40 Years with DQ Tau

Leveraging Archival Data to Investigate the Pulsed Accretion Archetype

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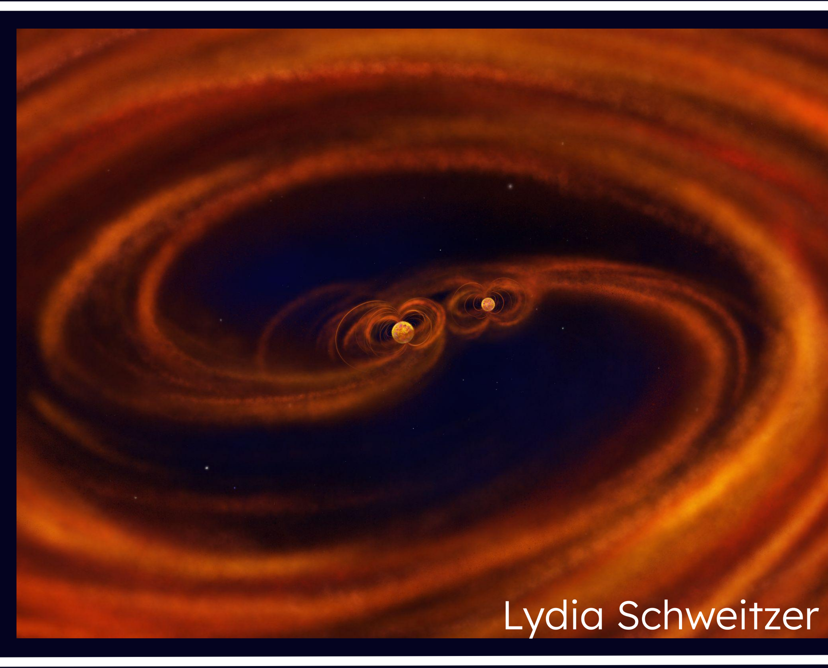
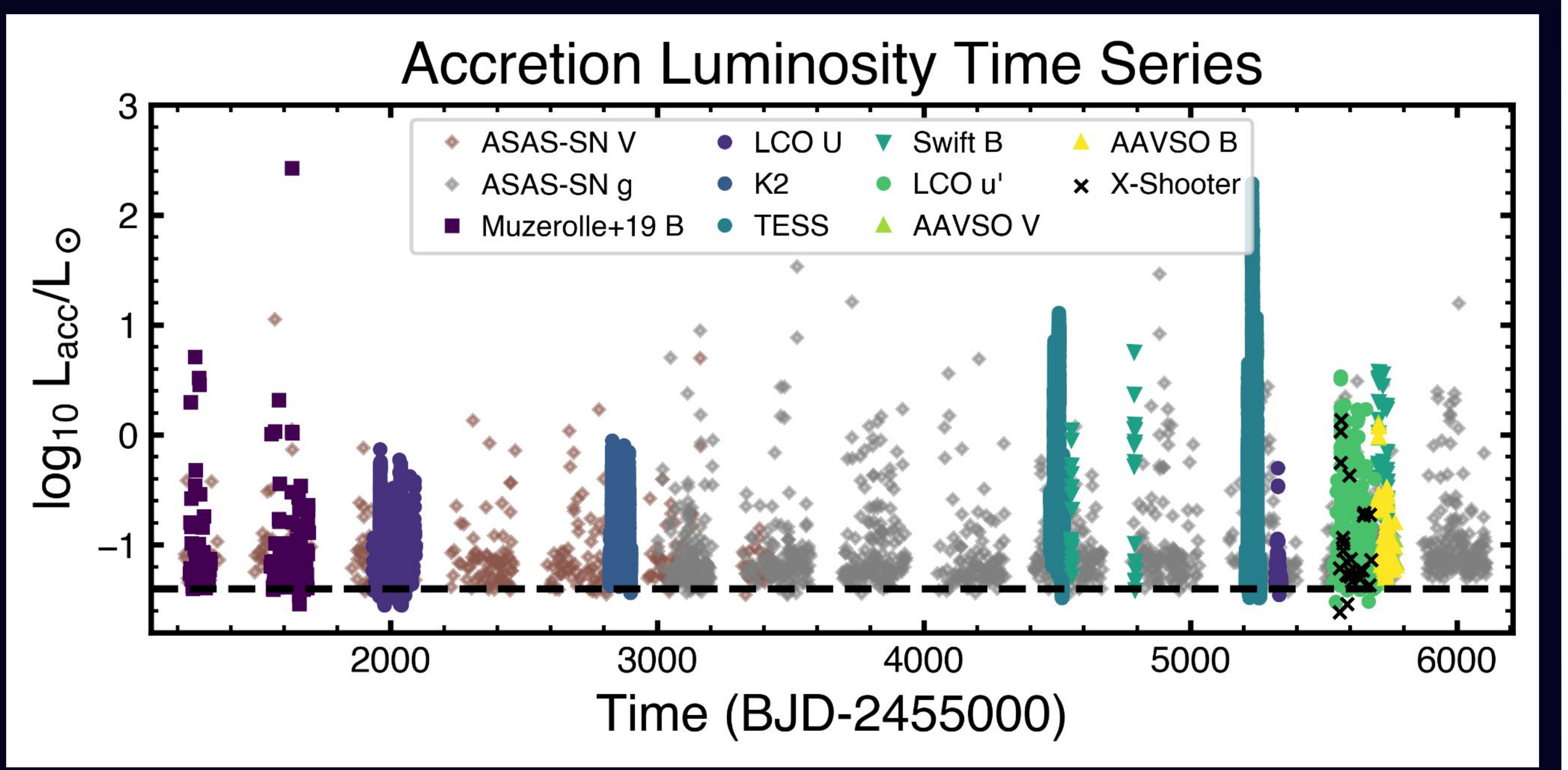
- DQ Tau is a T Tauri binary in an eccentric, 15.8-day orbit that is actively accreting material from a circumbinary disk.
- This architecture gives rise to periodic, pulsed accretion events. Orbital resonances launch streams of material from the circumbinary disk that cross a dynamically cleared gap and fuel bursts of accretion near each periastron passage.
- Dramatic and predictable accretion events make this system a unique dynamical laboratory.
- We leverage 40+ years of radial velocities and 10+ years of time-series photometry to search for secular evolution.

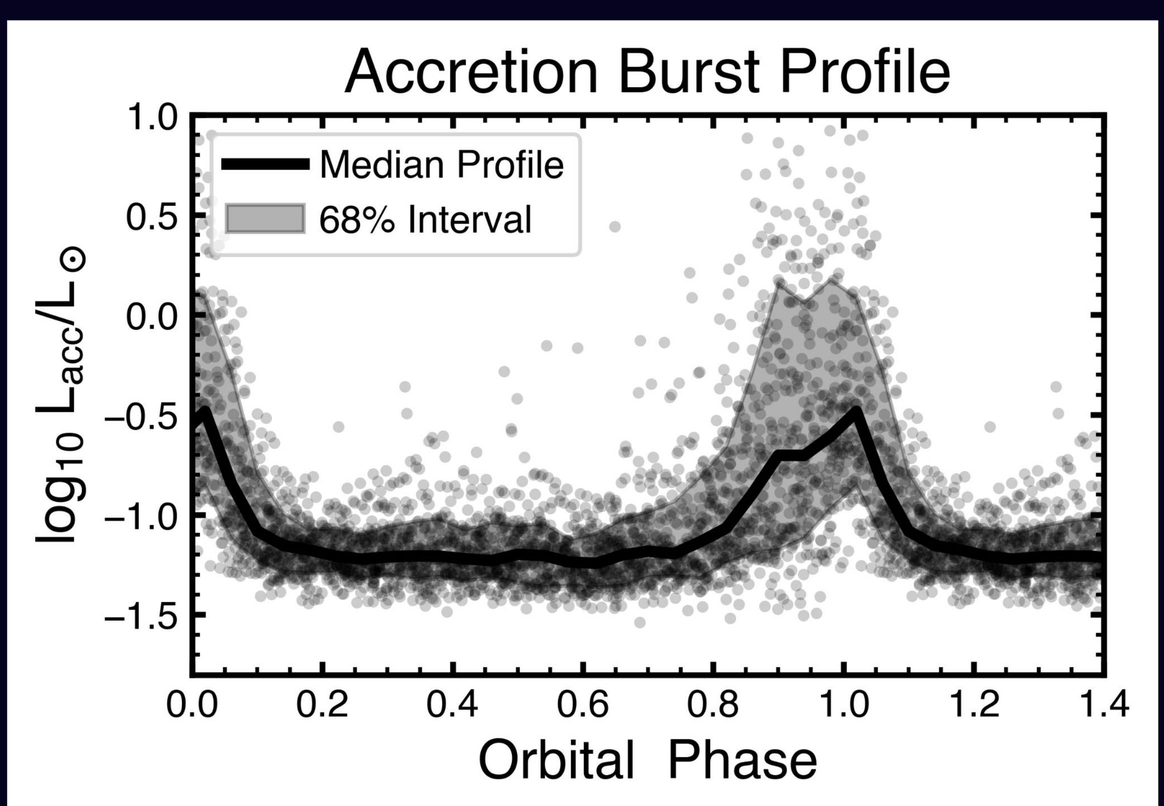

Lydia Schweitzer

10+ Years of Time-Series Photometry

New Dynamics: Inner Disk Variability on ~4-5 P_{orbit}

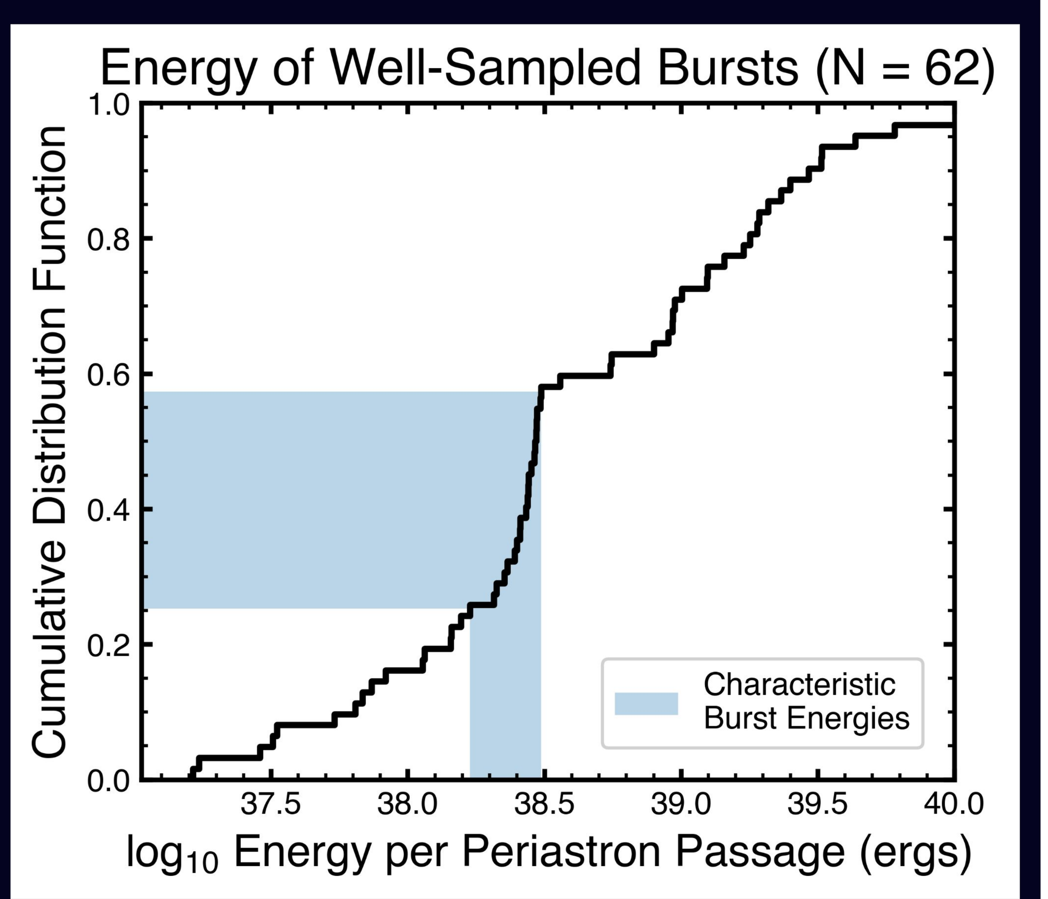


- A self-consistent calibration of the accretion luminosity is performed by bootstrapping off simultaneous XShooter spectra and LCO u' photometry [1].
- Survey data (ASAS-SN [2], AAVSO [3], K2 [4], TESS [5]) are combined with literature photometry [1,6,7] and new analyses of LCO and Swift data.



- Typical periastron accretion bursts increase L_{acc} by a factor of ~9.
- Large bursts can be >100x above the quiescent accretion level.

For well-sampled accretion bursts, we integrate L_{acc} to compute the accretion burst energy. The burst energy CDF reveals a narrow range of characteristic energies. Small bursts occur every ~4-5 orbits, if evenly distributed; studies of DQ Tau's inner circumbinary disk with NIR imaging [6] and JWST/MIRI spectroscopy [8] **suggest a filling-draining behavior** on the same time scale. As the inner disk recedes, accretion streams load less mass, resulting in small accretion bursts. Our archival study supports this scenario. **Current theory does not predict this behavior.**

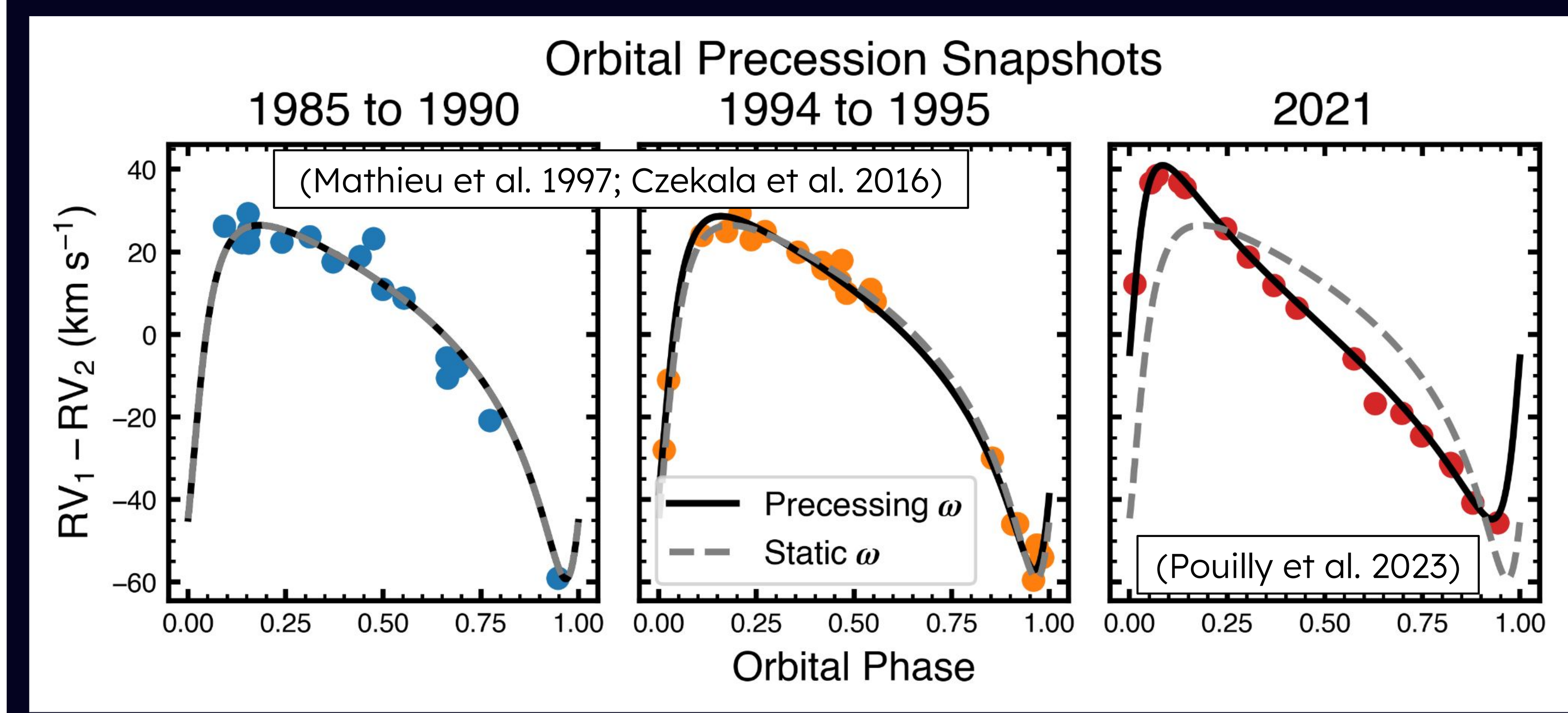


(An initial version of this analysis appears in Hyden et al. 2026, submitted.)

40+ Years of Radial Velocities

Detection of a Low-Mass Circumbinary Companion

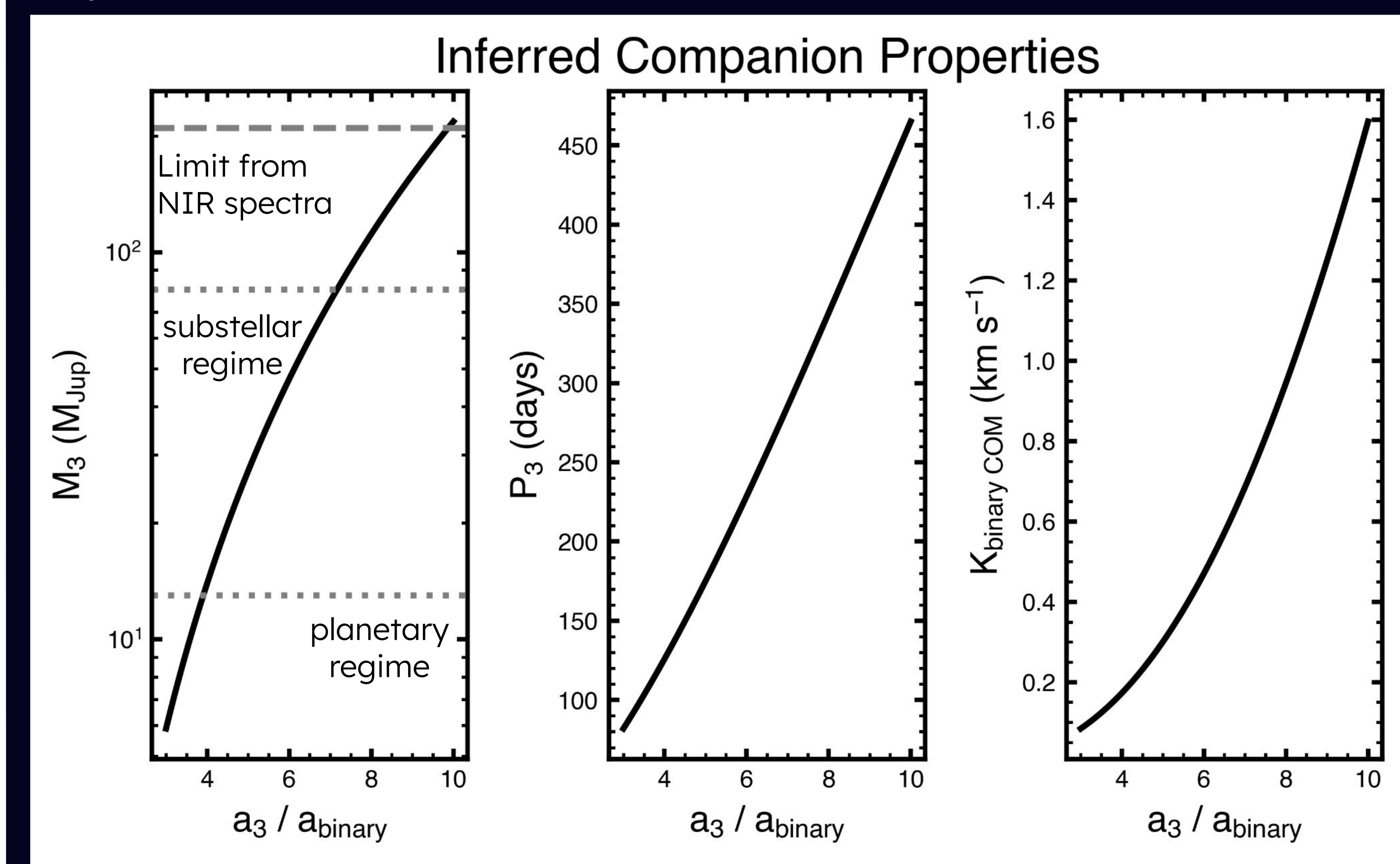
- Fast orbital precession (ω'_{obs} = 1.17±0.07° per year) is observed, dramatically altering the RV curve over time.
- We combine RVs from the literature [9,10,11,12,13,14,15] with new analyses of IGRINS [16] and UVES spectra.



Apsidal precession has contributions from general relativity, tides, and the interaction with the circumbinary disk. **These values are an orders of magnitude less than the observed rate.**

Assigning the residual precession to a cirumbinay companion ($\omega'_{resid} = \omega'_{obs} - \omega'_{GR} - \omega'_{tidal} - \omega'_{disk}$), we compute the inferred companion mass. The companion's orbital period and the semi-major amplitude (K) of the binary center-of-mass follow from a Keplerian orbit.

$$M_{out} = \frac{4}{3}\left(\frac{a_{out}}{a_{bin}}\right)^3 \frac{M_{bin}}{t_{prec}/t_{bin}}$$



Decomposition of the IGRINS NIR spectra rules out companions above ~0.2 Solar masses, **placing the companion within 10x the binary separation (≲1.4 AU).** The typical uncertainties of the center-of-mass RV measurements in this data set are too large (~2 km/s) to detect such companions.

References
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[5] Ricker et al. 2015
[6] Muzerolle et al. 2019
[7] Tofflemire et al. 2017a
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