DISSERTATION EXAM
Field of study: ASTRONOMY 4.1.7

Joint expert committee will determine one of the subjects listed below as the subject of the exam, according to the focus of a PhD student

Topics from the field: **CELESTIAL MECHANICS**

1. Two-body problem

Equations of motion. Integrals of motion. Conservation laws.

2. Kepler’s laws

3. Kepler’s equation

Anomalies. Kepler’s equations for elliptic and hyperbolic orbit. Solution methods of Kepler’s equation.

4. Orbital elements

Definition. Relation to integration constants of two-body problem. Velocity on Kepler’s orbit. Osculating elements. Proper elements (of asteroid families). Mean elements (of meteor showers).

5. Restricted 3-body problem

Equations of motion. Hill’s surfaces. Zero velocity curves. Lagrange libration points. Tisserand’s criterion.

6. N-body problem

Equations of motion. Integrals of motion. Conservation laws. Solvability.

7. Orbit perturbations

Explanation of term “perturbation problem”. Perturbation function. Equations of motion of N-body problem expressed in terms of perturbation function.

8. Lagrange equations

Formulation of the variation problem. Lagrange brackets. Meaning of Lagrange equations. Why they are expressed in Gauss form.

RECOMMENDED LITERATURE

● Brouwer, D., Clemence, J.: Methods of Celestial Mechanics. Academic Press, New York, 1964.
● Boccaletti D., Pucacco G.: Theory of orbits - 1. Integrable Systems and Non-perturbative Methods. Springer, Berlin, 2001.
● Boccaletti D., Pucacco G.: Theory of orbits - 2. Perturbative and Geometrical Methods. Springer, Berlin, 2002.

Topics from the field: **INTERPLANETARY MATTER**

1. Discoveries and theories of asteroid origin

History of discoveries, naming of minor planets. Photographic methods of discovering of minor planets – Wolf’s and Metcalf’s. Theories of asteroid origin.

2. Orbit types of minor planets

Statistics of orbits, commensurability, minor planet families. Minor planets on peculiar orbits: type Amor, Apollo, Athens, Trojans, Hidalgo, Centaurians.

3. Astrometry and photometry of asteroids

Basic aims and methods of astrometry (visual, photographic and CCD). Asteroid brightness – apparent, absolute magnitudes. Standard fields. Influence of phase angle on brightness of asteroids.

4. Masses and sizes of asteroids

Mass determination, masses and densities of largest asteroids, total mass of system. Determination of diameters – methods: interferometry, eclipses of minor planets by Moon, direct determination of diameters using occultations of starts by minor planets, in situ measurements.

5. Rotation and composition of asteroids

Effect of shape and of albedo, rotation periods, amplitudes, color indices. Types of asteroids from albedo. Taxonomic types. Relative representation of different types as a function of heliocentric distance.

6. NEA

Evolution of orbits of individual populations of interplanetary matter. Potentially dangerous asteroids. Their collisions with Earth. Programs Spacewatch, Spaceguard etc.

7. Discoveries of comets and theories of their origin

Discoveries of comets, preliminary and definitive denotation. Cometary orbits statistics. Ephemerides of comets. Theories of comet origin.

8. Oort cloud and further reservoirs of comets

Discovery of Oort cloud. Evolution of orbits. Original and current view of Oort cloud. Trans-Neptunian belt (plutinos and further resonances, cubewanos). Scattered disc. Relationship of comet reservoirs to origin of Solar System.

9. Brightness of comets and their physical evolution

Apparent and absolute magnitude. Changes of brightness – geometric, short-term (outbursts and brightenings) and secular. Physical evolution of comets.

10. Photometry and spectroscopy of coma

Characteristics of cometary spectrum. Specifics of photoelectric and CCD photometry of comets. Principal cometary emissions and their parent molecules

11. Nucleus

Chemical composition, structure, albedo and radius. Mass-loss and non-gravitational forces. Comets at large distances from the Sun. Decays of comets.

12. Comet tails and their dynamics

Dusty tails. Dynamics of particles in tails (synchronies and syndynames). Antitail. Ice halo. Particle release from nucleus. Ion tails. Relation to solar wind. Structures in plasma tails. Sodium tail. Hydrogen halo.

13. Meteoroid streams

Origin and evolution of streams. Their parent bodies. Formation of sporadic background.

14. Observational methods of meteoric astronomy.

Visual, photographic, telescopic, TV, spectroscopic, radar and cosmic.

15. Time variations of observed frequencies of meteors

Daily and annual variation of number of sporadic meteors and their origin. Meteor shower activity. Meteor showers.

16. Main meteor showers

Basic characteristics of main meteor showers. Radiant of meteor shower and methods of theoretical radiants' calculation.

17. Distribution by size and density of meteoroids

Meteor brightness. Representation by size and mass in sporadic background, in younger and older showers. Density of meteoroids. Flux of meteoric material falling on Earth.

18. Orbital parameters of meteoroids

Characteristics of orbital elements of meteoroids and their determination. Meteoroid velocities – extra-atmospheric, geocentric and helio-centric.

19. Flight of meteoroid in atmosphere

Meteoric zone. Flight of meteoroid in atmosphere – evaporation, deceleration, radiation, ionization. Meteoric trails, their creation and dissipation.

20. Fundamental equations of physics of meteors

21. Classification of meteorites

Classification of meteorites and their composition. Significant meteorite sites. Slovak meteorites.

22. Origin of meteorites

Age determination, origin. Distinguishing meteorites from terrestrial rocks. Meteoritic craters.

23. Mutual relationships between individual populations of interplanetary matter

Relationship of comets and asteroids. Comets in final stages of evolution. Relationship of asteroids, comets and meteor streams. Possible sources and collection of primitive material. Cosmic Dust Program.

RECOMMENDED LITERATURE

● Binzel, R.P., Gehrels, T., Matthews, M.S.: Asteroids II. Univ. Arizona Press, Tucson, 1989.
● Krishna Swamy, K.S.: Physics of comets. World Scientific Publ. Co., Singapore, 1986.
● Fenández, J.A., Rickman, H.: Periodic comets. Univ. Rep., Montevideo, 1991.
● Ceplecha, Z., Borovička, J., Elford, W.G., Revelle, D.O., Hawks, R.L., Porubčan, V., Šimek, M.:
Meteor Phenomena and Bodies. Space Science Reviews 84, 1998, 327-471.
● McKinley, D.W.R.: Meteor Science and Engineering. McGraw Hill Co., New York, 1961.
● Murad, E., Williams, I.P.: Meteors in the Earth Atmosphere. Cambridge Univ. Press, 2002.
● Heide, F., Wlotzka, F.: Meteorites. Springer, Berlin, 1995.

A specialist in a particular field of science (solar physics, interplanetary matter, variable stars) is moreover required to have knowledge of the selected field within the scope of the review papers at international conferences over the previous 5 years.