Bayesian modelling of intermediate-mass stars

SUMMARY.
This project consists in modelling stars in eclipsing binary systems. Thanks to spectroscopy and eclipse timing, we can derive accurate parameters like their mass, and radius. It focuses on intermediate-mass stars, whose rotation is often rapid, modifying the shape and interior of the star, making the inferred parameters less accurate and precise.
After lectures on stellar evolution and training on both the widespread evolution code MESA and Bayesian statistics, the student will use and improve our bespoke analysis pipeline to derive essential parameters for a large sample of stars. Beyond mass and radius, the models will yield rotational period, metallicity and age of each star. During this METEOR, this information will allow us to shed light on the rotational properties of the considered stars, but it is also crucial prior information for planetary searches around intermediate-mass stars or for the asteroseismic modelling of the stellar interiors.

OBJECTIVES

- The student will learn the evolution of stars, as well as strategies to characterize the parameters and structures of stars through asteroseismology, with a focus on their rotation.
- The project consists in fitting models to observations of intermediate-mass stars in eclipsing binaries (which allows for an accurate estimation of their parameters). This will be done by running and improving the pipeline based on model grids and Bayesian statistics developed in our group.

INSTITUTE

- Group of stellar evolution and nucleosynthesis
- Theoretical and Cosmos physics department, Universidad de Granada (Spain)
- Edificio Mecenas, campus de Fuentenueva, Granada, Spain

THEORY

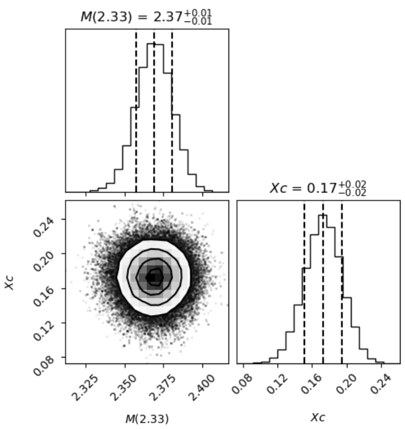
by G. Mirouh

This METEOR will include courses on stellar physics, with a focus on stellar rotation and multiplicity. After an overview of stellar modelling with the MESA stellar evolution code, practical work will include tutorials on the Bayesian statistics underlying the code developed in the group to fit observed data.

APPLICATIONS

by G. Mirouh

During this METEOR, the student will be provided a list of intermediate-mass stars in eclipsing binary systems. Coincident spectral observation and eclipse timing allowed for an accurate derivation of those stars' parameters [1]. Using a grid of models computed with the MESA code, and Bayesian statistics, it is possible to obtain a model fitting the observations along with uncertainties [2,3].
The student will use this pipeline to derive parameter estimates (mass, radius, metallicity, rotation rate) for the provided stars, possibly improving the code in the process. The parameters will be discussed with respect to literature estimates to decipher the rotational history of intermediate-mass stars.



Mass and central hydrogen abundance inference for a star observed through spectroscopy.

MAIN PROGRESSION STEPS

- Week 1-2: Stellar physics and asteroseismology courses.
- Week 3-4: Bayesian statistic tutorial and exercices.
- Weeks 5-9: Project.

EVALUATION

- **Theory grade [30%]**
  - Written exam: stellar physics (50%)
  - Presentation of an article (50%)
- **Practice grade [30%]**
  - Practical exercice: Bayesian pipeline (30%)
  - Project (70%)
- **Defense grade [40%]**
  - Oral and slides quality
  - Context
  - Project / Personal work
  - Answers to questions

BIBLIOGRAPHY & RESOURCES

- [1] DEBCat, an example catalogue of eclipsing binary stars.
- [2] SPInS, an interpolation code we took inspiration from.
- [3] Bazot et al. 2012, MNRAS, 427, 1847

CONTACT

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