INDIANA UNIVERSITY

University Graduate School
2009-2010
Academic Bulletin

Astronomy

College of Arts and Sciences
Bloomington

Chairperson
Professor John J. Salzer

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Graduate Faculty

(An asterisk [*] denotes membership in the University Graduate School faculty with the endorsement to direct doctoral dissertations.)

Professors
Haldan N. Cohn*, Richard H. Durisen*, Frank K. Edmondson (Emeritus), R. Kent Honeycutt* (Emeritus), Hollis R. Johnson* (Emeritus), Phyllis M. Lugger*, Stuart L. Mufson*, Catherine A. Pilachowski*, John J. Salzer

Associate Professors
Martin S. Burkhead* (Emeritus), Constantine P. Deliyannis*, Liese van Zee*

Assistant Professor
Katherine L. Rhode*

Senior Scientists
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Degrees Offered

Master of Arts and Doctor of Philosophy. The department also participates in the Ph.D. program in astrophysics.

Research Facilities

Members of the Department of Astronomy use the WIYN (Wisconsin-Indiana-Yale-National Optical Astronomy Observatories) 3.5m and 0.9m telescopes at Kitt Peak National Observatory near Tucson, Arizona, to carry out research in optical astronomy. The advanced-technology 3.5m telescope delivers superb image quality over a wide field and is also optimized for multiobject spectroscopy, including a high-spectral-resolution mode and high-spatial-resolution imaging. Indiana University holds a 17 percent share of the WIYN facility. Two fully robotic telescopes are located in the Morgan-Monroe State Forest 16 miles from campus. These are a 0.4m telescope that is used for automated CCD photometry and a new 1.25m telescope to be used for automated spectroscopy. A remote observing center in the department is equipped for communication with both the WIYN and local telescopes. The High-Energy Astrophysics Group carries out research with underground, spacecraft, and balloon-borne detectors that are developed within the department. Several instrument development labs and machine shops support the optical and high-energy research programs.

Research in the Department of Astronomy is supported by excellent computational facilities. Students, faculty, and research staff have fast desktop machines with 1-Gbps network connectivity within the department and to the outside world. The department maintains several multi-Terabyte file servers and a number of high-performance computer platforms for simulations and data analysis. Indiana University operates BigRed, one of the fastest university-owned supercomputers in the world, as well as SMP clusters called Quarry and Libra. These computational research capabilities are supported by two massive data processing and storage systems: the Data Capacitor, which is a fast file system that can manipulate up to 0.5 Petabytes of data simultaneously, and the Massive Data Storage Service, which can permanently archive more than 4 Petabytes of data.

Special Departmental Requirements

(See also general University Graduate School requirements.)

Admission Requirements
Good preparation for graduate work in astronomy or astrophysics requires the same training in physics and mathematics needed for a bachelor's degree in physics, plus a familiarity with the subject matter of introductory astronomy or astrophysics courses, such as A221-A222 or A451-452. An undergraduate major in astronomy, astrophysics, physics, or mathematics that

has provided such a background is usually required for admission. Any necessary undergraduate courses to strengthen students' backgrounds will not receive graduate credit.
All graduate applicants must submit Graduate Record Examination scores on both the General Test and the Subject Test in physics. Scores should be sent directly to the department, not to the University Graduate School.

Master of Arts Degree

Course Requirements
A minimum of 30 credit hours, including any three astronomy graduate core courses (see below).

Thesis
A thesis may be required, at the discretion of the department. Students for whom the thesis requirement is waived must still complete a project that demonstrates research proficiency.

Final Examination
An oral examination must be passed covering general astronomy at the A451-452 level, the core courses applied toward the degree, and the thesis research.

Doctor of Philosophy Degree

Course Requirements
A total of 90 credit hours. Students are required to take six of the following core courses: A505, A520, A540, A550, A570, A575, and A580. Normally, these courses are offered at the rate of three courses per year, and they may be taken in any sequence. The remainder of the graduate program consists of elective courses, seminars on advanced topics, research, and dissertation.

Grades
Grades below B (3.0) in core courses may be counted toward degree requirements only at the discretion of the department.

Minor
Most doctoral candidates in astronomy minor in physics or scientific computing. Other minors may be permitted at the discretion of the department.

Qualifying Examination
In order to be advanced to candidacy, a student must pass a written examination covering the core course material plus general astronomy at the A451-452 level. The examination may be taken no more than twice. The examination is usually offered once a year just prior to the start of the fall semester. In its current form, it consists of one four-hour exam and one three-and-a-half-hour exam covering the material in the core courses and general astronomy knowledge at the undergraduate level.

Candidacy Seminar
The candidacy seminar is an oral presentation to the research committee, usually consisting of a thesis proposal and/or a summary of past research activity. It must be completed within a year of passing the written qualifying examination (typically by the start of the fourth year of residence).

Final Examination
Oral defense of the dissertation.

Ph.D. Minor in Astronomy

Students from other departments who wish to minor in astronomy must complete at least 9 credit hours of graduate courses in astronomy at the 500 level with an average GPA of B (3.0) or higher. The student should discuss proposed course work for the minor with an advisor from the Department of Astronomy, usually the Director of Graduate Studies. One astronomy course at the 400 level (listed below) may be substituted for one of the 500 level courses upon approval by the student's astronomy advisor.

Courses

The 400-level courses listed here and described in the College of Arts and Sciences bulletin are open to graduate students at the discretion of the department.

A451 Stellar Astrophysics (3 cr.) P: Calculus, Physics P301 or equivalent. Application of basic physical principles to investigation of the Solar System, stars, the Milky Way galaxy, other galaxies, and cosmology.

A452 Extragalactic Astrophysics (3 cr.)

A453 Topical Astrophysics (3 cr.) P: Calculus, P301 or equivalent. Topics in astrophysics not covered extensively by other courses. The topic will vary depending on instructor. Possible topics include the solar system, celestial mechanics, astrobiology, stellar interiors, stellar atmospheres, stellar populations, galaxy dynamics, and cosmology. May be repeated once with a different topic for a maximum of 6 credit hours.

A505 Principles and Techniques of Observational Astronomy (4 cr.) P: Consent of instructor. Principles and techniques of astronomical data acquisition and reduction. Practical experience in CCD photometry, spectroscopy, and astronomical applications of electronic detectors.

A520 The Interstellar Medium (3 cr.) P: Consent of instructor. Structure and dynamics of the interstellar medium; review of observations and theory of interstellar gas, dust, and radiation.

A540 Stellar Atmospheres (3 cr.) P: Consent of instructor. Structure of atmospheres and formation of spectra.

A550 Stellar Interiors (3 cr.) P: Consent of instructor. Physical properties of stellar material; structure and evolution of stars.

A570 Galactic Dynamics (3 cr.) P: Consent of instructor. Principles of stellar dynamics. Analytic and computer methods. Applications to the galaxy and its star clusters.

A575 Structure and Evolution of Galaxies (3 cr.) P: Consent of instructor. Structure and evolution of galaxies, large-scale clustering of galaxies, active galactic nuclei, and quasars.

A580 Physical and Observational Cosmology (3 cr.) P: Consent of instructor. Observational basis for current cosmological theory. Early universe evolution, cosmic microwave background radiation, formation of cosmic structure.

A590 Graduate Reading Course (cr. arr.) Independent reading in astronomy and astrophysics.

A770 Seminar in Astrophysics (1-4 cr.) Selected topics of current research interest in astrophysics; includes topics such as stellar astrophysics, interstellar matter, planetary physics, high-energy astrophysics, and extragalactic astrophysics.

A780 Seminar in Astronomy (cr. arr.) Selected topics of current research interest in astronomy, such as observational techniques, instrumentation, galactic and extragalactic astronomy, and cosmology. May be repeated. S/F grading.

A890 Introduction to Research (cr. arr.) Literature and methods of astronomical research.

A899 Research (cr. arr.) Observational and theoretical investigations of current problems.

Astrophysics

G630 Nuclear Astrophysics (3 cr.) P: A451-A452, P453-P454, or consent of instructor. It is recommended that students have taken A550, P511. Applications of nuclear physics to astronomy. Fundamental properties of nuclei and nuclear reactions. Element synthesis and energy generation in the big bang, stellar interiors, and supernovae. Discussion of current topics: cosmological nucleosynthesis, solar neutrino flux, explosive nucleosynthesis, high-energy nuclear processes.

G650 High Energy Astrophysics (3 cr.) Covers cosmic rays from the perspective of astrophysics and high energy particle physics. Examples of topics which may be included are the production, propagation, and interactions of cosmic rays as well as the experimental detection of cosmic rays. Subtopics include atmospheric and solar neutrinos, magnetic monopoles, point sources of cosmic rays, neutrino oscillations, air showers, and stellar collapse detection.

G750 Topics in Astrophysical Sciences (1-3 cr.) A seminar in astrophysics with special emphasis on subjects involving more than one department. Examples of such topics include planetology, nucleosynthesis, nuclear cosmochronology, isotopic anomalies in meteorites, particle physics of the early universe, and atomic processes in astrophysical systems.