Study program: Astronomy and Astrophysics - PhD studies

Course Title: Analytical methods of celestial mechanics

Teacher: Zoran Knežević, Bojan Novaković

Status of course: optional

Credits: 9

Pre-requisites: none

Course goal: The acquisition of general and specific knowledge of analytical methods and tools of celestial mechanics.

Summary of Intended Learning Outcomes: Upon completion of the course, PhD student has a basic knowledge of analytical methods of celestial mechanics and the capability for further research work in this field.

Course content:

Lagrangian mechanics. Equations of motion. Keplerian, nonsingular and canonical orbital elements. Disturbing function: d*evelopment* of *power series*. Laplace's coefficients. Linear theory of secular perturbations. Canonical transformation. Generating transformation. D'Alembert rules. Hamiltonian mechanics. Hamiltonian systems and 2-body problem. Integrable and *quasi-integrable Hamiltonian systems*. Action-angle variables. The problem of small divisors. Normal forms. Secular dynamics. Chaotic secular motion of the planets. The dynamics of the rotation axis. The linear integrable approximation of the secular dynamics of small bodies. Kozai's integrable approximation. Proper orbital elements. Asteroid families. Secular resonances. Mean motion resonances. A simplified integrable approximation and a mechanism of impact protection. The case of 1:1 resonance. Overlapping of mean motion resonances. Resonant multiplets. Modulated pendulum approximation. 3-body mean motion resonances. The direct effect. Indirect effect. Secular dynamics inside mean motion resonances. The chaotic dynamics.

Literature:

1. Brouwer D., Clemence G. M.: **Methods of Celestial Mechanics**, Acad. Press, New York, 1961
2. Morbidelli A.: **Modern Celestial Mechanics; Aspects of Solar System Dynamics**, Taylor & Francis/Cambridge Scientific Publishers, 2001
3. Carl D. Murray, Stanley F. Dermott: **Solar System Dynamics,** Cambridge University Press, 2000
4. Souchay J., Dvorak R. (Eds.): **Dynamics of Small Solar System Bodies and Exoplanets**, Lect. Notes Phys. 790, Springer, Berlin Heidelberg, 2010
5. **Selected scientific papers**

Number of teachenig hours: 10	**Theoretical lessons**: 4	**Practical lessons:** 6

Methods of teaching: Frontal, Group, *Individual Research* Approach

Grading Score (maximum 100 points)

Pre-exam obligations	points	**Final exam**	points
In-class activity	10	Written exam	
Practical training		Oral exam	40
Midterm			
Seminars	50		