PLAnetary DYnamics and Stellar Evolution PLADYSE

SUMMARY.

Stellar evolution for star with mass between 1 an 8 solar masses is, at the end of the Main Sequence, a period of drastic transformations both for the star itself but also for the circumstellar environment. The travel from the Red Giant (RG) phase to the White Dwarf (WD) ultimate one (through AGB, post AGB and planetary nebulae (PN) stages) is a fast and violent transformation during which up to 1 solar mass of the star can be expelled in 10 000 years and the star luminosity can increase of several order of magnitude. The circumstellar environment is hence deeply modified during these phases. The dynamics of planets and small bodies around the central star will be deeply modified by these events and many non gravitational perturbations have to be considered in the dynamical equations. The student will develop numerical integrators to describe and study the pertubated dynamics of planets and small bodies during the late phases of stellar evolution.

```
$ make package
```

OBJECTIVES

Students will be able to

- model gravitational forces in N body problem
- model non-gravitational forces in N body problems
- use MESA code for stellar evolution
- couple gravitational code and MESA to study small body dynamic with respect with stellar evolution

PREREQUISITES

- ☒ S1. Data Sciences
- ☒ S1. Numerical methods
- ☒ S2. Stellar physics
- ☒ S2. Dynamics & Planetology

THEORY

by Ph. Bendjoya & G. Niccolini

Restricted three body problem. ! N body problem (N small).
Non gravitational forces : friction, wake , mass loss, Yarkovsky...
numerical ODE integration,
MESA code use

APPLICATIONS

by Ph. Bendjoya & G. Niccolini

Analytical derivation of equations of motion of gravitational and non gravitational perturbation interactions
Numerical coding of 2 body problem, restricted 3 body problem, general N body problem,
Numerciaml coding of non grvitaional perturbation.
Coupling stellar evolution in previous simulation

(Photo : Pixabay/Terranaut) JWST's Glimpse into the Future: Predicting Solar System's Fate through Exoplanet Observations

MAIN PROGRESSION STEPS

- First half of the period : theoretical courses : Revision 2 body and restricted 3 body problem.
- First half of the period in parallel: Numerical exercises. Introduction of different non gravitational forces
- Second half of the period : numerical project: application on student's chosen problem. Critical analysis of the simulations
- Last week : preparation of the final oral presentation.

EVALUATION

- `Theory grade [30%]`
  - base calculus from lectures
- `Practice grade [30%]`
  - Exercices (30%): thought-process and results
  - Project (70%): initiative, progress, analysis
- `Defense grade [40%]`
  - Oral and slides quality
  - Context
  - Project / Personal work
  - Answers to questions

BIBLIOGRAPHY & RESOURCES

- Solar System Dynamics, Carl D. Murray, and S. F. Dermott,Cambridge University Press (Book)
- https://github.com/maxmahlke/rocks

CONTACT

☎ +33.4.xx.xx.xx.xx
✉ meteor-mail@oca.eu