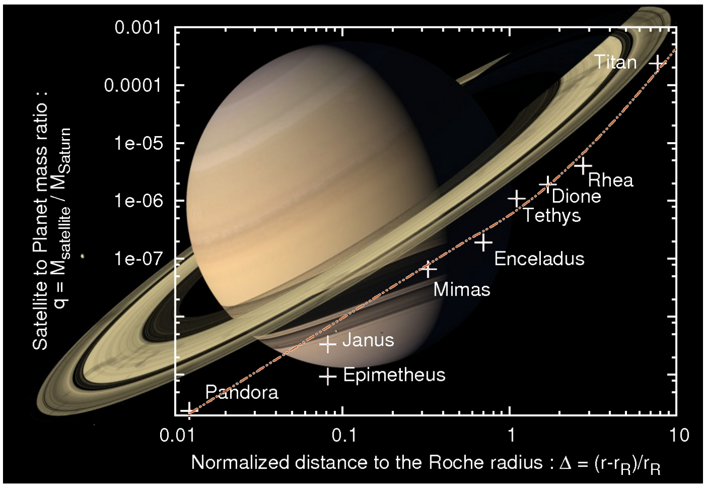
Dynamics and Planetology



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Objectives

The aim of this lecture is to provide the students with good knowledge of celestial mechanics and orbital dynamics, in order to understand key features in astrophysical problems. In particular, the 2- and 3- body problems will be presented and studied in detail with lectures, exercices, and applications to the internal structure of planets, mean motion resonances, and the distribution of the orbits of small bodies in the solar system.

In the second phase, we will focus on phenomenons that took place in the history of the solar system, but also probably of other planetary systems : tidal evolution of the orbits, formation of regular satellites from massive rings around planets like Saturn, planetary migration in the gaseous proto-planetary disk, and late dynamical instabilities.

Evaluation

Two small intermediary written exams: 25% each.
Final written exam: 50%.

Main progression steps

- First half of the period : theoretical courses + exercices on celestial mechanics.
- Second half of the period : theoretical courses + exercices on tides, rings, and satellites.
- Last week : Lecture on planetary migration and history of the Solar System.

Bibliography & Resources

The lecture notes will be available online on the MAUCA webpage.

Contents

Chapter 1: The 2-body problem, and applications

1. The two-body problem and Kepler's laws,
2. Orbital elements, link with orbital energy and angular momentum and applications,
3. Case of a non perfect central body:
   momenta J_n of the potential and link with the internal structure, notion of osculating orbit, applications.

Chapter 2: The restricted 3-body problem

1. Sphere of influence, Lagrange points, horseshoe orbits.
2. Notion of resonance and application to the perturbing potential.
3. Lagrangian and Hamiltonian formalism.
4. Application to the case of Planet 9.

Chapter 3: Tides

1. Definition and calculation of the tidal force.
2. Applications to oceanic tides and the dynamics of the Earth-Moon system, notion of synchronous orbit and tidal locking.
3. The Roche radius, application to Saturn's rings.

Chapter 4: History of Saturn's system, formation of satellites from spreading rings

1. Introduction to Saturn's system.
2. Evolution of the rings.
3. Evolution of the satellites.
4. Generalisation and discussion.

Chapter 5: Planetary migration

1. Type I migration (differential Lindblad torque, corotation torque, migration maps).
2. Gap opening and type II migration.
3. Migration of resonant planet pairs, application to the Solar System.
4. Planetesimal-driven migration and the Nice model.