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Dynamical constraints on the S2 (S0-2) star possible companions

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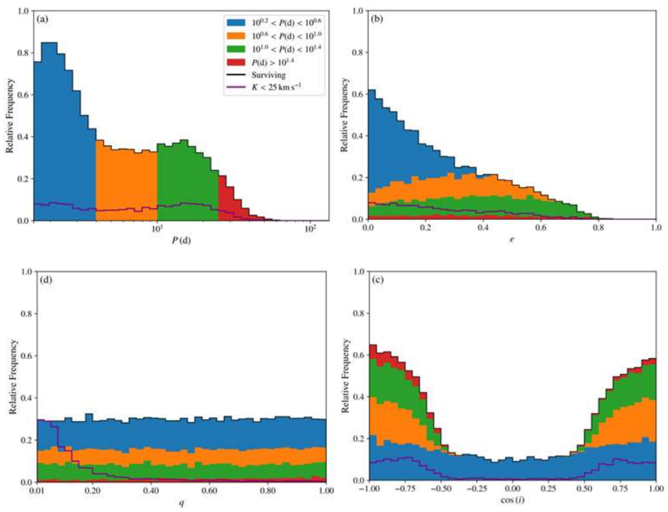
Introduction

At the Galactic Centre lies a cluster of massive stars, known as the S-cluster, which orbit the central supermassive black hole, Sagittarius A*. Although massive stars in the Galactic field are commonly found in binary systems [1], such companions appear to be absent among the S-cluster stars [2].
Within this cluster, the star S2 is particularly notable as one of the most extensively studied members. It has been used to test General Relativity [3–5], as well as to confirm the existence and constrain the properties of Sagittarius A* [6, 7].

Methods

1. We performed a Monte Carlo simulation using uniform distributions for all orbital parameters, except for the orbital inclination I and P, for which we adopted uniform distributions in $\cos I$ and $\log_{10} P$, respectively.
2. Discarded any initial conditions for which the pericenter distance is below the Roche limit.
3. We use the open-source N-body code TIDYMESS [8], incorporating 1PN corrections to evolve the system up to 1M yr.



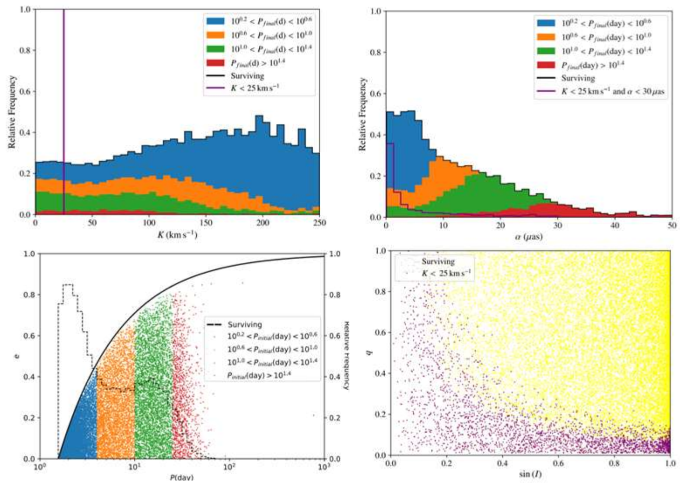
The astrometric semi-amplitude signal of a face-on elliptical orbit is given by [9]

$$\alpha = \frac{q}{(1+q)^{2/3}} \frac{(G m_A)^{1/3}}{n^{2/3} D}.$$

To account for an arbitrary orientation of the celestial body we derive the projected astrometric semi-amplitude

$$\alpha' = \alpha \left(\gamma + \sqrt{\gamma^2 - (1-e^2)\cos^2 I}\right)^{1/2},$$

$$\gamma = 1 - \frac{1}{2}\left[e^2 + (1 - e^2\cos^2\omega)\sin^2 I\right].$$



Results & Conclusions

1. A companion can only exist for orbital periods shorter than 100 days and with eccentricities up to 0.8.
2. Companions may exist at any mutual inclination, though near-coplanar configurations are favored.
3. Hidden spectroscopic configurations tend to have their orbital plane nearly perpendicular with the line of sight.
4. Current astrometric and spectroscopic measurements are unable to detect a companion due to observational limitations. However future ELT instrumentation (METIS/ANDES) will answer.

References

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