ASTROPHYSICAL AND PLANETARY SCIENCES - DOCTOR OF PHILOSOPHY (PHD)

Students pursuing a PhD from the Department of Astrophysical and Planetary Sciences generally specialize in the areas of astrophysics or planetary science.

The department does not offer a terminal, stand-alone master's degree program. Students enrolled in the doctoral program may earn their master's degree as they progress toward their PhD.

The program successfully integrates astrophysics, planetary science, Solar physics and space instrumentation with strong observational and theoretical components. These assets facilitate interaction and collaboration between the disciplines and enable students to explore a wide variety of research areas.

The Sommers--Bausch Observatory, conveniently located on campus, provides excellent hands--on experience with telescopes and observing, while the world--class Fiske Planetarium, supported by our department, offers a unique opportunity for public outreach. These campus resources are complemented by other affiliated research organizations in Boulder.

For more information, visit the department's Prospective Students (http://www.colorado.edu/aps/prospective-students/) webpage.

Requirements

A minimum of 37 credit hours of coursework (including 4 credit hours of graduate seminars) in courses numbered 5000 or above is required; however, the overall emphasis is on independent study and research. A minimum of 30 credit hours of PhD dissertation credit hours are required.

Students in the PhD program are required to remove any deficiencies identified at the preliminary interview; to pass a comprehensive examination composed of writing a research paper based on a semi-independent research project, then an oral exam on that paper and related topics within the field; and to satisfactorily defend the PhD thesis before a faculty committee.

During the first year of graduate study, students generally obtain a broad background in courses regarded as basic to all three areas in addition to more specialized studies. Many students take graduate-level courses in other departments (e.g., Departments of Physics, Atmospheric and Oceanic Sciences, Geological Sciences, Applied Mathematics, or Aerospace Engineering), depending upon their particular interests or participation in interdisciplinary programs (see below).

Required Courses and Credits

Code	Title	Credit Hours
ASTR 5110	Atomic and Molecular Processes	3
ASTR 5540	Mathematical Methods	3
ASTR 5400	Introduction to Fluid Dynamics	3
ASTR 5550	Observations, Data Analysis and Statistics	3
ASTR 5120	Radiative and Dynamical Processes	3
Total Credit Hours		**15**

Electives: Astrophysics Focus

The department offers a broad range of courses and research in this area, leading to the PhD degree. Graduate-level courses are offered in the following subjects:

Code	Title	Credit Hours
ASTR 5140	Astrophysical and Space Plasmas	3
ASTR 5700	Stellar Astrophysics	3
ASTR 5710	High-Energy Astrophysics	3
ASTR 5720	Galaxies	3
ASTR 5730	Stellar Atmospheres and Radiative Transfer	3
ASTR 5760	Astrophysical Instrumentation	3
ASTR 5770	Cosmology	3
ASTR 6000	Seminar in Astrophysics	1

Electives: Planetary Sciences Focus

As planetary sciences is an interdisciplinary field, students can obtain degrees from the Departments of Astrophysical and Planetary Sciences, Atmospheric and Oceanic Sciences, Geological Sciences, Physics or Aerospace Engineering. Boulder is also home to a division of the Southwest Research Institute, with over 25 planetary scientists, many of whom work with CU students. Research and courses related to the physics and dynamics of the atmospheres of other planets, planetary surfaces and interiors, and other solar system studies are available.

Graduate-level courses related to the physics and dynamics of the Earth's atmosphere are offered in the following subjects:

Code	Title	Credit Hours
ASTR 5140	Astrophysical and Space Plasmas	3
ASTR 5300	Introduction to Magnetospheres	3
ASTR 5330	Cosmochemistry	3
ASTR 5410	Fluid Instabilities, Waves, and Turbulence	3
ASTR 5800	Planetary Surfaces and Interiors	3
ASTR 5810	Planetary Atmospheres	3
ASTR 5820	Origin and Evolution of Planetary Systems	3
ASTR 5830	Topics in Planetary Science	3
ASTR 5835	Seminar in Planetary Science	1
ATOC 5050	Atmospheric Thermodynamics and Dynamics	3
ATOC 5560	Radiative Processes in Planetary Atmospheres	3

Research Opportunities

Observational and Theoretical Astrophysics

Research in this field is conducted in the following areas:

- Stellar atmospheres, radiative transfer, stellar winds of hot/cool stars
- Formation of stars and planetary systems
- Solar physics

- Interstellar and intergalactic medium
- Cosmology and large-scale structure of the universe; galaxy formation
- Stellar interiors, black holes and neutron stars
- Gravitational physics
- Cosmic X-ray sources, supernovae and their remnants and accretion phenomena, jets and clusters of galaxies
- Galactic evolution, quasars and active galaxies
- Radio and sub-millimeter astronomy, microwave background
- Plasma astrophysics and MHD
- Astrophysical fluid dynamics
- UV, optical, IR, submillimeter, radio and X-ray instrumentation
- Instrument and detector development
- Sounding rocket and balloon astronomy

Research is carried out with the ARC 3.5m Apache Point telescope, the Sloan Digital Sky Survey-V and these national telescopes and laboratories and international collaborators: High Altitude Observatory (HAO) in Boulder (Solar physics); National Optical Astronomical Observatories in Tucson and Chile (optical astronomy); National Radio Astronomy Observatory (NRAO); the Very Large Array (VLA); the Green Bank Telescope (GBT); the Hubble Space Telescope (HST); the Chandra, SWIFT, and XMM X-ray telescopes; the Fermi Gamma-Ray Space Telescope; and the Daniel K. Inouye Solar Telescope (DKIST) through collaboration with National Solar Observatory (NSO). CU Boulder also is involved with the Messenger (Mercury), MAVEN (Mars), JUNO (Jupiter), Cassini (Saturn), and New Horizons (Pluto) missions, as well as the HST Cosmic Origins Spectrograph.

Locally, APS operates a 24-inch Cassegrain-Coude and two 20-inch Cassegrain telescopes through Sommers-Bausch Observatory. These are available for photographic, photometric, and spectrographic observations, as well as for instrument and detector development. Opportunities for graduate research also are found with the university's Laboratory for Atmospheric and Space Physics (LASP), the Center for Astrophysics and Space Astronomy (CASA), and JILA.

Theoretical, Observational and Laboratory Atmospheric and Planetary Science

Research in this field is conducted in the following areas:

- Planetary disks, Kuiper Belt objects, extra-solar planets
- Dynamics and chemistry of planetary atmospheres, planetary clouds and planetary climates; evolution of planetary atmospheres; comparison of planetary and terrestrial atmospheres
- Planetary aeronomy, airglow and aurora, UV and IR spectroscopy, noctilucent clouds, structure and composition of planetary atmospheres (Venus, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto), planetary magnetospheres, and cometary physics
- Satellite monitoring of the Earth's atmosphere and environment, including remote sensing of mesospheric ozone, stratospheric trace species, convection, outgoing radiation and magnetospheric dynamics
- Planetary geology, planetary interiors and surfaces, and planetary geophysics

Graduate research opportunities exist with individual faculty members, as well as jointly with academic and research units, such as the Departments of Geological Sciences, Physics, and Aerospace Engineering, as well as the Department of Atmospheric and Oceanic Sciences (ATOC), the National Center for Atmospheric Research (NCAR), the National Oceanic and Atmospheric Administration (NOAA), and the Laboratory for Atmospheric and Space Physics (LASP). The latter is involved in space investigations of the Earth, Sun and planets. Financial support is available in connection with all of the above research activities.

Learning Outcomes

By the completion of our program, students will be able to:

- Demonstrate mastery of fundamental observational and theoretical foundations of astrophysics and planetary science, and be able to apply techniques to solve quantitative or conceptual problems across the core areas of astrophysics and planetary science.
- Read scientific papers and give a presentation on a scientific concept in astrophysics and planetary science.
- Analyze and evaluate scientific information in order to describe and address a question at the frontier of an astrophysical or planetary science discipline.
- Demonstrate the ability to carry out independent research in astrophysics or planetary science.