Information for University Reaccreditation
Reponse of the Department of Astronomy
Curriculum and Teaching Pedagogy
February 2005

1. Coursework

Students take five required three-point courses covering the major areas of modern astrophysics, four consecutive semesters of research seminar (see below) for six additional points, and three or more electives for a total of 30 points. Electives may be selected from among a rotating set of topical courses, advanced seminars, and courses in cognate departments such as Physics, Mathematics, Applied Physics and Applied Mathematics, etc. Most students complete the 30-point requirement in the first two years, although this is not required; indeed, students are strongly discouraged from taking more than two regular courses plus the research seminar per semester in order to leave them ample time to devote to their research projects (see below). All courses are given for letter grades with the exception of the Research Seminar which is graded P/F.

2. Comprehensive exams for the M.Phil.

We recently eliminated the written qualifying examination, replacing it with satisfactory performance on each of the five final examinations in the five required core courses. Admission to candidacy for the PhD., however also entails demonstration of research competence; this is assessed as described in the next section.

3. Additional requirements

The award of the PhD requires the demonstrated ability to perform independent, original research. Thus, our program focuses on building research competency from the first month of the first term. By the end of September in the first year, each new student must have chosen a research topic for the first-year project, and have secured a faculty advisor for that project. These arrangements are registered with the DGS. In May of the first year, each student forms (with DGS approval) a three-person *ad hoc* committee which meets to assess the student's progress on the first-year research project and to evaluate the plan for completing the project over the summer. In September, the committee meets to evaluate a written and oral presentation of the project.

The process is then repeated. The student must choose a different topic in a different area of Astronomy with a different faculty advisor to pursue in the second year. The May and September faculty reviews are repeated as well. If by May of the second year satisfactory progress toward independent, original research has not been shown, the student is asked to leave the program.

4. Dissertation supervision

In the fall of the third year, the student must present a written dissertation proposal and form a new faculty committee to assess it. Subsequently, this committee meets with the student once every six months for progress reports. These informal sessions include discussions of science, tactics for successfully completing the degree, and, toward the end of the student's tenure, career advice.

In addition, the progress of each student is discussed at the general faculty meeting in May of each year. Throughout the year, the DGS tracks student progress and reports on incipient problems at regular faculty meetings.

5. Teaching requirements

All PhD students in the Department are required to teach four semesters during their time in the program; additional teaching opportunities are sometimes available for additional compensation. In order to assure adequate time for the transition to a research focus, first-year students are not normally assigned a section to teach. Rather, they act as Assistant TAs, working with a second- or third-year student who is teaching a twelve-student section of an undergraduate laboratory course designed for non-science majors. Duties include being present during the three-hour lab to assist with demonstrations and answer student questions, as well as up to two hours of preparation and set-up for the lab. In addition, all first- through third-year students assist in grading midterm and final exams for the large undergraduate lecture courses.

In the second and third years of the program, most students teach a Lab section, building on the experience they gained as Assistant TAs. They are responsible for developing the curriculum for new labs as well as implementing existing, well-tested exercises; in conjunction with the Head TA and supervising faculty member, they also assign student grades. They are expected to hold at least one office-hour per week; in total, the teaching commitment is about ten hours per week. Attendance at regular TA meetings is also required, as is the exam grading referred to above.

TAs are required to distribute student teaching evaluation forms designed explicitly for the Laboratory they teach. These are read by the Department Chair and used in making teaching assignments, selecting the Head TA, etc.

Each student has a desk in one of several shared offices and often meet undergraduates there. In addition, the Department reading room can be reserved by graduate students for holding help sessions.

In addition to these teaching experiences, the Department Chair holds an intensive one-week course during the summer in which students work on both written and spoken communication skills. Assignments include writing proposals and research papers, as well as the oral presentation of short and more extended research talks and a public lecture.

The Department also runs an extensive education and outreach program that attracts thousands of community members to various events (lectures, telescope viewing, family astro, etc.). This program is largely run by graduate student volunteers, and offers additional venues in which they can improve their pedagogical skills.

6. Advising and Mentoring

The extensive, formal program of faculty committee meetings with students throughout their time in the program is described above. Primary mentoring, however, is done with the faculty member (or members) with whom the student is working. The number of contact hours varies enormously depending on the student's level of independence, the type of project in which he or she is engaged (e.g., a large group effort to design and build an new instrument vs. a lone theoretical calculation), and the stage in the student's career. Some students have almost daily interactions with their supervisors, while others may meet formally only once or twice a month. Since all students have desks and computers in the Department, they are typically in the building every day, and are expected to attend various weekly Department gatherings (see below); this nearly constant presence fosters frequent interactions between students and faculty.

7. Informal interactions

The Department holds a number of weekly and annual events at which students, postdoctoral fellows, and faculty interact informally. There is a Physics Colloquium every Monday afternoon which roughly one-third of the time is on a topic of astrophysical interest. Tuesday we hold Pizza Lunch at which all members of the Department hear the announcements of the week and present short, informal updates on their research, astropolitics, etc.; occasionally visitors also offer presentations on their work in this forum. Wednesday afternoon the Astronomy Colloquium is held; graduate student attendance is expected. The students take the speaker to lunch the day of the colloquium (without faculty present); all Department members gather after the talk for wine, cheese, and conversation. On Thursday, there are two informal group meetings for those working in high energy astrophysics and in radio astronomy. Friday noon is cosmology lunch, followed by the weekly talk sponsored

by the Institute for Strings, Cosmology, and Astrophsyics. Occasional additional talks by visitors are scheduled on an *ad hoc* basis during the week.

Each year, we hold three major Department-wide events. Astrofest kicks off each Fall with a full day of short talks by graduate students, postdoctoral researchers, faculty, and adjunct members from such places as the Goddard Institute for Space Studies and the American Museum of Natural History. This provides an excellent introduction for new students to the scope of research carried out in the Department and the Astrophysics Laboratory, and in our sister institutions. The event is followed by Astrofeast, a very-well attended event that stretches well into the hours astronomers are expected to be up observing. The second major annual event is the Jeffrey Bishop Lecture, an endowed lectureship that brings a leading astronomer to campus for two or more days. The lecture is followed by a Departmental banquet. The third event is a Department Retreat, held at the Chair's summer house in Eastern Long Island. The graduate students arrive Friday morning and depart Saturday evening, while the faculty arrive Saturday morning and depart Sunday evening. In addition to numerous social activities, the Saturday overlap period allows for extended conversations, typically in several "working groups" which provide the basis for changes to Departmental policies and procedures.

Other informal events arise spontaneously. For example, last Fall saw the first of what is likely to be an annual Iron Chef competition pitting the Department Chair against one of the graduate students (the student won, casting serious doubt on the qualifications of the judges – all students). There is also an active gourmet club which hosts rotating dinners at student and faculty apartments, and a variety of other student- and faculty-initiated social events each year.

8. Cognate programs

The Columbia Astrophysics Laboratory is a joint enterprise of the Department of Astronomy and the Department of Physics, and serves as the nexus of all research activity in astronomy and astrophysics at Columbia. The Lab now includes 23 full-time faculty (including our Barnard colleagues), an additional 23 PhD-level researcher staff, and 37 graduate students from the two Departments. All Lab faculty as well as several of the research scientists are available as first- and second-year project mentors as well as dissertation advisors, greatly expanding the range of projects to which Astronomy graduate students have access. Maintaining this integrated approach is important to our program; at present, the arrangement is working well.

We have recently begun the latest incarnation of a cooperative arrangement with the Department of Physics on the graduate curriculum. For example, Physics recently introduced a graduate course in high energy astrophysics similar in content to what we have offered in alternate years; Astronomy will suspend this course for a period to see if the Physics course meets the needs of our students. Next Fall, a Physics faculty member will teach the

Cosmology course that is one of our five required courses; considerable effort was expended to assure that the syllabus was acceptable to both Departments. This sort of coordination proceeds on a relatively informal basis; given faculty turnover and the somewhat different cultures of the two Departments, this approach seems to work more successfully than some of our previous attempts involving formal agreements for cross-teaching and cross-listing courses, etc. At present, the demands of Physics students for our courses does not significantly impact our program for Astronomy students; indeed, the existence of additional courses on astrophysical subjects in Physics enhances our program.

Our students also take courses in Mathematics, Applied Physics and Applied Mathematics, and other departments in very small numbers, so coordination is not a significant issue. Our program is small enough that class time schedules are flexible from year to year and can be changed to meet any conflicts with courses of interest in other departments as they arise.

9. Self-assessment questions

9.1. Potential program modifications

We are just completing a two-year review and revision of our graduate program requirements and curriculum; almost by definition, then, we believe (today) we have optimized the program. If our applicant pool continues to grow in size and strength along recent lines (applications up 55% over last year), further revisions may be warranted.

9.2. M.Phil. Exams

The rigorous review of research performance over the first two years, described above, serves well to establish which students are qualified to continue on to the PhD.

9.3. Preparation for teaching careers

The TAs are given broad latitude over how they run their introductory laboratory sections, both as a group and individually. This requires them to develop new materials, plan the semester's activities, and evaluate the results of their work. This level of independence and responsibility is reasonable preparation for future teaching responsibilities. We do very little, however, in direct instruction in pedagogy; the advent of the GSAS Teaching Center should improve this aspect of our training *if* we can get our students to attend their activities.

9.4. Realism of requirements

We believe we have produced a set of program requirements that are realistic for motivated students. In the first year, they take two classes ($\sim$ 10 hours each), do a maximum of 5 hours per week as assistant TAs (see above), spend $\sim$ 5 hours a week in regularly scheduled Department activities (pizza lunch, colloquia, etc.), leaving 10-20 hours for research (of which only 3-4 are spent on the research seminar activities). Their summers are almost complete free for research (all students are fully supported in the summer on grant funds). In the second year they may again have two classes each semester, spend 10-12 hours per week on teaching (one three-hour lab, one office hour, four hours for preparation and two hours for grading seems generous with only twelve students per lab section), leaving five hours for departmental activities and 10-15 hours for research. In the third year they will *at most* be taking one class per semester and teaching the same course a second time (requiring less preparation time); research time should by this point dominate their schedules. In the fourth year and beyond, they have no course or teaching responsibilities.

Our goal is to have students complete the degree in five years; actual times range from 4 to 7 years. In some observing projects, weather and other circumstances beyond the student's control can extend the time-to-degree; in experimental projects, launch slips and other similarly uncontrollable events can cause delays. It is our belief, however, that the requirements of the program *per se* are quite manageable within a five-year period.

9.5. Timetable of student progress

The outline of a student's progression through the program is described in detail above: incoming assessment, first-year (research project, two classes, and assistant TA responsibilities), second year (new research project, up to two classes per semester, TA), third year (0-1 classes per semester, thesis proposal, TA), fourth year and beyond (dissertation with semi-annual reviews of progress). Students are funded in the first two year with GSAS Fellowships (with grant funding guaranteed for the summer months); thereafter, they are funded (at an outrageously high cost) from federal research grants. This has no impact on their program schedules.

9.6. Advising and mentoring improvements

Our stated system of advisory committees and regular reviews throughout the student's tenure is most satisfactory. Our strict adherence to this sytem is not. The biggest improvement we can make is to adhere to the stated rules. Progress is being made toward that end. A second issue is the use of the research scientist staff as first- and second-year project advisors. After several less-than-optimal experiences we now strongly discourage,

or closely monitor, students who chose to do projects with non-faculty research staff. This is a delicate issues, because many of these researchers have exciting projects for students to pursue, but the fact that their positions provide zero incentives for them to be careful mentors means problems often ensue.

9.7. Comparison with peer programs

We have not done a detailed comparison with programs at peer institutions; we have a lot of anecdotal information, but do not view this as sufficient for a worthwhile comparative study. Our applicants (and matriculating students) universally cite the early focus on research as an issue driving choice of our program; to our knowledge, only Princeton is comparable in this early research focus, although many programs do it to some degree. At a recent national meeting of Astronomy Department Chairs, the trend toward eliminating formal qualifying exams and instituting oral research exams seemed quite pronounced. The only thing preventing us from carrying out an extensive study of other program in order to distill a set of best practices is time, and we see no prospect of that time becoming available before the acceleration of the universal expansion carries all other program beyond our event horizon.