

Astrophysics

Aims and Scope of the Graduate Program

With the goal of understanding the physical processes that govern the universe, its constituents, and their evolution, astronomy uses the apparatus and methodology of physics to gather and interpret data. Theoretical work and technology development round out astrophysics. In what follows, we use the terms “astronomy” and “astrophysics” interchangeably.

The primary aim of the graduate astrophysics program at Caltech is to prepare students for creative and productive careers in astrophysical research and a variety of other challenging vocations. The astrophysics program emphasizes independent research by graduate students, who are free to pursue study in virtually any area of astrophysics. The opportunity exists to take advantage of the many observational facilities owned and operated by Caltech (see page 110).

Admission. Incoming students should have a strong background in physics, and although a good preparation in astronomy is helpful, this is not required for admission to the graduate program. All applicants, including those from foreign countries, are requested to submit Graduate Record Examination scores for verbal and quantitative aptitude tests and the advanced test in physics.

Master's Degree

While the option does not offer a master's degree program in itself, students who fulfill the general Institute requirements for such a degree, and the specific option requirements (see below), can receive a master's degree, either en route to a final Ph.D. degree if admitted to candidacy, or as a terminal degree if the candidacy requirements are not met.

The choice of astronomy and other science elective courses must be approved by the option representative. At least 36 units of the 135 units must be selected from Ay 121–127. The courses Ph 106, Ph 125, and Ph 129 may be required of those students whose previous training in some of these subjects proves to be insufficient. At least 27 units of advanced courses in fields other than astronomy are required.

Degree of Doctor of Philosophy

Astrophysics Program. The student's proposed overall program of study must be approved by the option representative during the first year. The following are required of all students for candidacy: Ay 121, Ay 123, Ay 124, Ay 125, Ay 126, and Ay 127. The student should take these courses in the first year. Students must also take at least one term of Ay 122 unless exempted. Also required are research and reading projects. Credit for this work will be given under courses Ay 142 and Ay 143. The above courses must be passed with a grade of B– or better.

Physics Program. The student's program during the first two years of graduate study should include at least 36 units of physics courses, exclusive of Ph 106, Ph 125, and Ph 129, and should include Ph 136 a and Ph 136 b, unless specifically exempted. Cross-listed courses (e.g., Ph/Ay) in general do not count toward the physics units requirement, unless specifically allowed by prior consultation between the student, the instructor, and the student's option representative. This requirement may be reduced on written approval for students who take substantial numbers of units in Ph 106, Ph 125, and Ph 129. Students in radio astronomy may substitute an advanced course in electrical engineering or applied mechanics for up to nine units of the required 36 units of physics. Theoretical astrophysics students should include at least 54 units of physics courses in their programs. Students in planetary physics may substitute appropriate advanced courses in geophysics and geochemistry. All the above courses must be passed with a grade of C or better, or a P upon prior written permission from the option representative to take the course pass/fail.

Other Requirements. An ability to explain concepts and to verbally present one's work is vital to a successful career in research and/or teaching. To this end, all graduate students in astrophysics are required to serve as teaching assistants during their second year, and to make oral presentations as part of the course Ay 141, required of all students in their second year and all subsequent years.

The Minor. It is recommended that students take a subject minor in physics. Other fields in which subject minors are taken include geology or engineering, depending on the student's field of specialization.

Language Requirement. Although the department believes that knowledge of foreign languages is generally useful, there is no formal foreign-language requirement. However, graduate students for whom English is a second language may be required to demonstrate fluency in oral and written English at the time of their candidacy exam. The examining committee will administer a test when this is deemed necessary.

Admission to Candidacy. To be recommended for candidacy for the Ph.D. degree in astrophysics, a student must, in addition to meeting the general Institute requirements:

- complete satisfactorily 36 units of research (Ay 142) or reading (Ay 143);
- pass satisfactorily, or by special examination, the required astrophysics course (see above);
- pass a general oral examination (see below);
- pass a thesis-related examination (see below);
- complete the physics course requirement (see above);
- satisfy a teaching requirement (at least one term as a GTA);
- fulfill the language requirement if applicable (see above); and
- be accepted for thesis research by a member of the faculty.

In fall of their second year, all students are required to take a general oral qualifying examination. Students will be examined on the substance and status of, as well as their performance on, a research project, which should be started not later than the summer following the first year. They will further be examined on their broad understanding of current topics in, and fundamentals of, astrophysics. Both of these aspects of the examination are intended to evaluate the candidate's aptitude for a research career in astrophysics. In addition, at the discretion of the executive officer, students who have not done well in one, or at most two, areas covered in the Ay 120 course series during their first year will be retested in these areas during the examination. Students must pass all of the aspects of this examination, as judged by the faculty committee conducting it, in order to continue in the Ph.D. program.

Students who do not meet the minimum grade requirements in the Ay 121–127 series, or who do not pass the general candidacy examination described above, will not be able to continue in the Ph.D. program. They may receive a terminal master's degree, provided that they fulfill the requirements for it (see above).

Advising and Thesis Supervision. By the summer of their first year, students should be spending most of their time on research. During their first two years, students are free to work with any faculty they wish, on one or more projects. However, by the summer of their second year at the latest, they should have defined a thesis project and been accepted by a faculty research adviser for that project (in cases where the thesis involves multiple projects, a second faculty adviser may supervise part of the research, but one must be selected as primary adviser). An oral candidacy exam dealing with the student's proposed thesis research should be taken before the end of the third year. The date and time of the exam are the responsibility of the student to arrange. The examining committee is chosen by the executive officer in consultation with the student's adviser. It will stand until the final examination, and be charged with ensuring that satisfactory progress toward the Ph.D. is being made.

If the candidate does not pass the oral candidacy exam, then the examining committee may at its discretion offer the candidate a second oral examination. This examination must be successfully completed by the end of the third term of the third year.

After the oral candidacy exam, the adviser and the student together have primary responsibility for the student's progress and career development. To ensure that these remain on course, both student and adviser must submit annual progress reports to the executive officer (or in the case of a conflict of interest, to the astrophysics option representative or the division chair). If at any stage the student, the adviser, or the executive officer feels that there are serious problems developing, they may consult in confidence with the astrophysics option representative, the executive

officer, or the division chair. They may also request a meeting of the oral candidacy exam committee or seek the advice or help of other faculty members. Students may also seek confidential advice and help from the Counseling Center and the Ombuds Office.

Final Examination. A final draft of the thesis must be submitted at least six weeks before the commencement at which the degree is to be conferred. At least two weeks after submission of the thesis, the student will be examined orally on the scope of his or her thesis and its relation to current research in astrophysics. The examination will be conducted by a committee selected in the same way as the oral candidacy committee. The examination should occur before the end of the fifth year.

Typical Timeline

Year 1: Ay 121, Ay 123–127; at least three advanced physics courses; reading and independent study. Begin research.

Year 2: Early fall—general oral qualifying examination. Research projects; select thesis and adviser. Fulfill teaching requirement. Complete 36 units of physics (54 for theorists); Ay 122 if applicable; optional advanced astronomy courses. Ay 141.

Year 3: Take oral candidacy exam on thesis before end of second term. Annual report from student and adviser. Ay 141.

Year 4: Annual report from student and adviser. Ay 141.

Year 5: Annual report from student and adviser. Ay 141. Complete Ph.D. thesis before end of year 5. Final oral examination.

Subject Minor

The program for a subject minor in astrophysics must be approved by the department before admission to candidacy. In addition to general Institute requirements, the student must complete satisfactorily, with a grade of C or better, 45 units in advanced courses in astronomy.

Behavioral and Social Neuroscience

Aims and Scope of the Graduate Program

The Caltech Ph.D. program in behavioral and social neuroscience (BSN) provides students with in-depth training in neuroscience, and in economics and political science. It prepares scholars for an academic career at the intersection of neuroscience and social science.

Master's Degree

Students who are enrolled in the BSN Ph.D. program may earn a M.S. degree after successful completion of 36 units of course work, approved at least with a B grade, in addition to completing the coursework required for the first year of the Ph.D. program.