An eccentric stellar companion in the hot dust system κ Tuc A

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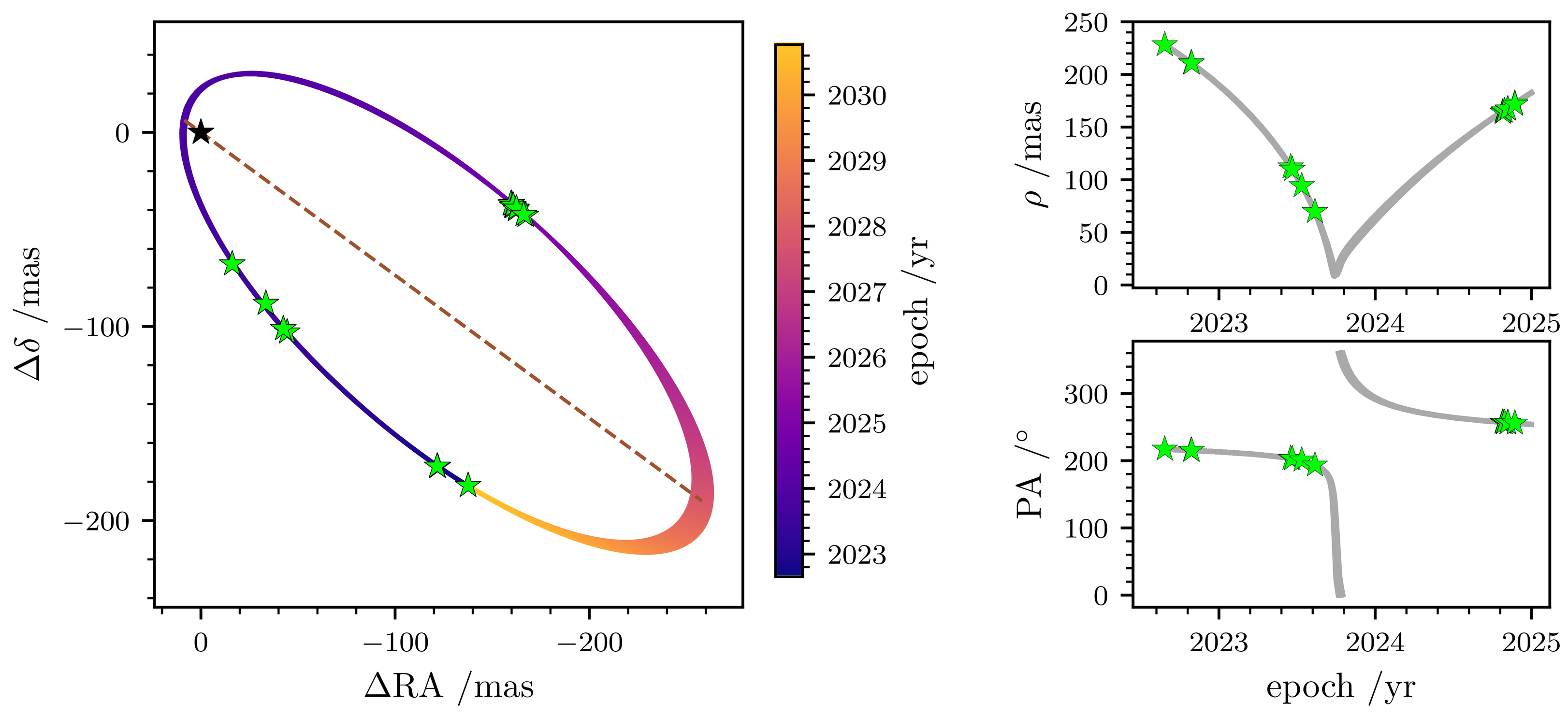
Introduction

Besides exoplanets, there is dust in planetary systems that forms a debris disk. Both debris disk and exoplanets influence each other and also appear together in observations. Hot exozodiacal dust is a special component of a debris disk that consists of sub-micrometer sized dust grains that reside in the sub-au vicinity of their host star. There they exhibit temperatures of 1000 K and more.
This hot dust can jeopardize any attempt to directly image an exo-Earth (Ertel et al. 2025). On the one hand, the dust is located at fractions of the inner working angle of coronagraphs where it causes coronagraphic leakage. On the other hand, the dust grains might traverse the habitable zone where they can add confusion in the regions where exo-Earths are hoped to be detected.
However, the physical mechanisms underlying the hot dust phenomenon are poorly understood, which strongly impairs strategies trying to mitigate its impact on exo-Earth surveys.

Using MATISSE and GRAVITY at the Very Large Telescope Interferometer, we detected a new stellar companion to the F6-type star κ Tuc A that also hosts hot dust (Kirchschlager et al. 2020). This opens an exciting new path to investigate the hot dust phenomenon via interactions of the stellar companion with the hot dust itself or a possible unseen outer reservoir of planetesimals.

The author is happy to chat about hot dust, why it is an enigma, how it can jeopardize exo-Earth detections, interferometry, the complex architecture of the κ Tuc system, or any questions you might have!

Eccentric companion orbit



Orbit constraints derived from MCMC fit to relative astrometry (green stars). *Left:* Orbits show the displacement of the companion with respect to the primary star (black star). Colors indicate the companion's position along the orbits, starting with our first detection on 2022 August 27, and ending after one orbital period. The dashed brown line connects the peri- and apoastron. *Right:* Gray curves show the binary separation ρ and the position angle PA of the companion. Orbit fit and plots made with `orbitize!` (Blunt et al. 2020).

Companion properties

- Semi-major axis: 4.8 au
- Periastron: 0.3 au
- Apoastron: 9.3 au
- Eccentricity: e = 0.94
- Orbital period: 8.4 yr
- Spectral type: M3.0 V - M4.5 V

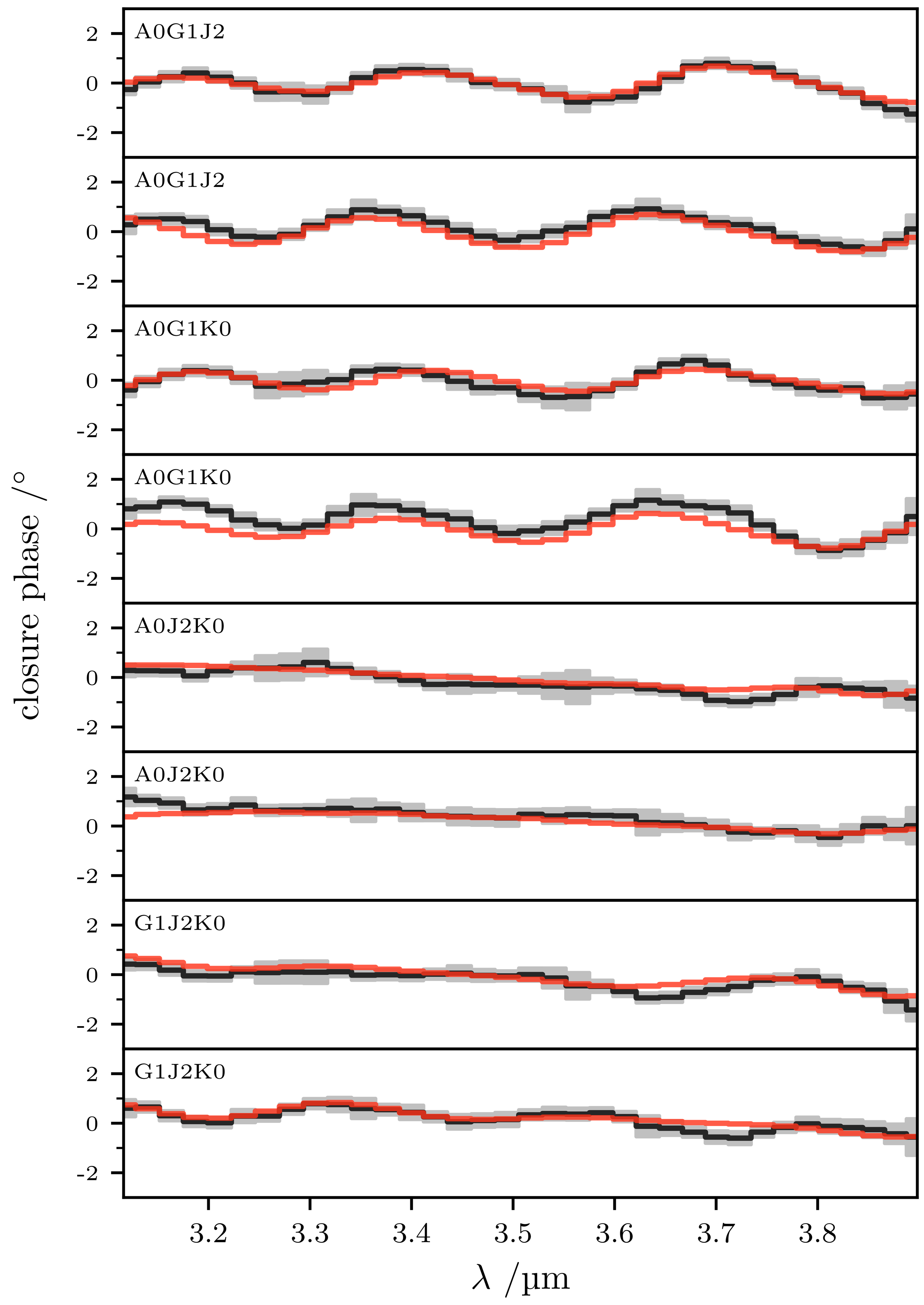
New paths to explore hot exozodiacal dust

1) The companion could decrease the amount of hot dust by
   - scattering the dust distribution at every periastron passage.
   - adding radiation and corpuscular pressure on the dust grains, blowing them out of the system.
   - heating the dust grains and hence fostering sublimation.
2) The companion could increase the amount of hot dust by
   - exciting unseen planetesimals on to cometary orbits.
   - trapping dust grains in its vicinity, for instance by magnetic or gas trapping.

Very Large Telescope Interferometer (VLTI)

Image of Cerro Paranal with the four 8.2 m Unitary Telescoped (UTs) and the 1.8 m Auxiliary Telescopes (ATs), which can be positioned on differed stations indicated by the white circles. Credits: G. Hüdepohl (atacamaphoto.com)/ESO 2015.

Companion detection with MATISSE closure phases



Binary star model (red) fit to MATISSE closure phases for different triplets of VLTI telescope stations (e.g., A0G1J2 for stations A0, G1, and J2). This is the record holder for the **lowest contrast** companion detection using MATISSE closure phases.

References

Blunt, S., Wang, J. J., Angelo, I., et al. 2020, AJ, 159, 89

Ertel, S., Pearce, T. D., Debes, J. H., et al. 2025, PASP, 137, 031001

Kirchschlager, F., Ertel, S., Wolf, S., Matter, A., & Krivov, A. V. 2020, MNRAS, 499, L47