Evolution of stars in Tight Triple Systems

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What are Tight Triple Systems?

Tight triple systems (TTS) are stellar systems where two stars are orbiting in a small orbit around each other while the third star orbits these two stars in an orbit of less than 1000 day period. These stars are arranged in a special type of configuration called hierarchical orbits where the inner binary system can be approximated as a single star when taken with respect to the third star. This also explains the stability of three-body dynamics which is otherwise chaotic.

Why should we study them?

TTS was thought to be rare previously, but there has been a surge in the discovery of such systems with new space observation missions like TESS and Kepler telescopes. Usually, triple systems have been used as an explanation for the formation of close binaries, blue stragglers, planetary nebulae, and also the merger of several black holes. But most of these systems have long outer periods and their dynamic effects can have timescales of several centuries. Therefore studying them in detail can be a time taking process. But the dynamic processes in TTS can be observed in time scales less than a human lifetime. Therefore understanding these systems would give us insights to probe multiple-star, binary-star, and also single-star evolution.

How will we study them?

If we can get TTS where the inner binary is a Detached Eclipsing Binary (DEB), we can obtain very accurate stellar and orbital parameters of not only the binary but also of the third star. DEBs are two stars that rotate around each other but their plane of rotation is in our line of sight. Therefore these stars eclipse each other and from understanding the geometry of the eclipses, and combining with their velocities obtained from their spectra, we can extract very accurate parameters. Also, apart from gravity, the stars do not interact with each other, so they evolve as single stars. Studying different aspects can also help us obtain various signatures of the third star and therefore give accurate parameters of all three stars. The relative errors in the measurement of these parameters can be lower than 1%, even down to 0.1%, which is crucial for testing modern astrophysics.

What do we expect from this study?

Till now, the number of known TTS' is less than 1000. Only a few of these targets have been studied in the detail that our study proposes. Apart from contributing to complete studies of these rare targets, this study will contribute to the collection of accurate parameters of DEBs too. With triples we can better test stellar evolution models using our parameters as checkpoints or markers. The current star-formation theories of triple star systems can be understood better with the orbits and masses that we obtain for our targets. Follow-up observations based on our analysis can also help us monitor changes in TTS and help us constrain the dynamics of such systems more accurately. This demonstrates that our study has multi-faceted significance for stellar astrophysics.