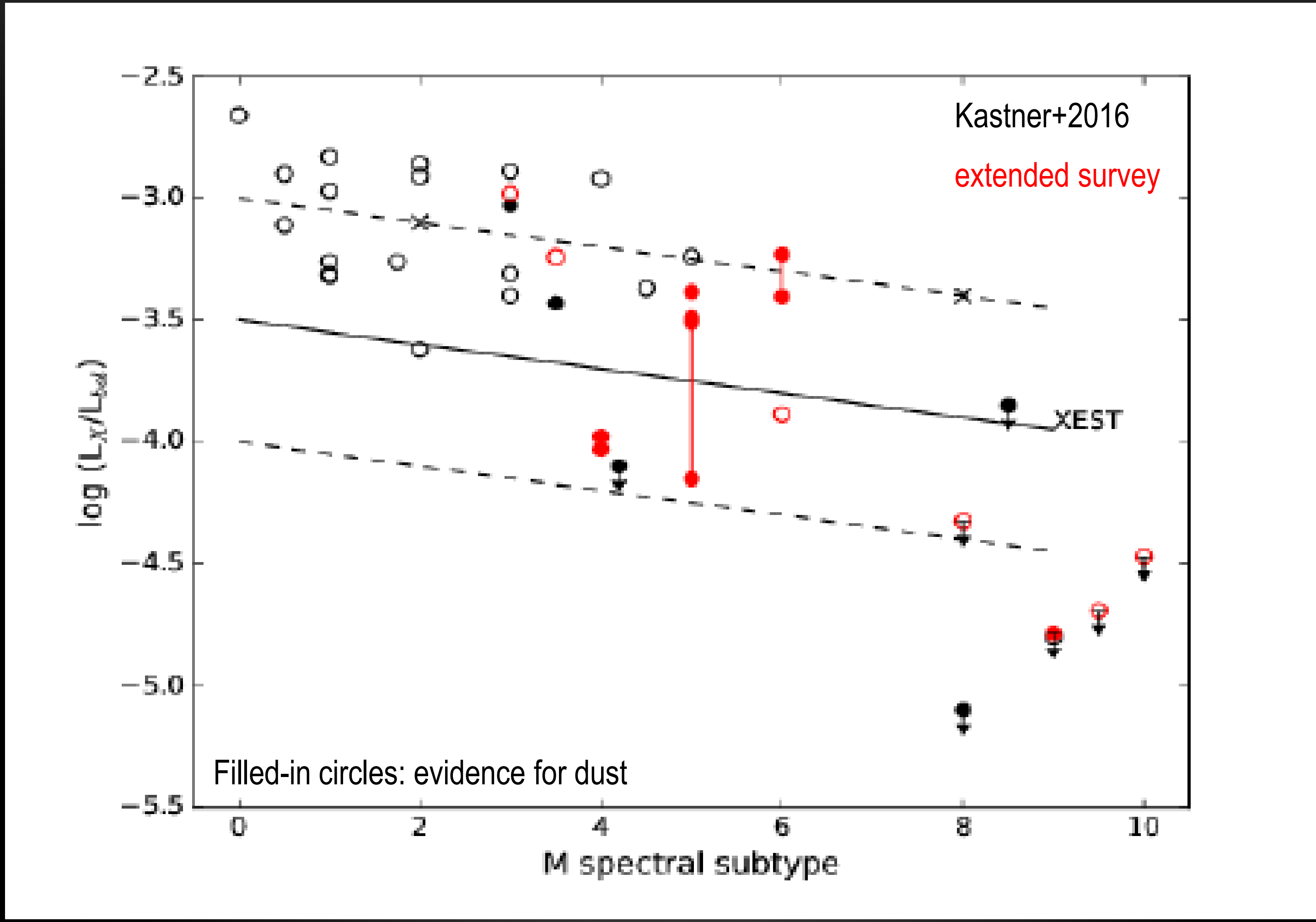
Object	sp. type	D (pc)	evidence for disk?[a]	exp[b] (ks)
TWA 15AB[c]	M3+M3.5	113	N (W)	20
J1012−3124	M4+M4	57	Y (W)	20
TWA 33	M5	41	Y/Y (W/A)	30
TWA 34[d]	M5	50	Y/Y (W/A)	30
TWA 32	M6+M6?	66	Y/Y (W/A)	60
J1111−2655	M6	44	N/N (W/A)	30
J1203−3821	M8	56	Y?/N (W/A)	60
J1247−3816	M9	64	Y/N (W/A)	70
TWA 29	M9.5	26	Y?/N (W/A)	30
J1207−3900	L0/1	60	Y?/N (W/A)	65

a) W = WISE mid-IR excess (Y) or lack thereof (N), A = circumstellar dust detection (Y) or nondetection (N) based on ALMA survey data [32]. b) Estimated exposure time required to reach $\log(L_X/L_{bol}) = -5.0$ (stars M5 and earlier) or $\log(L_X/L_{bol}) = -4.5$ (stars M6 and later); see Feasibility. c) ROSAT detection, with 6″ binary unresolved; $\log(L_X/L_{bol}) = -3.88$ for composite (A+B) system [20]. d) ALMA also detected circumstellar CO.

Our observations more than double the number of TWA members in the M4 -- M9/L0 range with sensitive X-ray observations

Early-M star and mid- to late-M star regimes are now equally represented!

CYCLE 18 RESULTS



Spec Type > M3

Disk Fraction = 2 / 20

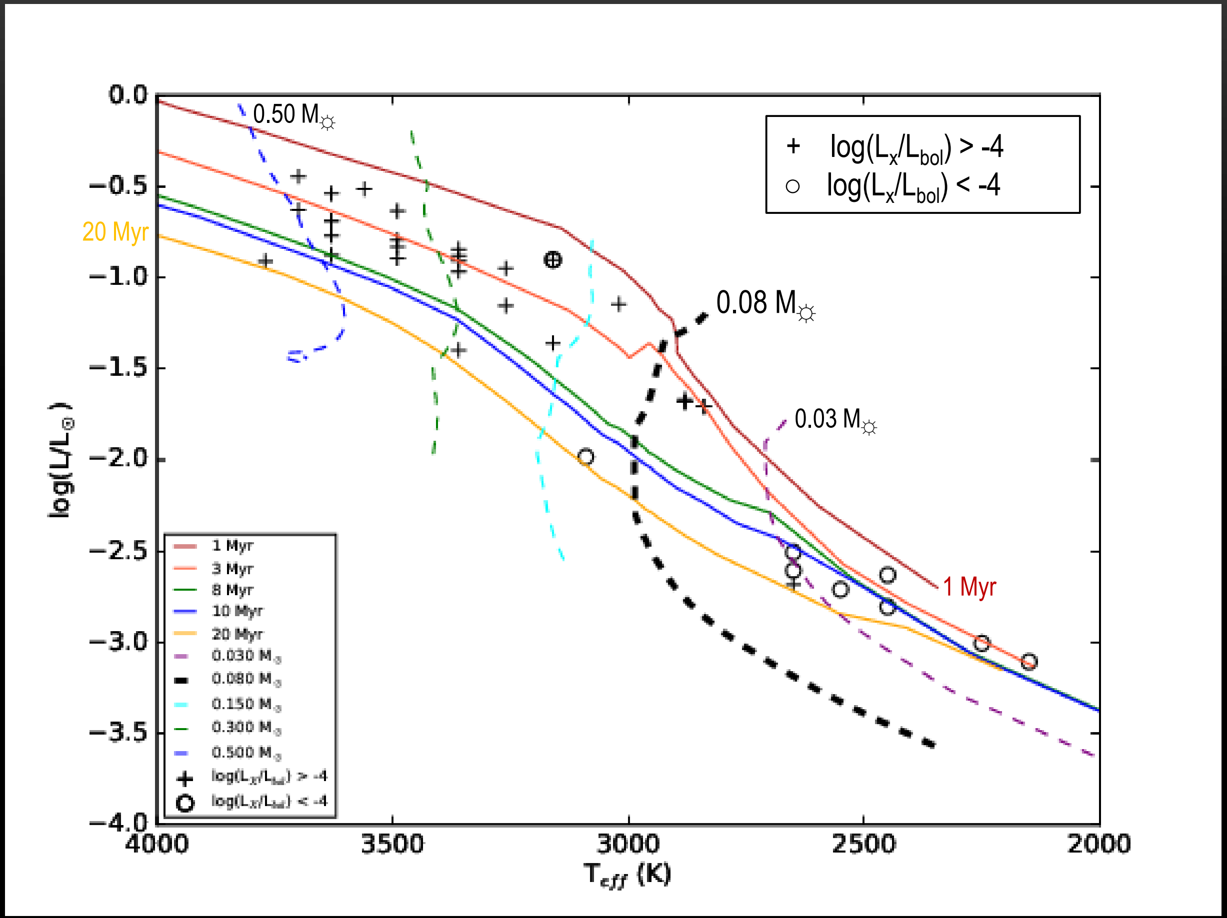
Spec Type < M3

Disk Fraction = 13 / 22

DISCUSSION

Observed drop in $\log(L_X/L_{bol})$:

- may predict stellar/substellar boundary
  - doesn't rely on evolutionary models
- result of different fundamental processes?
  - nuclear fusion (stars)
  - electron degeneracy (brown dwarfs)



Drop may allow us to infer the topology of the magnetic fields of our sources:

- More complex magnetic topology → larger observed value of $\log(L_X/L_{bol})$
- Less complex magnetic field → smaller observed value of $\log(L_X/L_{bol})$

Caveat:

Information about the magnetic topologies (magnetic maps from spectropolarimetric observations) of very low mass pre-MS objects have yet to be obtained.

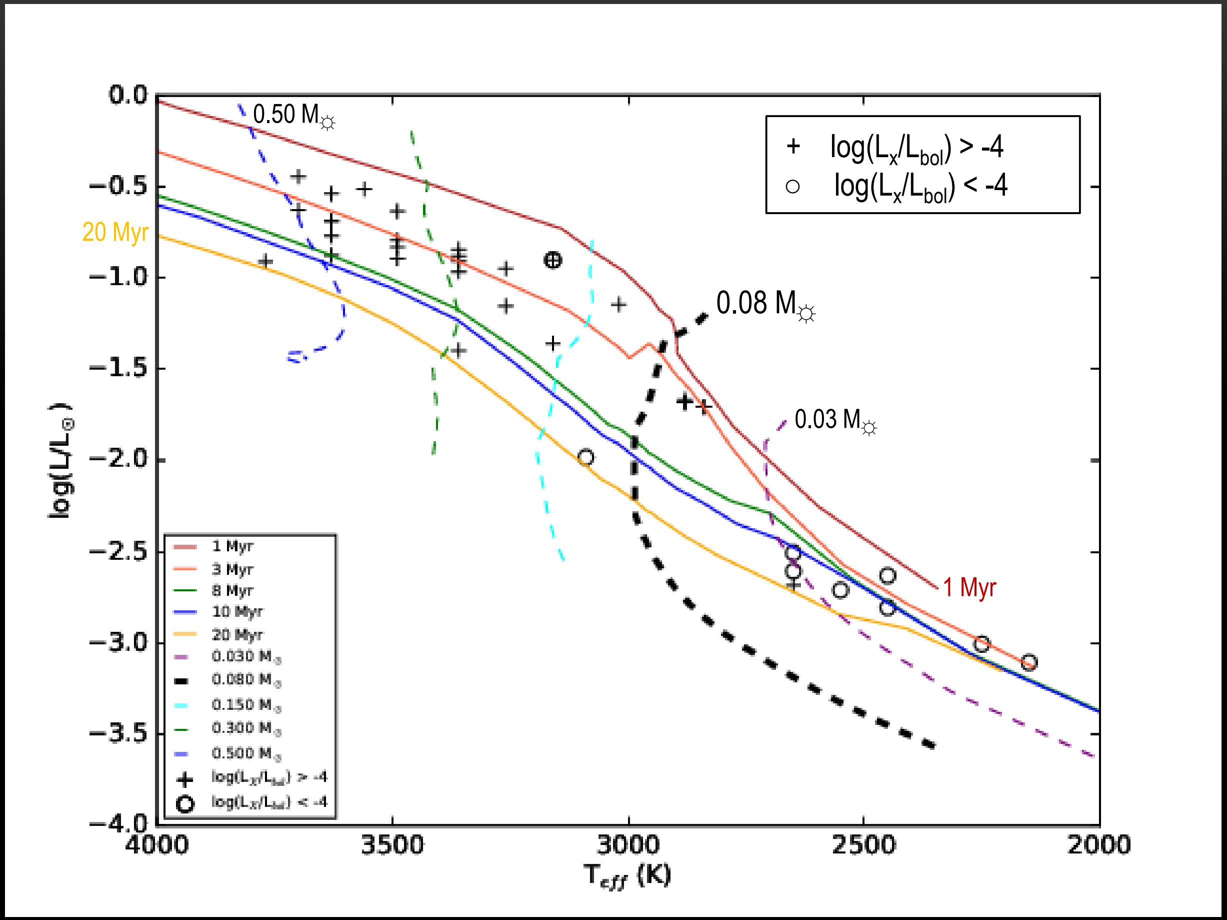
CONCLUSIONS

Observed drop in $\log(L_X/L_{bol})$:

- may predict stellar/substellar boundary without relying on evolutionary models

This may allow us to:

- infer the topology of the magnetic fields of our sources
- use $\log(L_X/L_{bol})$ as a diagnostic of the eventual core H-burning status of the lowest-mass pre-MS stars



Contact me!

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