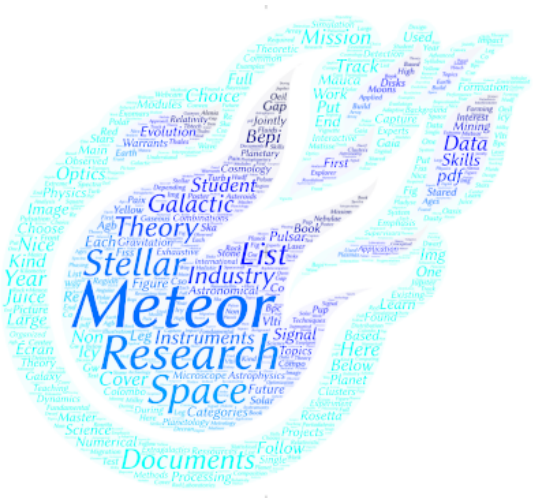
Interior structures of solar system bodies: from Artemis to Juice



SUMMARY.

The interior structure of solar system bodies are key information for understanding the formation and evolution of these bodies. In this METERO, we are focusing on using radio science data and tidal deformation for deciphering the internal structure of planetary bodies such as Mars or Mercury but also icy satellites such as Ganymede in the Jupiter system. The choice of these bodies of interests is not just random but it correspond to main targets which will be visited by space missions in which Observatoire de la Côte d'Azur team is involved such as Insight for Mars, Artémis for the Moon, Bepi-Colombo for Mercury, Envision and Veritas for Venus and Juice for the Jupiter system.

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OBJECTIVES

The objectives of the METEOR is to learn how we understand the interior structures of planetary bodies (including natural satellites) only in using remote observations (no in-situ measurements). The student will learn the mechanisms behind the tides, how the tides deform bodies and how the body deformations induced by tides depend on its internal structure. The student will be introduced to spacecraft navigation and will understand how to use a spacecraft orbiting a body for determining its mass and shape and how these informations can be related to the tidal deformations. He will finally use numerical simulations for simulating how using radio tracking observations we can constraint the density, thickness and viscosity of the different layers of a planetary body.

PREREQUISITES

- ☒ S1. Data Sciences
- ☒ S1. Numerical methods
- ☒ S2. Dynamics & Planetology
- ☒ S2. Statistics
- ☒ S2. General mechanics

THEORY

by Anthony Mémin

In this METEOR, we will see the theoretical aspects related to the deformation of planetary body, including basic rheology laws and energy dissipation. These will tell us how the internal structure can induce different possible deformations. (Course A)

by Agnès Fienga

We will also see how to compute and constraint the orbit of a spacecraft using tracking data (doppler and range) and we will see how to determine the deformation of a planetary body using spacecraft orbitography. (Course B)

APPLICATIONS

by Anthony Mémin

In using the software ALMA3, the student will simulate different deformations induced by different possible internal structures, from a planetary satellite such as the moon, to earth-like planet such as Venus to icy satellite like Ganymede. (project A)

by Agnès Fienga

In using the software rebound, the student will simulate tracking data of a spacecraft orbiting a planetary body (Moon, Mercury, Venus, Ganymede) and he/she will simulate how well the tidal deformation of these bodies can be constrained from the tracking data. (project B) He/she will be then able to determine which orbital configuration can give stringent constraint on the different parameters of the internal structures (ie salinity of the Ganymede subsurface ocean). (project C)

MAIN PROGRESSION STEPS

The student can chose the objects of interest among Venus, Mercury and Ganymede and the associated missions (ENvision, BepiColombo and JUICE)

- `Part 1`: courses A/B and project A an B
- `Part 2`: project C

EVALUATION

- `Theory grade [30%]`
  This evaluation will be presentation of an article either one the Course A either on the Course B. The global understanding and the critical spirit will be evaluated.
- `Practice grade [30%]`
  - projects A and B (30%): thought-process and results
  - Project C (70%): initiative, progress, analysis
- `Defense grade [40%]`
  - Oral and slides quality
  - Context
  - Project / Personal work
  - Answers to questions

BIBLIOGRAPHY & RESOURCES

- Review on JUICE mission
- BepiColombo and Mercury internal structure
- Example of icy satellites internal structure modelings
- Envision: From Earth to Venus

CONTACT

☎ +33.4.83618545
✉ agnes.fiengal@oca.eu