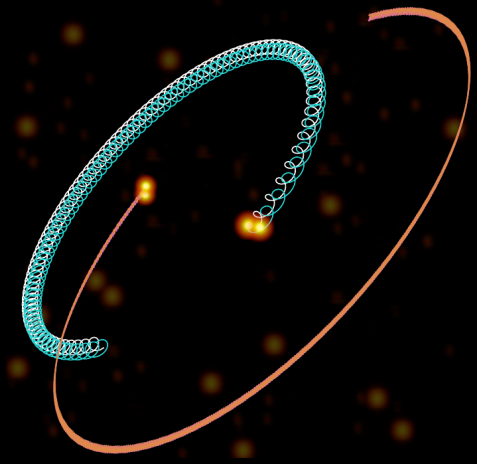
Stellar multiplicity

Quadruples in spectroscopic surveys



SUMMARY.
Most of the stars form in binaries or multiples which could significantly affect the physico-chemical properties of stellar evolution. Type of hierarchical structures becomes relevant starting with stellar quadruples. Short-period systems are detected as Spectroscopic Binaries with 4 components (SB4). Such rare systems started to be discovered in large ground-based spectroscopic surveys like Gaia-ESO, APOGEE or GALAH. Recent simulations demonstrated that quadruple systems with 2+2 architecture undergoing Kozai-Lidov oscillations with tidal friction could also be very good candidates to form type Ia supernovae. In this METEOR the student will familiarise himself/herself with the Radial Velocities (RV) method widely used for SB2 orbital characterization and apply it to the characterization of SB4.

OBJECTIVES

The main objective is to introduce the student to the modeling of stellar architecture by means of the radial velocities method to derive the orbital parameters (period, eccentricity, RV amplitude, etc.) of each pair of a quadruple stellar system.

PREREQUISITES

Previous courses on General Astrophysics and Stellar Physics are recommended. Basic programming skills are needed to achieve the main goals (Python is an asset).

THEORY

by T. Merle

The gravitational two-body problem – Observing binaries (with focus on spectroscopic binaries and the method of radial velocities) – Fundamental parameters derived from binaries – Tidal forces.

APPLICATIONS

by T. Merle

The student will solve short practical exercises related to the theoretical parts studied. Then the project will consist in deriving partial or complete orbital solutions to determine the architecture of candidate SB4 detected in large ground-based spectroscopic surveys like Gaia-ESO, APOGEE and GALAH. The student will familiarize himself/herself with data reduction and analysis of high resolution spectra for some SB4 candidates obtained with the HERMES and HRS spectrographs at Meractor (North hemisphere) and SALT (South hemisphere) telescopes. He/she will determine the RV of each component by computing cross-correlation functions of spectra with templates and compute orbital solutions for inner and outer pairs. Comparison with the few other existing characterized SB4 may also be performed.

MAIN PROGRESSION STEPS

First 3 weeks of the period: theoretical courses and short practical exercises. Other 5 weeks of the period: numerical project. Last week: preparation of the final oral presentation.

EVALUATION

Evaluation of the theoretical part(weight: 0.5). Written report on the project (weight: 0.5). The student's production will be evaluated according to the completion of intermediate goals defined during the development of the project.

BIBLIOGRAPHY & RESSOURCES

Merle et al. Nature Astronomy (2022): Example of an SB4
Tokovinin Universe (2021): Architecture of stellar systems

CONTACT

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