University of Maryland
Graduate Program in Astronomy:

A Handbook for Graduate Students

Last revised April 2018 by Eric M.

1. Introduction

1.1 General

This document is meant to give you, a graduate student in the Department of Astronomy, a general overview of the graduate program in Astronomy at the University of Maryland. It contains mainly information on the rules, regulations, etc. of the Department of Astronomy. Information on University regulations and deadlines can be found at the Graduate School's website (www.gradschool.umd.edu/). Please note that you are responsible for meeting all University deadlines (for filing for candidacy, degrees, etc.). Make sure you know when these deadlines are.

In general the Department of Astronomy is quite flexible and if at any point you think there is sufficient reason, you may petition for a waiver of the rules. You should recognize that if you propose a major change in the regulations, the burden of proof that it is justified will be on you. Do not embark on any program which departs from the regulations unless you have discussed it with your study committee.

1.2 Physics/Astronomy

The Department of Astronomy is separate from the Department of Physics. Both Physics and Astronomy have their own degree programs. However, because of the close connection between the two, it is quite possible for a student in either department to carry out thesis research in the other department. The degree will be given in the department which admitted the student and the requirements of which must be satisfied.

1.3 Degree Options

A student in the Department of Astronomy is expected to work towards a PhD, and as an intermediate step, may obtain an MS degree. The latter can be earned either with or without a written thesis. Tables 1 and 2 are capsule summaries of the stages towards the degrees. References are given to the sections where each aspect is discussed in detail.

1.3.1 Joint PhD with PUC

After admission to the Ph.D. program (typically at the beginning of the 3rd year of study), UM students may either pursue the standard Ph.D. path or pursue a joint Ph.D. option with the Pontificia Universidad Católica de Chile (PUC). The joint Ph.D. option is similarly open to PUC graduate students who have fulfilled the requirements for a M.S. degree from the Departamento de Astronomía y Astrofísica.

Students in the joint Ph.D. option will be simultaneous full-time students of both institutions. Curriculum details are provided in the various curricular stages discussed below.

Table 1: PhD Program Summary

Step	Time Limit[1]	Requirements	References
Admission to Graduate School	N/A	3.0 or better GPA, GRE scores, Letters of Reference.	Section 2
Second year research project	Due in May of second year	Reviewed/approved by your project committee. Oral exam by the Second-Year Examining Committee.	Section 4.2.1
Departmental Admission to PhD program	September of third year	Based on research project and course work	Section 4.2.2
Advancing to PhD candidacy	3 years from admission to the Graduate School (Department deadline)	Course of studies and research topic must be approved by your thesis committee. 3.0 or better GPA. Incompletes must be removed. Department requirements must be completed.	Section 4.4
Completing the Ph.D.	Minimum of 1 year and maximum of 4 years from admission to candidacy	3.0 or better GPA. Successful defense of dissertation. Minimum of 3 years of residency. Minimum of 12 credits of Ph.D. research (ASTR 899).	Section 4.5

[1]University time limits are the same for all students (full-time or part-time).

Table 2: MS Program Summary

Step	Time Limit[1]	Requirements	References
Admission to Graduate School	N/A	3.0 or better GPA, GRE scores, Letters of Reference.	Section 2
MS (non-thesis)	5 years from admission to Graduate School.	Minimum number of courses in various areas. 3.0 or better GPA. Scholarly paper(s).	Section 5.1
MS (thesis)	5 years from admission to Graduate School.	Minimum number of courses in various areas. 3.0 or better GPA. Writing and defense of thesis.	Section 5.2

[1]University time limits are the same for all students (full-time or part-time).

Admission to the Graduate School does not imply admission to candidacy for an advanced degree. Admission status is normally to seek a PhD degree or as an Advanced Special Student (course work only, not degree seeking). Termination of graduate status occurs when the original degree objective is obtained or when the University time limit expires. Students admitted to seek the PhD may obtain an MS in the process without terminating their admission status. Students are only admitted to seek the PhD if the department thinks that they are capable of completing the PhD, but students are free to change their objective from seeking the PhD to seeking the MS.

2. Admission

Most regulations are University-wide and are included in the packet containing the admission forms. The Department of Astronomy relies on a combination of course grades, letters of recommendation and the GRE scores in deciding on admission. The GRE Advanced Physics is required for all applicants.

It is normally expected that the following subjects should have been studied previous to admission to graduate work: General Physics, Heat, Intermediate Mechanics, Optics, Electricity and Magnetism, Modern Physics, Advanced Calculus and Differential Equations. Any deficiencies in such background courses should be made up as soon as possible.

No formal undergraduate course work in astronomy is required. However, an entering student should have a working knowledge of the basic facts of Astronomy such as are obtainable from one of the many introductory Astronomy texts. A more advanced knowledge of astronomy will, of course, enable a student to progress more rapidly during the first years of graduate work.

3. General Graduate Matters

3.1 Advising

All incoming students have the same advisor – the Graduate Director, who will meet with you at least once a semester to advise you on courses. By the beginning of the second year, a second-year project committee will be set up for each student with the membership reflecting your research interests. They will also advise you on courses and on your research. It is your responsibility and that of your research project advisor to set up this new committee. Beyond the second year, the second year advisor continues as your primary advisor until either you or your second year advisor informs the Graduate Director that a new advisor has been identified or that the second year advisor is unable to continue. In the latter case, the Graduate Director will work with you to identify a new research advisor. During your third year, your advisor will work with you to determine your thesis committee.

Before the end of each academic year, students in the third year and beyond will make a brief presentation to their research committee on progress during the past year and plans for the coming year. They should also provide a two-page summary report to the committee in advance of the presentation. Goals are to 1) inform the committee as to your progress and thesis and career plans; 2) provide committee feedback to you and your advisor; and 3) allow you to gain practice and receive feedback in giving presentations. Please ensure that a copy of this report is also sent to the Associate Director for your student file. After the committee presentation, your primary advisor will forward a brief summary of the comments provided by the committee to the Associate Director, with a copy to you and the other members of your research committee. Other types of presentations such as the thesis proposal defense or conference presentations (at which committee members are present) may be substituted for the yearly committee presentation at the discretion of the committee, although the reports are still required.

The Graduate Faculty of the Department of Astronomy holds periodic sessions to discuss the academic progress of the graduate students in the program. If specific actions are required, the students involved will be informed in writing. The discussions at these meetings are otherwise kept confidential.

3.1.1 The Student's Role

All graduate students should take an active role in their advising - both for course work and for research. It is your responsibility to make sure that you meet with your committee at least once per year. If the advisor does not set up the meeting then you should take the initiative and find a suitable time. You should meet with the individual members of your committee in addition to the minimal one meeting per year of the entire committee. It is important, particularly in the second year project and the beginning of the thesis, that several faculty members understand your research capabilities.

Our graduate students are generally expected to make presentations at 2-3 conferences during their graduate career. Typically, the research advisor provides funding for travel to conferences; if grant funding is unavailable, the research advisor can request department funding to help meet the minimum expectations for graduate student travel to conferences.

After acceptance to the PhD program it is up to you to define a suitable PhD thesis topic in consultation with an advisor. This should be your primary goal during the third year of studies.

3.2 Assistantships

Normally full-time graduate students are awarded either a teaching or a research assistantship. It is necessary to petition the faculty in order to obtain a waiver from this regulation. The rights, wrongs, and regulations of these assistantships are discussed in the Graduate Catalog at www.gradschool.umd.edu/. Full-time teaching and research assistants receive 10 credits of tuition exemption per semester. This is enough to cover the normal course load during the first two years of three courses per semester (plus ASTR 695 in the first year only).

The continuation of an assistantship is contingent on making adequate progress towards the degree. Adequate progress includes maintaining a GPA of 3.0 or better (Graduate School Requirement), passing the English competency exam (if required) by the end of the first year, admission to the PhD program at the beginning of the third year, definition of an approved thesis topic by the end of the third year, and satisfactory performance in the assistantship position. If you meet all the criteria for adequate progress, you can expect continued funding of one sort or another for up to six years, at which time it is presumed that you should have completed the degree. Some students are awarded fellowships, either from the Graduate School or from other sources. Such students receive tuition remission for up to twelve credits since a student without assistantship duties should be able to carry a heavier load of courses. Because teaching is an important part of astronomy, fellows are allowed and encouraged to take on half of a teaching assistantship for two or more semesters (during which they are limited to ten credits). Details on the pay scales for graduate assistants and fellows are circulated yearly.

3.3 Transfer and Duration of Credits

There are specific University regulations regarding the conditions (e.g. time limits, maximum number of credits) for transfer of credit. (See Graduate School's catalog website at www.gradschool.umd.edu/). Be sure you are familiar with the regulations if you intend to transfer credits. There are formal University requirements on courses for MS degree and as a result, there is a formal procedure for transferring credits in this case. The only course requirements for the PhD, other than 12 credits of thesis research, are departmental requirements. Rather than transfer credits, the normal procedure for PhD students is to petition the faculty for a waiver of the requirement based on work done elsewhere.

There are also specific time limits in various phases of the graduate program. Most of these are noted in the following sections. Please be familiar with these regulations.

3.4 Status in the University

3.4.1 Full-Time/Part-Time

This is a University distinction. It is totally determined by the number of credits taken and by the level of those courses. The formula can be found in the Graduate Catalog at www.gradschool.umd.edu/.

3.4.2 Residency

Residency is determined by the Graduate School and information on the procedures can be obtained from the Graduate School's web site at www.gradschool.umd.edu/. Do not assume that voting and paying taxes in Maryland imply residency. The regulations are more complex than that.

4. PhD Program

The following information is for full-time students. Part-time students should refer to Section 6 for modifications to the regulations.

4.1 Course Requirements

The university has no requirements except for 12 credits of PhD thesis research (ASTR 899). All other requirements for courses are determined by the department.

A minimum of **eight** 3 or 4 credit graduate courses are required. During the first two years, full time students must take at least six of the nine ASTR 600 level courses routinely offered by the department, or show that they have already had equivalent courses. Representative syllabi of the astronomy courses are given in Appendix A. A research project, taken as ASTR 699 or 898, is required during the second year. You are also expected to take a 1-credit seminar, ASTR 695 - Introduction to Research, during one or both semesters of the first year. This seminar is intended to introduce you to the range of research being carried out in the department and to help you to choose a second-year research project (and subsequently a thesis). See the department website for detailed information about course registration.

Additional graduate coursework beyond the 6 above will vary with individual student interest, including physics courses, astronomy courses, and courses from other relevant departments (math, computer science, engineering, etc.). Courses beyond the required 8 are often necessary for advanced research. This will be assessed by the student's thesis committee. The minimum requirement of 8 courses must be completed by the end of the third year. The University requires that the total GPA in your graduate courses be at least 3.0.

It is expected that a student will have completed no less than 7 (of the required 8) courses before admission to the Ph.D. program. This corresponds to two 3 (or 4) credit courses in three of the four semesters of the first two years and at least one 3 (or 4) credit course in the other semester. Exceptions may be considered in unusual circumstances, such as illness.

Please note that these 7 (and 8) courses are normal graduate learning courses: courses connected in one way or another with research work (e.g. ASTR 695, ASTR 699, ASTR 799, ASTR 899) or undergraduate level classes do not count to either the 7 or the 8.

PUC students follow the requirements of their home department.

4.2 Stage 1 - From Admission to Graduate School to Admission to the PhD Program

Admission to the PhD program is a Department of Astronomy decision. It indicates an initial judgment by the faculty that the student is capable of doing independent research and is likely to be able to complete a PhD thesis. Search for a PhD research topic and an advisor does not occur until after admission to the PhD program. The decision is based on the student's course work and the quality of the research project. The decision on admission to the PhD program is normally made in September of the student's third year. During the first two years of graduate work, you should expect to concentrate on formal course work (see Section 4.1) and the second-year research project (see Section 4.2.1).

PUC students follow the requirements of their home department.

4.2.1 Second Year Research Project

A research project is required to be done by all PhD-seeking graduate students in their second year. This has the two-fold purpose of introducing the graduate students to the excitement of research and of allowing the faculty to evaluate the student's ability to carry out a research project, particularly including dealing with problems that arise in the course of such work. The seminar ASTR 695 – Introduction to Research consists of seminars by individual faculty members and postdoctoral researchers describing their research interests. Many presenters will discuss specific second-year projects they would be willing to supervise while others will discuss general areas in which they are working and would supervise projects. By the end of the first year, you should be familiar with what the faculty is doing. Equally important are the weekly Department Colloquia; you should regularly attend these to learn about other areas of research which may be suitable for a second year project. You are also strongly encouraged to discuss potential advisors and research projects with more senior graduate students.

Table 3 lists typical second year project deadlines for both students and committees. By the end of your first year (May), you should choose a research topic under an advisor on the full-time Graduate Faculty (see http://apps.gradschool.umd.edu/catalog/grad_faculty_policies.htm). You should also have selected a second-year-project committee by this time. This committee should consist of three (or more) people with expertise relevant to the research project (including the advisor), at least two of whom are on the graduate faculty of the department. Students working on a project outside the department, e.g. at Goddard, will normally include their direct supervisor as a committee member. Most students begin at least the reading for the second-year project during the summer between first and second years and many begin the work for the project at that time. During the Fall semester, you should register for ASTR 699 – Independent Study (normally 1-3 credits) and start or continue work on the topic. No grade is given for this course – you should register for the S/U grading option. Most of the research should be done by the end of the Fall semester and the writing should be well under way by late January. A progress report on the status of the project must be submitted in writing to the committee by January.

During the Spring semester (registering for ASTR 699 or 898) a first draft must be submitted to your committee by c. March 1st; it will be returned with written comments in no more than two weeks. The completed paper should be submitted to your committee by early April. Your committee will make any last suggestions.

There is a single departmental Second-Year Examining Committee which will conduct a brief (typically one hour) oral examination of all second-year students. This committee must receive copies of the project report by c. Apr. 15. The exams will usually be scheduled prior to final exams for the spring semester. Your advisor is expected to be present for the exam. The exam is a miniature version of a thesis defense: you are expected to make a short (15

minutes) presentation summarizing the project and the committee will ask questions about the work done and about its implications. There is no pass or fail decision on the exam but the committee will prepare a written evaluation of your performance on the project itself and on the oral exam. You should typically receive a copy of this report within about two weeks.

The final version of the paper, in a format suitable for publication, shall be submitted by the end of the spring semester.

Throughout both semesters you should meet with your entire committee as a group often enough to keep the committee appraised of progress. This is particularly important for projects with an off-campus advisor. It is the responsibility of both the student and the advisor to be sure these meetings occur. The normal schedule is 1) an initial meeting by May of your 1st year to set goals and expectations for the summer, 2) a meeting by mid-September of your 2nd year to assess your progress and set goals and expectations for the Fall semester and Winter term, and 3) a meeting by the 1st week of the Spring semester to assess your progress and set goals and expectations for the Spring semester.

It is important to stress that, while the second year project should be of publishable quality, its primary purpose is not to be published but to allow students to understand the kinds of problems and solutions routinely encountered in doing research, to allow students to think critically about their research, and to allow the faculty to evaluate how well students approach research. Not all research projects will result in a published paper. You are strongly encouraged to also write a cover letter of a few pages both to describe the aspects of the research project which were not appropriate to a journal format but which were nonetheless significant aspects of the learning and to describe your own role *vis* the role of other collaborators in the project.

Table 3: Second Year Research Project Deadlines
(all dates are approximate)

Date	Year	Description
Sept-May	1st	Attend ASTR 695 and Departmental Colloquia
Last day of Spring classes	1st	Choose research topic; form advisory committee
Jan	2nd	Progress report to committee before Jan. committee meeting
March 1st	2nd	First draft of paper to committee
March 15th	2nd	Committee members return first draft with written comments
Apr. 25th	2nd	Final report to Second-Year Examining Committee

4.2.2 Admission to the PhD Program

The graduate faculty determines admission to the PhD Program based on performance in coursework and in the written and oral aspects of your 2nd Year research project. The faculty's decision will normally be made at the beginning of your 3rd Year, typically by mid-September. You will be informed in writing of the outcome, which can be:

1. Admission to the PhD program.
2. Conditional admission to the PhD. The conditions will be specified, but normally consist of revision of your 2nd year research paper and/or additional coursework.
3. Rejection from the PhD program. In this case, you may petition the graduate faculty for reconsideration.

If you meet the minimum requirements, you can, if you choose to, obtain a Master's of Science Degree. (See Section 5.)

4.3 Joint PhD with PUC *(optional)*

After admission to the Ph.D. program, University of Maryland (UM) or Pontificia Universidad Católica de Chile (PUC) students who are interested in pursuing a joint doctoral degree must identify a Chilean and a U.S. co-advisor among the professorial faculty at both institutions. Each student then applies to the partner institution (PUC or the UM Graduate School). Each student also prepares an application for the Joint Doctoral Program Committee. The latter application package should contain 1) a transcript of courses and grades; 2) a copy of the completed research projects; 3) a two-page description of the intended thesis project, the observations and/or simulations necessary and how they will be obtained, and the expected stays at both institutions; and 4) letters from both co-advisors supporting the application and describing how the student will be funded throughout his or her thesis work.

The Joint Doctoral Program Committee will rank the candidates based on their submitted application materials. The chairpersons at UM and PUC will then recommend a number of the candidates thus ranked for acceptance into the joint doctoral program. They will then become registered as students at both institutions. Students that are not admitted into the joint doctoral program option are free to pursue the standard doctoral program at their home institutions.

4.4 Stage 2 – Thesis Committee and Advancing to PhD Candidacy

After admission to the PhD program, all students, whether following the standard or joint Ph.D. options, should concentrate on selecting and beginning work on a research project which will eventually become their Ph.D. thesis. A research advisory committee will be constituted to reflect the student's research interests. As per UM requirements, the advisor(s) must be a member of the Graduate Faculty of the University of Maryland. The Department of Astronomy further requires that a member of the Graduate Faculty within Astronomy unofficially look after the student if the primary advisor of the thesis is outside the department. In the case of a joint Ph.D. student, the research advisory committee members may be from either institution but will always include at least one member from each (the co-advisors). PUC faculty willbe established as Special Members of the Graduate Faculty as necessary.

Students are required to hold annual meetings with their committee (see Sect. 3.1). See the department website for detailed information about course registration.

Before the end of your third year and in consultation with your advisor, you will need to prepare for and defend your Ph.D. Thesis Proposal in writing and orally. You and your advisor(s) will nominate your Thesis Proposal Defense Committee. This committee (including advisors) typically has 3-4 members, but must include at least two UMD Astronomy Tenure-Track Faculty. In addition, a departmental representative outside your proposed field of study will be appointed by the chair to augment the Thesis Proposal Defense Committee in order to provide breadth and help ensure a common approach among proposal defenses.

The written component of the thesis proposal must be in a proposal style that specifies the research topics, scope, and anticipated outcomes. The proposal must include a schedule with enough detail to allow the committee to evaluate the realism of the overall plan, with specific milestones for paper and chapter completion, and anticipated presentations at professional meetings. Typically proposals are expected to be about 10 pages (plus figures and references), but details should be agreed upon by you and your advisor. The written Thesis Proposal must be distributed to the Thesis Proposal Defense Committee at least one week in advance of the Thesis Proposal Defense.

The entire graduate faculty of the department must be informed of the Thesis Proposal Defense and be invited to attend at least one week in advance. If you are a joint Ph.D. student, the meeting must be advertised and open to both departments. The presentation is expected to take place at your home institution and will be transmitted by videoconference to the partner institution.

At the Thesis Proposal Defense, you will give a brief (15-20 minute) presentation followed by questions that is open to the department as a whole. Following this presentation, the Thesis Proposal Defense Committee will meet with you in a closed-door session to:

1. Establish whether you have the background and knowledge to succeed in carrying out the proposed research;
2. Judge in detail the scientific viability and suitability of your thesis topic and plan; and
3. Determine if the scope and timeline are realistic.

A particular objective is to identify your strengths and weaknesses in order to provide focused advice (e.g., on topics that need more attention, the addition of committee members with specific knowledge, re-scoping the proposed effort, etc.). As such, questioning will emphasize topics related to the thesis proposal itself, but will explicitly not be limited to it. Thus in addition to questions in the broad area of your proposed research, you should also expect to be probed with general questions and you should prepare for them.

Based on the evaluation by the Proposal Defense Committee, you may pass unconditionally, pass with conditions (e.g., revision of parts of the thesis proposal, future presentation of specific topics in more detail, additional coursework), or, if the presentation and examination are deemed unsatisfactory, you may be given an opportunity to repeat the Thesis Proposal Defense in its entirety. Once you pass the PhD Proposal Defense and you have meet all other departmental requirements, you may apply to the Graduate School for Admission to Candidacy.

4.4.1 Regulations

University – The official forms for filing for candidacy are available online and in the Astronomy departmental office. It is the student's responsibility to file these forms in a timely manner.

Department of Astronomy – Admission to Candidacy must occur within four years of admission to the Graduate School. All the departmental requirements for admission to the PhD program must, of course, have been fulfilled. In addition, all incompletes must have been removed except for those in research courses where the work is part of the PhD research. All departmental course requirements must have been satisfied.

4.5 Stage 3 – From Candidacy to Completion of the PhD

During this period, you should concentrate on completing the PhD research work and on writing the dissertation. Students are required to continue their annual meetings with their committee (see Sect. 3.1). Be aware that you may need to register in the summer if you are defending then.

The thesis must involve significant, original, and independent research, performed under the supervision of the advisor. The thesis must be of the quality normally required for publication in recognized research journals. It is usual that several drafts are gone through before the final thesis is produced. The Department will normally bear the cost of reproducing the final draft of the thesis. There are University regulations as to the format of

the thesis and the mechanics of submitting it to the Graduate School (See the Graduate School's website at www.gradschool.umd.edu).

4.5.1 Regulations

University – A minimum of one and a maximum of four years is allowed between admission to candidacy and completion of the PhD, of which at least one year must be spent at the University of Maryland. During this time you must be continuously registered each semester (not including summer semesters). This is true even if you are not in residence; in this case you must fill out the Continuous Registration Form and pay a nominal fee each semester. When filing for the degree, all Incompletes in the courses being used for the PhD must be completed and a minimum grade point average of 3.0 must be obtained. There are specific deadlines each semester for applying for a degree and for submitting the final dissertation. (See the Graduate School's website at www.gradschool.umd.edu/).

Department – A complete draft of the thesis must be submitted to the examining committee two weeks before the final defense. It is your responsibility and that of your advisor to see that the entire Graduate faculty is informed of the examination date and time at least two weeks in advance. You must also have a copy of the thesis available for examination by any other faculty who might wish to attend the defense. To do this, place a copy in the library and post the thesis electronically in an internal directory. (See instructions at /home/www/docs/resources/internal/protectedfiles/DraftTheses/README .) The link to the thesis should be included in the e-mail announcing the defense. You are responsible for seeing that the final thesis reaches the Graduate School. Also, the department requires that the student post the final thesis as submitted to the Graduate School on the department website, following the README instructions above.

4.5.2 Dissertation Defense *(Standard PhD Option)*

Once the dissertation is completed, it is defended in front of a committee consisting of members of the Department of Astronomy, members of the University faculty who are not members of the Department of Astronomy (e.g. the Dean's Representative), and external examiners from other universities who have been made members of the University of Maryland's Graduate Faculty. A discussion of the guidelines for the Ph.D. oral can be found on the Graduate School's website at www.gradschool.umd.edu/. Once the committee has approved the dissertation, it can be submitted to the Graduate School. More details can be found in Appendix B.

4.5.3 Dissertation Defense *(Joint PhD Option)*

Once the dissertation is completed, it will be defended in front of a dissertation review committee. The committee membership will consist of members of both Departments of Astronomy, members of each university's faculty from other departments (including official representatives such as the University of Maryland's Dean's Representative), and external examiners from other universities. Both the latter and all PUC faculty must be established as members of the University of Maryland's Graduate Faculty in order to serve on the committee.

The defense will physically take place at one of the partner institutions, and be transmitted by videoconference to the other. Physical presence of the student's co-advisor from the partner institution is required; physical presence of the partner institutions' other committee members will not be required. The examination date and time will be advertised to the entire Graduate Faculty of both institutions.

More details can be found in Appendix B, with the modifications noted in this section.

Final drafts of the thesis, written in English and incorporating the recommendations from the dissertation review committee, should be submitted by the candidate to the Graduate Schools of both institutions compliant with their required formats. Acceptance of the dissertation by both schools will complete the Ph.D.

5. MS Program

The Department of Astronomy allows the options of obtaining an MS degree with or without a written thesis. Those students choosing the thesis option are expected to finish a significant research project and write up the results in an acceptable format. Students choosing a non-thesis option are expected to acquire a broader knowledge of astronomy. The general conditions discussed in Section 3 also apply here. MS students choosing the non-thesis option would normally be advised by the Graduate Director. Where the thesis option has been chosen, the composition of the advising committee is determined by the research work being done. A summary of the program is found in Table 2; details are in the following sections.

5.1 Non-Thesis Option

5.1.1 Course Requirements and Regulations

University – Courses totaling 30 credits are required of which a minimum of 18 must be at the level of 600 or above. Students must have a GPA of 3.0 or greater. In addition, one or more scholarly papers must be submitted.

Department (Courses) – Students must take six of the nine principal Astronomy graduate courses. Additional courses in Astronomy and supporting areas must be taken to fulfill University requirements. The final list of courses must be approved by the graduate advisor.

Department (Other) – The scholarly papers required by the Graduate School can be papers required as part of a graduate level astronomy course if the faculty approves. The report for the second year project will normally satisfy this requirement.

As for all other cases, the student is responsible for knowing and meeting University deadlines.

5.2 Thesis Option

5.2.1 Course Requirements

University – Graduate courses totaling 30 credits are required of which 6 credits are to be Master's thesis research (ASTR 799). Of the remaining 24 credits, no less than 12 must be in the major and no less than 12 must be at the level of 600 or above. Students must have a GPA of 3.0 or greater.

Department – Students must satisfy the same course requirements as for the Ph.D. program (see section 4). The final list of courses must be approved by the graduate advisor.

5.2.2 Thesis

The research topic must be approved by the student's study committee and the thesis must be written in accordance with University regulations. The student's 2nd Year Project and written report can serve the basis for their Master’s thesis. Whenever possible, the cost of reproducing the final draft of the thesis will be assumed by the Department. A final oral examination will cover the thesis work as well as the primary supporting fields of the

candidate. Approval of the committee must be unanimous. In some cases the committee may recommend that the candidate return for a second examination at a later date.

5.2.3 Regulations

As with the PhD thesis, there are deadlines which must be met if the degree is to be awarded in a given semester. The student is responsible for knowing these details. There is a University limit of five years from first enrolling in the Graduate School to obtaining the MS degree.

6. Special Status

6.1 Part-Time Students

Although the University has a specific formula for determining full vs. part-time status, there are no special provisions made for part-time students, e.g. their time limits are the same as for full-time students. However, the Graduate School will normally waive the time limits (within reason) at the request of the Department. The Department of Astronomy treats all its deadlines for the part-time PhD students as being set back by 2 years. In those cases where this policy would need a waiver of University deadlines, the Department will support such a request. Part-time MS students will be treated on an individual basis. Normally, the five-year University time limit is sufficient to complete an MS thesis even on a part-time basis.

6.2 Provisionally Admitted Students

All such cases are dealt with on an individual basis. Provisionally admitted students are informed at the time of admission of the conditions needed to remove the provisional status. Occasionally, a student may be admitted with a deficient academic record. The cases are again dealt with on an individual basis. The normal procedure would be to set up a long-range program for the student and to adjust departmental deadlines accordingly.

7. Appendix A: Representative Course Syllabi

ASTR 601- Radiative Processes

1. Thermodynamics and Statistical Mechanics

1. Quantum Statistical Mechanics (Bose-Einstein and Fermi-Dirac)
2. Thermal Radiation
3. Eq. of State
4. LTE
5. Boltzmann eq
6. Saha Eq
7. Einstein A and B Coefficients

2. Radiative Transfer

1. Specific Intensity, Radiation Density and Pressure
2. Transfer Equation, Optical Depth
3. Gray Opacities, Dust Opacities, Rosseland Mean
4. Eddington Approximation
5. Scattering and Random Walks

3. Atomic and Molecular Radiative Processes

1. Semi-Classical Theory of Radiation
2. Oscillator Strength
3. Transition Rates (Bound-Bound and Bound-Free for H, H-)

4. Plasma Radiative and Transfer Processes

1. Radiation from Moving Charges
2. Bremsstrahlung
3. Synchrotron
4. Compton Scattering
5. EM waves in Plasmas; Dispersion and Faraday Rotation

7. Appendix A: Representative Course Syllabi

ASTR 606 - Stellar Structure and Evolution

1. Stellar Atmosphere Models

1. Grey Models
2. Flux Constant Models

2. Convection Using Mixing Length Theory

3. Determining the Properties of Stars

1. Metal Abundances
2. Temperatures
3. Surface Gravities

4. Introduction to Stellar Interiors

1. Applications of the Virial Theorem
2. Global Energetics
3. Kelvin-Helmholtz Time Scale
4. Estimates of Stellar Temperatures
5. Constant Density Model
6. Energy Generation and Transport
7. Main Sequence Lifetimes

5. Overview of Observational Data and Stellar Evolution Results

1. Pre-Main Sequence Evolution
2. Evolution On and Off the Main Sequence
3. Late Stages of Evolution
4. Intrinsic Variables
5. Supernovae
6. Polytropes

6. Nuclear Energy Sources

1. The *pp* Chain
2. CN Cycle
3. He Burning
4. CNO Burning
5. Si Burning

7. Stellar Modeling

1. Henyey Method
2. White Dwarfs

7. Appendix A: Representative Course Syllabi

ASTR 610 - Astronomical Instrumentation and Techniques

1. Coordinate Systems
    1. Precession and Nutation
    2. Conceptual Differences Between B1950 and J2000
    3. Spherical Trigonometry for Coordinate Transforms, Ecliptic and Galactic Systems, Time Systems - UT vs. ET vs. TDT vs. TDB

2. Optical Theory
    1. Presume Complete Knowledge of Basic Ray Optics and Do a Basic Review of Terms to be Used
    2. Consider Basic Things Like Thick Parallel Plates in a Converging Beam, Combining Two or More Elements into a System, Two -Mirror Systems Including Cassegrain and Gregorian Designs (Radio as well as Optical).
    3. Outline Use of S tops and Pupils
    4. Fernats Principle
    5. Seidel Theory of Aberrations. Circle of Least Confusion
    6. Schmidt Telescope
    7. Ritchy -Chretien System s. Plus the Following Non -Core Items if There is Time: Baker Designs, Schmidt-Cassegrains, Meniscus Correctors
    8. X-Ray Cassegrains

3. Aperture Theory and Fourier Transforms
    1. Far-Field Pattern as Fourier Transform of Aperture Illumination
    2. Basic Theorems of Fourier Transforms (Convolution, Correlation, Sampling, Aliasing, etc.)
    3. Picture-Book Transforms a la Bracewell
    4. Apodizing Apertures, Illumination of the Primary by a Feed Horn, etc.
    5. Cassegrain Telescopes - Diffraction Patterns by Fourier Transform Theory
    6. Aperture Mask Transforms (Applications to High Energy Geometrical Collimators)

4. Radio Astronomy Basics
    1. Definitions of Terms
    2. Noise Limits

5. Interferometry
    1. Arrays of Apertures, Beam Steering
    2. Diffraction Gratings and Linear Dipole Arrays
    3. Adding vs. Multiplying Interferometers
    4. Fringe Visibility Optical and Radio
    5. Aperture Synthesis
    6. UV Plane
    7. Phase Errors and Phase Closure

6. Spectral Analysis
    1. Filter Banks
    2. Autocorrelation Receivers and FTS
    3. Etendue and Spectral Resolution
    4. Fabry-Perot and Interference Filter Systems
    5. Grating Spectrometers Including Bragg Crystals, Echelles, etc. (Spectral Analysis by the Detector is Considered Later)

7. Polarization - (Not really part of the core material and there is usually not time to cover this)

1. Stokes Vectors
2. Poincare Sphere

8. Detectors

1. Radio Detection - Bolometers, Simple Diodes, etc.
2. Photography - (Could be dropped and is not normally covered for lack of time)
3. Photoconduction - IR Detectors
4. Arrays - CCDs, InSb and HgCdTe Arrays
5. Energy-Sensitive Detectors - Proportional Counters, Solid State Arrays, etc.

9. Atmospheric and Ionospheric Effects - (In recent years there has not been time to cover this material)

1. Attenuation
2. Refraction
3. Scintillation and Seeing
4. Active Optics and Laser guide stars

7. Appendix A: Representative Course Syllabi

ASTR 615 – Computational Astrophysics

Sample syllabus: http://www.astro.umd.edu/graduate/pdf/ASTR615.pdf

7. Appendix A: Representative Course Syllabi

ASTR 620 – Galaxies

1. Introduction and Review

1. General Outlook on Galaxies
2. Review of Stars and Stellar Evolution
3. Review of Galactic Distance Scale

2. Stellar Populations and their Distribution

1. Star Counts and Stellar Luminosity Function
2. Initial Mass Function, and Stellar Birth Rate
3. Distribution and Kinematics of Stellar Populations

3. Galactic Rotation and Stellar Dynamics

1. Solar Motion and the Local Standard of Rest
2. Oort Constants
3. Stellar Motions in Disk and Elliptical Potentials
4. Rotation Curve of Our Galaxy
5. Rotation and Dynamics in External Galaxies

4. Disk Dynamics and Spiral Structure

1. Stability of Disks
2. Spiral Density Wave Theory
3. Tracers of Spiral Structure
4. Stochastic Star Formation
5. Bars and Warps

5. Elliptical Galaxies

1. Equations of Stellar Hydrodynamics
2. Stellar Relaxation, Velocity Ellipsoids, and Triaxiality
3. Mass Profiles

6. Galactic Nuclei

1. Observational Summary of Our Galactic Center
2. Search for Dormant Black Holes in Nearby Galaxies
3. Active Galactic Nuclei & Starbursts

7. Galaxy Evolution and the Effects of Environment

1. Chemical Evolution
2. Tidal Interaction, Dynamical Friction, and Merger
3. Galaxy Luminosity Function
4. Observational Status of Galaxy Evolution
5. Formation Models for Galaxies

8. Extragalactic Distance Scale

1. Standard Candle Methods
2. Tully-Fisher Relation for Spiral Galaxies
3. Fundamental Plane of Elliptical Galaxies
4. Surface Brightness Fluctuations
5. SZ- X-Ray Method

9. Dark Matter

1. Mass Determinations and Mass-To-Light Ratios on Various Scale
2. Composition of Dark Matter

7. Appendix A: Representative Course Syllabi

ASTR 622 – Cosmology

Sample syllabus: http://www.astro.umd.edu/graduate/pdf/ASTR622.pdf

ASTR 630 – Planetary Science

Sample syllabus: http://www.astro.umd.edu/graduate/pdf/ASTR630.pdf

7. Appendix A: Representative Course Syllabi

ASTR 670 - The Interstellar Medium and Gas Dynamics

1. Content and Phases of the ISM
    1. Neutral HI
    2. Molecular Gas
    3. Dust
    4. Ionized Gas
    5. Magnetic Fields
    6. Cosmic Rays

2. Physical Processes in the ISM

    1. Ionization Equilibrium
    2. Heating and Cooling; Thermal Equilibrium
    3. Extinction, Polarization, and Physical Properties of Grains
    4. ISM Chemistry (Gas Phase and with Dust)

3. Gas Dynamics

    1. Fluid Equations of Motion
    2. Self-Gravitating Hydrostatic Equilibria
    3. Viscous and Inviscid Flows
    4. Fluid Instabilities: Convective, Rotational (Rayleigh _s Criterion), Rayleigh-Taylor, Kelvin-Helmholtz, Thermal, Gravitational (Jeans Criterion)
    5. Turbulence
    6. Sound Waves and Wave Steepening
    7. Shocks: Jump Conditions for Non-Radiative and Radiative Shocks
    8. Supernova and Blast Waves
    9. HII Regions, Ionization Fronts, and Expansion

4. Magnetohydrodynamics

    1. Equations of MHD
    2. Force-Free Fields
    3. MHD Waves
    4. Self-Gravitating MHD Equilibria and Parker Instability
    5. MHD Instabilities
    6. MHD Shocks
    7. Dynamos
    8. Resistivity and Ambipolar Diffusion

7. Appendix A: Representative Course Syllabi

ASTR 680 – High Energy Astrophysics

Sample syllabus: http://www.astro.umd.edu/graduate/pdf/ASTR680.pdf

8. Appendix B: Dissertation Defense

When planning the timing of your defense, be aware that you may need to register for the semester(s) in which you defend and complete your final revisions, even if they happen in the summer. The summer can also be a difficult time to assemble a full committee. Finally, please also be aware that there can be complications with tuition remission if you are an RA for only part of a semester. Talk to the department's front office staff for more information.

There are extensive University regulations concerning the composition of the dissertation committee and the conduct of the exam. These are in the Graduate Catalog which is online. Students and their advisors should be familiar with these regulations. University deadlines for graduation are also posted on the University's website at www.gradschool.umd.edu/. The following deals mostly with departmental regulations and procedures which are in addition to those of the University.

Composition of the Committee

1. University Requirements:

1. A minimum of five members, ALL of whom must be members of the Graduate Faculty (see http://apps.gradschool.umd.edu/Catalog/policy.php?graduate-faculty-policies) of the University of Maryland. Thus, department faculty who are not Graduate Faculty must be nominated as Adjunct Members of the Graduate Faculty, and persons who are not on the faculty at the University of Maryland must be nominated as Special Members of the Graduate Faculty. This requires documentation and an approval process (see below). The University requires a six week lead time for the nomination of the committee. It is prudent to heed this deadline. The department's front office staff can assist with any questions.

2. At least three members of the committee must be Full members of the Graduate Faculty. (In general, this means that they are from the tenure/tenure track faculty.)

3. A faculty member who will serve as a representative of the Dean of the Graduate School. This is a tenured member of the Graduate Faculty from another tenure home than the student's primary advisor, or co-advisor(s).

2. Department of Astronomy requirements:

1. Committee chair is a member of the faculty of Department of Astronomy and a Full member of the Graduate Faculty.

2. One or two External Examiners who are not members of the faculty of the University of Maryland. (Note: People who are based elsewhere, such as Goddard, **are** eligible even if they are UMD adjunct professors or are employed through UMD.)

3. Three members of the Department faculty. (Note: This can include Research Associates or Research Scientists.)

4. The Chair of the Department of Astronomy is an ex officio member of all dissertation committees.

Please note that one person can satisfy more than one of the above requirements. This should help in keeping the size of the committee manageable.

Obtaining Approval for the Committee Membership

The student is responsible for giving the Nomination of Dissertation Committee form to the Graduate Director with the advisor's signature by one week before the Graduate School

deadline or at least seven weeks prior to the defense, whichever is earlier. The Graduate Director will sign the form and give it to the front office, who will submit it to the Registrar's Office.

Separately, in an email to the Department's front office staff (currently MaryAnn and Eric), with the advisor cc'ed, the student should send: 1) the thesis title, 2) the proposed defense date, and 3) a list of proposed committee members. For each committee member who is not already a member of the Graduate Faculty (see above), the student's email must also provide a brief justification for including the member on the committee. Additionally, for each member not on the Graduate Faculty, the student must ask the member to contact MaryAnn with their CV and (if not a UMD employee) their date of birth. (The front office can assist if the student is uncertain whether a committee member is a member of the Graduate Faculty.) The front office will then prepare Nomination to the Graduate Faculty Forms. The student's email and committee member info should be delivered to the front office at least seven weeks prior to the defense.

Once the front office has received all of the information in the preceding paragraph, the front office staff will relay the information and Graduate Faculty nomination forms to the Graduate Director. The Graduate Director will seek approval from the Department professorial faculty for the Graduate Faculty nominations and will then sign and return the Graduate Faculty nomination forms to the front office. Meanwhile, the front office will prepare letters to the Dean of the Graduate School to seek approval for the appointments to the Graduate Faculty. The front office will obtain the Graduate Director's signature on the letters and then forward the nomination forms and letters to the Graduate School.

The department's front office staff can assist with any questions relating to these forms.

Scheduling and Conduct of the Dissertation

The scheduling of the date of the exam and the selecting of the composition of the committee shall be the responsibility of the candidate and his or her advisor subject to the approval of the Director of the Program. The faculty examiners must normally be given ten working days to read the dissertation. The thesis advisor must announce the defense time and place to all members of the Graduate Faculty and graduate students at least five working days in advance, and at this time a copy of the dissertation must be placed in the library and a link to the draft thesis included in the announcement. (See instructions at /home/www/docs/resources/internal/protectedfiles/DraftTheses/README .)

A member of the committee may participate remotely by video teleconference if the chair of the dissertation committee obtains permission from the Assistant Dean/Chief of Staff of the Graduate School. See the Graduate Catalog for details.

The committee having convened, it meets briefly in private to agree on procedures; e.g., length of time for the initial presentation by the candidate if one is given; maximum time interval allowed to an individual examiner on the first round of questioning.

The usual examination procedure will be for the candidate to make a short presentation which will be followed by questioning by the Committee.

Dissertation Standards

It is expected that the material or major results in an acceptable dissertation will be equivalent to that in a paper published in a major journal. The dissertation will contain a statement by the candidate saying which part of the work has been carried out by the candidate and which part by other people.

Conclusion of the Examination

After the examination is concluded, the candidate withdraws and the committee deliberates in private on the performance of the candidate. At this point the committee should proceed deliberately but expeditiously to a conclusion. Appropriately, the Chairman might ask each examiner in turn to comment on his part of the examination; after these comments, he might ask each member to comment on his view of the entire examination. Following this, the members should be polled for their vote. The various possible outcomes are as outlined in the University regulations.

Bound Dissertation Copies and Final Electronic Version

After the dissertation has been finalized, the Department will reimburse the candidate for the cost of up to 5 bound copies (max cost of $250), including four personal copies and one which is to be provided to the Department for inclusion in the Astronomy Library.
Also, the department requires that the student post the final thesis as submitted to the Graduate School on the department web site. (See instructions at /home/www/docs/resources/internal/protectedfiles/DraftTheses/README .)