

Orbital Architecture and Dynamics of Planetary Systems

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As instruments gain in precision, observations reveal an increasing diversity in the architecture of planetary systems: eccentric orbits, gravitational resonances, hierarchical multiples, and more. These complex orbital configurations reshape the structure of surrounding dust discs, leaving gravitational signatures. In return, discs serve as valuable records of the dynamic history of systems. This work presents a general methodology that combines observational constraints (positions and velocities of bodies, disc morphology) with theoretical modeling, in order to estimate planetary orbits and explore the dynamical links between bodies and debris discs. The goal is to reconstruct the current state of these systems and better understand their dynamical evolution.

We apply our method to the GG Tauri system, a multiple system in which five stars collectively sculpt a dust disc surrounding the central triple. The well-resolved configuration and quality of the available observations make it a particularly suitable case for implementing the first step of our approach: reconstructing the orbits of the bodies.

We then implement the second step of our method, which consists of dynamical modeling, in the emblematic Beta Pictoris system. Using N-body numerical simulations, we study the joint evolution of the two known super-Jupiters and the debris disc. Our analysis shows that the inner edge of the disc, located at 50 AU, cannot be explained by the two planets alone, suggesting the influence of a third, still undetected, planetary body.

Some systems do not allow for the first step of our method due to limited data. In these cases, disc analysis becomes the starting point for the dynamical study. This is the case for the TWA7 system: although one planet has been detected, its orbit remains uncertain. The disc, however, provides complementary dynamical clues: the position of its inner edge suggests, as in Beta Pictoris, the presence of an additional planet, while the presence of trojan-like structures along the orbit of the known planet constrains the orbital parameters of all bodies in the system.