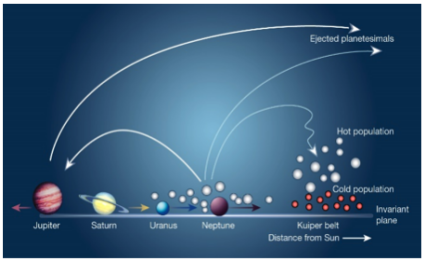
Planetology



Applications of Celestial Mechanics in Planetology and Astrodynamics

In recent years, celestial mechanics – the powerful mathematical theory that describes the motions of celestial bodies and systems – has reached its full applications potential, due to the evolution in our theoretical understanding of chaotic phenomena as well as of computational methods and technology. Its applications encompass a wide range of space-related topics, such as: origin and dynamical evolution of our solar system and exoplanetary systems, dynamics of small-bodies and systems, manifold dynamics and advanced space mission design, and long-term dynamical evolution of satellites and space debris mitigation strategies. In this METEOR, we discuss the basic theoretical and numerical tools of celestial mechanics, placing emphasis on a wide range of applications.

Fundamental knowledge

by K. TSIGANIS, G. VOYATZIS

I) Fundamental Celestial Mechanics:
– Beyond Keplerian Motion
– Basic physical models (3- and N-body problems, gravitational And non-gravitational perturbations)
– Dynamical systems and Chaos basics
– Examples from Solar System dynamics (asteroids, planets, satellites)

II) Computational Methods:
– Numerical integration techniques (general and symplectic methods)
– Analysis tools (frequency and deviation methods)
– Regular and chaotic motions: sources and typical signatures
– What do these mean for the long-term evolution of celestial systems?

III) Applications I: Planetary systems
– Planetary, satellite and small-body dynamics on short and long timescales
– Asteroid families and NEAs
– Dynamics tracing the origins of the solar system
– Evolution of model types of extrasolar systems

IV) Applications II: Astrodynamics
– Basic formalism and concepts
– Beyond classical astrodynamics (dynamical systems approach)
– Advanced mission design (manifolds dynamics)
– Dynamics and passive debris mitigation strategies

Theory & Computations

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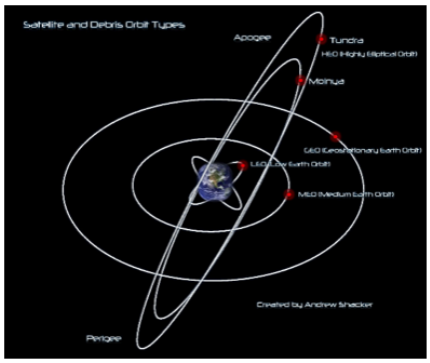

In general, the students are expected to learn:
- How to use fundamental concepts of dynamical systems theory (perturbation approach; chaos, sources and long-term effects) and build models of celestial mechanics (few-body problem and variants)
- How to perform numerical computations in general problems of space dynamics, using suitable schemes
- How to analyse and interpret the results, using advances tools and their theoretical knowledge

More specifically, for the applications studied, the students are expected to learn:
- How to study planetary, small-body and artificial satellites dynamics
- How to use dynamics as tracers of the origin and future evolution of natural and artificial celestial systems

Contacts

☎ +30-2310-998963 (K. Tsiganis)
✉ tsiganis@auth.gr
☎ +30-2310-998060 (G. Voyatzis)
✉ voyatzis@auth.gr