

Space and Planetary Sciences at the University of Cologne, Germany

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Abstract:

Space and Planetary Sciences are part of the curriculum within the Geophysics & Meteorology Program at the University of Cologne, Germany. While our Bachelor Program covers very broad skills in mathematics, physics and basic geophysics/meteorology, our English language Master Program is research oriented. Space and planetary sciences enter on the Bachelor level within the classes "Introduction to Geophysics" and "Geophysical Fluid Dynamics". The fluid dynamics class introduces the students to the physics of fluids including electrically conductive fluids with applications to space physics and the geodynamo. On the master level, our "Space Plasma Physics" class resembles a class in theoretical/statistical physics. We focus on a rigorous derivation of the set of Maxwell-Vlasov equations and derive the multi-fluid and single fluid MHD equations from moments of the distribution function. We quantitatively analyze properties of MHD flows, waves and discontinuities. The class is supplemented with an overview of the sun, the solar wind, magnetospheres, ionospheres and auroral physics. Another master level class "Geophysics of the Solar System" covers planetary and exoplanetary sciences including the structure and dynamics of planetary bodies, their atmospheres and magnetic fields.

Bachelor of Science

Geophysics and Meteorology (in German)

Program builds foundation for space and planetary sciences

Lectures include:

- Mathematics: Algebra, vector analysis, differential equations, complex analysis
- Physics: experimental and theoretical physics
- Introduction to geophysics
- Data processing and programming
- Mathematical methods for geophysics (e.g., time-series analysis, numerical methods)
- Geophysical fluid dynamics (including basics of MHD)
- Geophysics of the earth
- Applied geophysics
- Suit of meteorology classes

Master of Science:

Physics of Earth and Atmosphere (in English)

Module: Space Physics

3 h lecture, 2 h exercises

Aims of the module and acquired skills

Understanding the space environment around the earth and other planetary bodies including the solar wind. Understanding the basic properties of space plasmas with focus on the basic physical laws.

The acquired skills are the applications of mathematical/physical tools from statistical mechanics and fluid dynamics as applied to plasmas. Derivations of the plasma descriptions from first principles.

Contents of the module

- Introduction to space plasmas
- Single particle dynamics
- Kinetic theory (Boltzmann and Vlasov equation)
- Velocity moments of the distribution function
- Derivation of magnetohydrodynamic (MHD) equations
- Properties of MHD fluids
- Waves in plasmas
- Shocks and discontinuities
- Instabilities
- Magnetospheres, solar wind, aurorae

Master of Science:

Physics of the Earth and Atmosphere (in English)

Module: Planetary Sciences (Geophysics of the Solar System)

2 h lecture, 2 h exercises

Aims of the module and acquired skills

Students will get an overview of the planetary bodies in our solar system, their geophysical properties and interactions.

Acquired skills are mathematical/geophysical tools to describe: global properties of planetary bodies, dynamical evolution of planetary bodies.

Contents of the module

- Structure/Overview of the solar system
- Formation of the solar system
- Dynamics of the solar system:
 - Point masses and Kepler's laws
 - n-body problem
 - Dynamics of rigid bodies based on Euler's equation (e.g., precession and nutation)
 - Dynamics of non-rigid bodies and Liouville equation (e.g., tidal interactions and spin orbit coupling)
- Internal structure of the planets
- Planetary atmospheres
- Planetary magnetic fields, including a phenomenological overview of their space plasma environments and aurorae
- The sun
- Minor bodies: Comets, asteroids, ...
- Extra-solar solar planets



Institute of Geophysics & Meteorology

- University: 45,000 students
- Institute: 40 Bachelor students per year, 15 Master students per year
- 2 Geophysics Faculty
- 4 Meteorology Faculty
- <http://www.geomet.uni-koeln.de>