# ASTRONOMY, PHD

*for the degree of Doctor of Philosophy in Astronomy*

The Department of Astronomy offers graduate programs leading to the Master of Science and Doctor of Philosophy degrees. The goal of the graduate program in astronomy is to provide broadly based training in modern astrophysics and astronomy for a small and carefully selected student body. Individually designed programs involving close contact with faculty members are encouraged, and an understanding of fundamental principles and techniques and their applications to research problems of current interest is emphasized. Students are expected to acquire a solid knowledge of modem physics as well as of general astronomy. A major objective is to maintain an exciting intellectual environment in which students can develop their scientific creativity and their enthusiasm for astronomy.

**Admission**

Admission to the astronomy graduate program requires an outstanding record of accomplishment and clear evidence of considerable academic promise, as judged by undergraduate transcripts, resume (or c.v.), letters of recommendation, personal statement, and strong intellectual achievements. A bachelor's degree or its equivalent in astronomy, physics, chemistry, mathematics, or another related technical field from an accredited college or university in the U.S. or an approved institution of higher learning abroad is required for admission.

A minimum grade point average of 3.0 (A = 4.0) is required for admission. Course preparation in intermediate and advanced undergraduate physics and astronomy are essential. Students are expected to make up deficiencies during the first graduate year.

The GRE General Test and Subject Test in Physics are not required for admission, and most applicants do not provide GRE scores. Scores on the General Test will not be considered at all. Scores on the Physics Test, if provided, will only be used to help interpret physics preparation, and will only be made available to the review committee after the initial screening of applications has been completed. If applicants wish to provide a Physics score, they must ask ETS to send official score reports to Illinois (institution code 1836).

All applicants whose native language is not English are required to submit the results of the TOEFL or IELTS as evidence of English proficiency, as required by Graduate College policy. More information on the English Proficiency Requirement can be found at the Graduate College Admissions Web site (http://www.grad.illinois.edu/admissions/instructions/04c/).

Admission decisions are normally made once a year in the spring. Applications for admission and financial assistance must be received by January 15. In rare circumstances, applicants may be admitted for the spring semester, in addition to the customary fall semester admissions.

See the Astronomy graduate admissions Web site (http://catalog.illinois.edu/graduate/las/astronomy-ms/www.astro.illinois.edu/academics/graduate/) for more information and application materials.

**Graduate Teaching Experience**

Although teaching is not a general Graduate College requirement, experience in teaching is considered an important part of the graduate experience in this program.

**Faculty Research Interests**

Research activity in the Department of Astronomy includes observational and theoretical investigations of a wide array of astronomical objects:

- Early-universe cosmology (inflation, particle dark matter, cosmic nucleosynthesis)
- Large-scale structure of the universe (cosmic microwave background, galaxy clusters)
- Extragalactic systems (galaxy structure and evolution, interacting galaxies, active galaxies, jets, and quasars)
- Interstellar medium (multiple phases, molecular clouds, HII regions, bubbles and superbubbles, planetary nebulae, supernova remnants, magnetic fields, and galactic structure)
- Stars (formation, structure and evolution, atmospheres, nucleosynthesis, novae, supernovae, pulsars, and stellar statistics)
- Compact objects (black holes, neutron stars, white dwarfs)

Theoretical astrophysics is also a strong research interest many faculty members in the Department of Astronomy and the Department of Physics. Current activity centers on:

- Astrophysical fluid dynamics, magnetohydrodynamics and radiation hydrodynamics
- Physics of dense stellar matter
- Accretion phenomena
- High energy and relativistic astrophysics
- Cosmic inflation and structure formation
- Nuclear and particle processes in cosmology and astrophysics
- Black hole physics and astrophysics
- Gravitational lensing
- Gravitational wave phenomena

**Facilities and Resources**

- The Dark Energy Survey
- The Vera C. Rubin Observatory
- The South Pole Telescope
- Astronomy students and faculty successfully compete for time on national facilities. These include ground-based telescopes of the National Radio Astronomy Observatory, such as the Atacama Large Millimeter Telescope and the Very Large Array, and the National Optical Astronomy Observatory telescopes. Illinois research involves many space-based telescopes, including the Hubble, Planck, Spitzer, Herschel, Chandra, and Fermi.
- A number of projects in the Department of Astronomy partner with the National Center for Supercomputing Applications (NCSA) at Illinois. This includes development and application of astrophysical simulations such as the FLASH package and general relativistic magnetohydrodynamic codes that provide insight into the nature of structure formation and the physics of black holes. Astronomy faculty also leverage NCSA's pioneering development of cyberinfrastructure environments to facilitate data transport for the Sloan Digital Sky Survey (SDSS), the Dark Energy Survey, the Square Kilometer Array, and the Vera C. Rubin Observatory's Legacy Survey of Space and Time. Faculty from NCSA, and Astronomy and Physics Departments are also involved in the Center for Astrophysical Surveys

(CAPS), applying novel algorithms to the rich large datasets from several major projects including the Sloan Digital Sky Survey (SDSS), the Dark Energy Survey (DES), the Young Supernova Experiment (YSE), the Laser Interferometric Gravitational Wave Observatory (LIGO), the Vera Rubin Observatory (VRO), and the South Pole Telescope (SPT).

- Illinois is the home of the Blue Waters National Petascale Computing Facility, one of the most powerful supercomputers in the world, and the most powerful on a university campus. A portion of Blue Waters time is dedicated to Illinois faculty, and Astronomy students and faculty use Blue Waters for their research.

**Financial Aid**

University fellowships are available and may be combined with part-time teaching assistantships. Most resident students are supported for their first two or three years by half-time teaching assistantships. The typical teaching assistant takes two or three graduate courses per semester and spends twenty hours per week handling quiz sections in elementary astronomy courses. Teaching assistantships are responsible positions, and the concomitant duties are considered to be a valuable part of the student's educational experience. Advanced students may compete for research assistantships offered by faculty members whose research is partially supported by federal grants.

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For additional details and requirements refer to the department's Graduate Programs (http://www.astro.illinois.edu/academics/graduate/programs/) and the Graduate College Handbook (http://www.grad.illinois.edu/gradhandbook/).

# Astronomy, PhD

## Entering with approved M.A./M.S. degree

| Code | Title | Hours |
|---|---|---|
| ASTR 501 & ASTR 502 | Radiative Processes and Astrophysical Dynamics | 8 |
| Students entering with an approved M.A. or M.S. degree may proficiency out of these with departmental approval. Other 500-level ASTR graduate courses must be taken in the unit for substitute credit hours. | | |
| Demonstrated Proficiency in Astronomy: A maximum of 8 hours of these courses may be applied to the degree (See details below.) | | 8 |
| Research/Project/Independent Study Hours (e.g. ASTR 590 min/max applied toward degree): | | 4-24 |
| ASTR 599 | Thesis Research (min/max applied toward degree) | 32-52 |
| **Total Hours** | | **64** |

### Other Requirements

| Requirement | Description |
|---|---|
| Other requirements may overlap | |
| Students may add a graduate concentration in Astrochemistry. | |
| Qualifying Exam Required | No |
| Preliminary Exam Required | Yes |
| Final Exam/Dissertation Defense Required | Yes |
| Dissertation Deposit Required | Yes |
| Minimum GPA: | 3.0 |
| Demonstrated Proficiency in Astronomy: Students must show proficiency in ASTR 404, ASTR 405, ASTR 406 and ASTR 414 by one of the following options: | |
| -Pass the appropriate section of the placement exam (four sections aligned to the four courses), which is offered at the start of every Fall semester. A student can petition to take the exam once more the following year. The decision on petition approval by the graduate advisor will depend on the student's background and proficiency plan. | |
| -Pass the course with a B grade or better. | |
| -Students who have had an equivalent course at another institution (B grade or better) may petition for those courses to count as proficiency. | |

## Entering with approved B.A./B.S. degree

| Code | Title | Hours |
|---|---|---|
| ASTR 501 & ASTR 502 | Radiative Processes and Astrophysical Dynamics | 8 |
| Demonstrated Proficiency in Astronomy: A maximum of 8 hours of these courses may be applied to the degree (See details below.) | | 8 |
| Additional formal coursework (excluding thesis research, non-thesis research and independent study credit hours, e.g., ASTR 599, ASTR 590) [3,4] | | 24 |
| Of the additional formal coursework, 8 is the minimum number of hours in the unit (excluding thesis research, non-thesis research, and independent study credit hours) | | |
| Of the additional formal coursework, 8 (with 4 in the unit) is the minimum number of 500-level hours (excluding thesis research, non-thesis research, and independent study credit hours) | | |
| Research/Project/Independent Study Hours (e.g. ASTR 590 min/max applied toward degree): | | 4-32 |
| ASTR 599 | Thesis Research (min/max applied toward degree) | 32-60 |
| **Total Hours** | | **96** |

### Other Requirements

| Requirement | Description |
|---|---|
| Other requirements may overlap | |
| Demonstrated Proficiency in Astronomy: In the first year students must show proficiency in ASTR 404, ASTR 405, ASTR 406 and ASTR 414 by one of the following options: | |

| | |
|---|---|
| -Pass the appropriate section of the placement exam (four sections aligned to the four courses), which is offered at the start of every Fall semester. A student can petition to take the exam once more the following year. The decision on petition approval by the graduate advisor will depend on the student's background and proficiency plan. | |
| -Pass the course with a B grade or better. | |
| -Students who have had an equivalent course at another institution (B grade or better) may petition for those courses to count as proficiency. | |
| Students may add a graduate concentration in Astrochemistry. | |
| First Summer Research Project (4 hours) | During the first summer in residence, each student will enroll in ASTR 590 (independent Study) and will complete a research project with an Astronomy Department faculty member. A paper reporting the results is required, which must be prepared in scientific journal style and approved by the faculty member. |
| Master's Degree Required Before Admission to PhD? | No |
| Qualifying Exam Required | No |
| Preliminary Exam Required | Ph.D. Preliminary Examination consists of a written preliminary paper on the Ph.D. research topic and an oral examination. It must be passed by the end of the third year of study. |
| Final Exam/Dissertation Defense Required | Completion of an original research project culminating in a dissertation thesis publishable in whole or in part is required. The final examination is a defense of the doctoral dissertation. |
| Dissertation Deposit Required | Yes |
| Minimum GPA: | 3.0 |

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LO1. Infer and characterize the physical mechanisms that govern the observable properties of the Universe and its constituents, including galaxies, stars, and planets, as well as the changes in those properties over time.

LO2. Understand how the observational, statistical, and computational methods of modern astronomy are used to generate the scientific knowledge referred to in LO1.

LO3. Plan and perform original research in astronomy and astrophysics.

LO4. Effectively communicate astronomy knowledge and research results in both oral and written form to a variety of audiences.

LO5. Demonstrate the ability to formulate and write a research proposal.

**Graduate Degree Programs in Astronomy**

- Astronomy, MS (http://catalog.illinois.edu/graduate/las/astronomy-ms/)
- Astronomy, PhD (p. 1)
- optional concentration: Astrochemistry (http://catalog.illinois.edu/graduate/las/concentration/astrochemistry/)

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**Astronomy Department**
Head of the Department: Leslie Looney
Director of Graduate Studies: Paul Ricker
Astronomy Department website (https://astro.illinois.edu/)
103 Astronomy Building, 1002 West Green Street, Urbana, IL 61801
(217) 333-3090
Astronomy Department email (astronomy@illinois.edu)

**College of Liberal Arts & Sciences**
College of Liberal Arts & Sciences website (https://las.illinois.edu/)

**Admissions**
Astronomy Graduate Admissions (http://www.astro.illinois.edu/academics/graduate/)
Graduate College Admissions & Requirements (https://grad.illinois.edu/admissions/apply/)

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