March 2, 2009

MEMORANDUM

TO: Dr. David W. Reed  
Chair, Graduate Council

Dr. Robert C. Webb  
Interim Dean of Graduate Studies

FROM: Dr. Mark J. Zoran, Associate Dean for Graduate Studies  
Chair, Graduate Instruction Committee  
College of Science

SUBJECT: Proposed Graduate Program in Astronomy

Please find attached a proposal to the Texas Higher Education Coordinating Board for Master's and Doctoral degrees in Astronomy. The Department of Physics and the College of Science seek approval for this program from the Graduate Council. This proposal has been reviewed and approved by the College of Science Graduate Instruction Committee at its meeting of February 25, 2009.

Thank you for your consideration of this request.
MEMORANDUM

TO          David Reed  
            Chair  
            Graduate Council

THROUGH    H. Joseph Newton  
            Dean  
            College of Science

FROM       Edward S. Fry  
            Department Head

DATE       March 2, 2009

SUBJECT  Proposal for graduate program in astronomy

Dear Dr. Reed:

The attached proposal for a graduate program in astronomy is submitted for your review. It represents a significant milestone in a continuing six-year effort by our department to position Texas A&M University as a top-level institution in this field of research.

Aided by President Gates’s Faculty Reinvestment Program and the generosity of several donors, we now have seven faculty members who specialize in astronomy and are guiding the research of several graduate students in the department. Future growth in this area is intimately tied to our ability to provide appropriate coursework and training for graduate students who are interested in pursuing a career in Astronomy.

Thank you in advance for your consideration of this proposal.
A PROPOSAL

to the

TEXAS HIGHER EDUCATION COORDINATING BOARD

to authorize a

Doctor of Philosophy in Astronomy

Master of Science in Astronomy (Thesis Option)

Master of Science in Astronomy (Non-Thesis Option)

Offered by:

Department of Physics and Astronomy

College of Science

TEXAS A&M UNIVERSITY
Substantive Degree Program Request - Title Page

Name of Institution: Texas A&M University

Name of Proposed Program: Graduate Program in Astronomy

Display how proposed program(s) would appear on the Coordinating Board program inventory; include Texas CIP designation(s).

Astronomy ASTR 40.02

How would the name(s) of program(s) appear on student diplomas?

Doctor of Philosophy in Astronomy

Administrative unit(s) responsible for the program(s):

Department of Physics and Astronomy

Proposed date for implementation of program: Fall 2010

Persons to be contacted for further information about proposed program:

Name: Dr. Edward Fry
Phone: 979/845-1910
Title: Chair, Dept. of Physics & Astronomy, TAMU
e-mail: fry@physics.tamu.edu

Name: Dr. H. Joseph Newton
Phone: 979/845-8817
Title: Dean, College of Science, TAMU
email: jnewton@stat.tamu.edu

Signatures:

TAMU Campus Chief Executive Officer Date

System Chief Executive Officer Date

Governing Board approval date: 
Administrative Approval

Dr. Theresa A. Maldonado
Interim Vice President for Research

Dr. Robert C. Webb
Interim Dean of Graduate Studies

Dr. H. Joseph Newton
Dean of Science
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EXECUTIVE SUMMARY

Overview

This proposal is for the Department of Physics and Astronomy to administer a Graduate Program in Astronomy and to offer Doctor of Philosophy and Master of Science degrees in Astronomy from Texas A&M University.

Astronomy, the study of all celestial bodies, has been revolutionized in the past few decades as consequence of advances in semiconductor and computer technology. As a result, our view and understanding of the Universe has changed dramatically. Two of the most dramatic examples of this revolution in our knowledge include the discovery of a cosmic dark energy that is accelerating the expansion of the Universe and the detection of hundreds of planetary systems around nearby stars. Not surprisingly, the public fascination with astronomy continues to grow thanks to these and other discoveries, and this enthusiasm translates into a strong interest by undergraduate students across the nation to take Astronomy 101 as one of their science electives.

Faculty members in the Department have been engaged in astrophysics-related research for many decades, yet a department research group in this area did not exist until very recently. The events that led to its creation started in a meeting held during the Spring semester of 2003 between President Gates and the Physics Department chair, Ed Fry. Thanks to the Faculty Reinvestment Program, the Physics Department obtained funding for four faculty positions in Astronomy. A panel of experts, funded by Mr. George Mitchell, was convened shortly thereafter to make recommendations to the Department about the approach to follow in the establishment of this new research area. The panel, chaired by Dr. Wendy Freedman (director of the Carnegie Observatories), visited the campus during the Fall semester of 2003 and made several key recommendations; their final report is attached as Appendix A. Texas A&M joined the Giant Magellan Telescope consortium in 2005. In the summer of 2008, through President Murano’s signature, A&M was the second institution to sign the Giant Magellan Telescope founding member’s memorandum of understanding. As of 2009, A&M has contributed 18.2% of the funds available for the construction of the GMT, a figure only surpassed by the Carnegie Observatories.

The first astronomer hired as a faculty member in the Department under this plan was Dr. Nicholas Sunzetteff in the March of 2006. Six other faculty members were hired in the following two years (see Appendix F for biographical sketches). Our goal is to become a first-rank program in astronomy, based on the quality of the research carried out by our faculty and the facilities to which they will have access to enable that research. Our faculty has significant experience in several key areas of modern astronomy, including: standard candles for the extragalactic distance scale (Cepheids and supernovae), galaxy formation and evolution, searches for extrasolar planets, and major instrumentation. Over the past decade, our current faculty members have published over 200 research papers. Research in astronomy receives significant support from the National Science Foundation, the National Aeronautics and Space Administration, and the Department of Energy. Thus, it is not surprising that our faculty members have successfully competed for high levels of extramural research dollars. Over the past five years, our faculty has received approximately $5M of research funding in multi-year, single- or multi-investigator grant awards.
The Department of Physics and Astronomy is dedicated to administering a graduate program that promotes diversity in its faculty and students. The current faculty membership includes 4 female professors and 3 underrepresented minority professors. The faculty will aggressively target these underrepresented groups in its future recruiting efforts.

The Department of Physics and Astronomy conducts several important public service activities for the local scientific and lay community. These activities include:

- a faculty colloquium that invites top physicists and astronomers to present public lectures and department seminars.

- outreach events such as the Physics Festival (held every Spring), Physics Shows for schools, the Saturday Morning Physics Program, and the Chemistry Open House and Science Exploration Gallery (held every Fall). The astronomy group is committed to pursue an active outreach program both locally and statewide.

- scientific and social activities for the local physics and astronomy community including annual meetings, symposia and poster sessions. Travel grants by the TAMU Office of the Vice President for Research are available for students to attend scientific meetings.

**Doctoral Degree in Astronomy**

The Department of Physics and Astronomy is dedicated to providing excellent training for future astronomers. We request the addition of a doctoral degree to a Department that is well established and has a long successful record of training students. Currently, the Department of Physics and Astronomy has roughly 175 graduate students and its faculty members are currently training about 30 postdoctoral associates.

The proposed graduate degree programs and their associated curricula have been designed to be the central venue for this astronomy educational effort. The graduate studies program will offer new courses under the aegis of the ASTR (Astronomy) prefix. The program will consist of a two-year core curriculum followed by a comprehensive examination. The core curriculum will be comprised of six astronomy courses, an astronomy journal club, and a four-semester sequence of research activities. In addition, students will be expected to enroll in two graduate-level physics courses to ameliorate any deficiencies in their undergraduate education or to enhance their graduate training. During their second year, students will be expected to identify a major advisor, develop a dissertation proposal, and submit a graduate degree plan to the advisory committee. The preliminary examination will be held at the end of the second year. Upon successful completion of this examination and the acceptance of the dissertation proposal, the student will be admitted to candidacy in the doctoral program.

The Graduate Program in Astronomy will promote the education of master’s level graduate students, as well as doctoral students, by providing both degrees. Additionally, the faculty and program will provide valuable educational resources for undergraduate majors in a diversity of departments, especially with regard to undergraduate research supervision and academic coursework.
Program Needs

The Department of Physics and Astronomy has made a tremendous amount of progress in the past few years in terms of setting up a vibrant faculty research group in Astronomy. In order to further enhance the program’s standing in the eyes of university, state, national and global scientific communities, a curriculum has been developed that will evolve into a premier training program in this important area. Approval of this degree and curriculum is critical for the development of this discipline at TAMU. The program will begin to recruit new graduate students for study and the faculty members will strive to become a premier astronomical community by building on current strengths and growing into a truly first-rate graduate studies program. The rapid expansion of the faculty, the investment in the new Mitchell Institute and Physics Buildings, and joining the Giant Magellan Telescope consortium have already positioned this proposed program to be immediately successful in its training of the next generation of astronomers.

Goals of the Graduate Program in Astronomy

The goal of the program is to attract high-quality students who wish to pursue astronomy and astrophysics careers in higher education, in government labs, or in private industry. By providing an excellent core curriculum and premier research experiences, the program will ensure that highly qualified individuals receive broad training in astronomy.

Program Design

The program will focus on formal coursework and research activities. Essential components of the program are:

1. Training from members and adjunct members in the Department of Physics and Astronomy.
2. A core curriculum of six broad-based ASTR courses, and two PHYS courses (for doctoral students only).
3. A requirement that the students enroll in both the astronomy journal club and directed research courses for the first four semesters.
4. A preliminary examination at the end of the second year (for doctoral students only).
5. An extensive research experience, a significant body of astronomical discovery, and the writing of an approved doctoral dissertation.

Degree Options

Students will earn a Doctor of Philosophy in Astronomy with 96 total semester credit hours or 64 semester credit hours with an approved Masters degree at admission to the program. Master degrees (both Thesis and Non-Thesis options) will be available for students with those educational needs. All degrees will be conferred by Texas A&M University.
Admission

Prospective students may apply to the Graduate Program in Astronomy through the TAMU Office of Graduate Studies. All student applicants will be expected to meet all the requirements for admission to graduate studies at TAMU. The overall admission criteria will be based on the entire record of the applicant and the availability of space and resources within the Program.

Prospective Student Demand and Job Market

Astronomy is a relatively small field, with about 6,000 professional astronomers in North America. Over the past decade, the production of PhDs in Astronomy by all U.S. universities has averaged 180 per year (source: Survey of Earned Doctorates by NSF, 2006 edition). We expect to admit 2 to 4 students per year into our program, and to eventually reach a steady-state size of about 12 to 15 students. Typically, at any given time a professor in astronomy will oversee the research activities of two students in different stages of their training; for example, the PhD in Astronomy program offered by the University of Texas at Austin currently has 22 active faculty members and 45 graduate students. Thus, given the current size of our faculty (6 professors) we can expect about a dozen students in the program five years from now, with some room for growth as additional faculty members join the program.

The job market for Astronomy PhD recipients is healthy, with a good balance between PhD production and vacant positions. In almost all cases, a graduating student will first be employed in a temporary post-doctoral position. The amount of time spent as a post-doc varies, but there is usually a minimum of three years and a maximum of six years before a more permanent position is attained. These are usually in academia (research university or college), or in a federally-funded (NASA, NSF, DoE, DoD) laboratory or observatory. Some graduates find astronomy-related employment in the private sector, either at optical or space sciences companies. Finally, as is the case with other physical sciences, the problem-solving abilities obtained as part of a PhD education are highly regarded by management consulting and investment firms. Hence, a small fraction of graduates find employment in the business sector.
I. PROGRAM ADMINISTRATION

A. Describe how the program would be administered.

1. Indicate the name and title of person(s) who would be responsible for curriculum development and on-going review.

The Chair of the Physics and Astronomy Department will administer the Graduate Program in Astronomy. The Chair will receive input from the Department’s Astronomy Committee (comprised of all faculty members engaged in astronomical research and teaching) regarding curriculum development and on-going review of the program’s progress.

2. Describe the responsibilities for student advisement and supervision.

One of the astronomy faculty members will serve in the Department’s Curriculum and Graduate Programs Committees and will serve as overall graduate advisor for the program, aided by the Program Coordinator. The role of the graduate advisor will be to lead the recruiting effort and to communicate information regarding graduate student issues between the student, faculty and Programs Committee and between the Graduate Program and the Office of Graduate Studies at TAMU.

Upon admission to the Astronomy program, the Admissions Committee will assign the new student an interim advisor from the faculty membership, based upon the student’s research interests and the wishes of the faculty member. The interim advisor will provide guidance for the student as the student progresses through the first two years of core courses and research activities. By the end of the second year, the student must choose a permanent advisor and advisory committee, comprising four members of the graduate faculty at TAMU. This committee will advise and supervise the student throughout his/her academic career at this institution. The graduate advisor, assisted by the Program Coordinator, will maintain overall supervisory authority for advising all graduate students in the program with respect to assisting in registration, thesis or dissertation deadlines, etc., and will report to the Chair of the Department.

3. If the program would be administered by more than one administrative unit, what factors would make this desirable?

The Department of Physics and Astronomy will be the only administrative unit responsible for administering this program.

B. If a non-academic administrative unit, e.g. "institute" or "center" would be involved in administering the program, describe the relationships.

No non-academic units will be involved in the administration of the Astronomy Program.
C. If a new organizational unit would be created, or an existing organizational entity modified as a result of this program, identify and describe the anticipated result.

No new organizational unit would be created. There will be a modification (in name only) to the Department of Physics, which would now be called Department of Physics and Astronomy.

II. PROGRAM DESCRIPTION

A. Educational Objectives

1. Describe the educational objectives of this program. Include reference to preparation of students for licensure or certification, if appropriate and any special outcomes or competencies which the program would provide that are not available from existing degree programs.

*Doctoral Program in Astronomy*

The educational objectives of the Doctoral Program in Astronomy are three-fold:

(1) To provide comprehensive education to graduate students so that they can become independent and productive astronomers in institutions of higher education, the government, industry or non-profit agencies.

(2) To train young astronomers to become highly qualified educators and researchers in the field.

(3) To produce highly educated members of society who will make informed choices on science and public policy issues.

The Doctoral Program in Astronomy will add increased diversity to the graduate programs in physical sciences offered at TAMU. New courses will be developed under the aegis of the ASTR prefix, to target core knowledge required of all students and important new areas of astronomy as they arise. The proposed Ph.D. program consists of a two-year core curriculum, elective courses, journal club, directed research, and a comprehensive examination following the second year in the program. Successful completion of each of these steps will be required for advancement to candidacy.

The two-year core curriculum will comprise six comprehensive courses that cover all basic areas of modern astronomy. In addition, students will register for the astronomy journal club and directed research under the supervision of a faculty member who will serve as advisor and mentor prior to candidacy. In addition, students will be expected to enroll and obtain a satisfactory grade in two courses from the physics graduate curriculum in areas where their undergraduate education may have been weak, or if no such deficiency exists, in areas that will augment their expertise in their chosen field of specialization. Once all coursework is completed, the student will be required to take a comprehensive examination, to be administered by a subset of the faculty selected by the Curriculum or Graduate Program Committee.
During their second year in the program, students will be expected to identify a major advisor, develop a dissertation proposal, assemble an advisory committee and submit their degree plan. Upon successful completion of the comprehensive examination and the acceptance of the proposal, the student will be admitted to candidacy. Each student will be expected to register for the astronomy journal club throughout the remainder of his/her graduate career. Research must be conducted in a timely fashion; a dissertation must be produced and orally defended in a public forum, nominally within four years following advancement to candidacy.

Master’s Program in Astronomy
Students with interests in careers in astronomy may desire to pursue a Master’s degree rather than a Ph.D. For these students, we propose to offer a Master of Science in Astronomy. The proposed M.S. program consists of the same two-year core curriculum of six astronomy graduate courses in addition to journal club and master’s thesis research (for those pursuing the Thesis option). Following completion of the Master’s degree plan and the approval of their master’s thesis research (for those pursuing the Thesis option), students will be required to satisfactorily complete a final examination.

Additional Objectives of the Graduate Program in Astronomy
The proposed graduate program will foster several additional objectives that compliment the primary educational goals outlined above. These equally important objectives are:
(a) to prepare students for professional careers in astronomy in Texas as well as both at the national and international levels, within academic, industrial, governmental, national research laboratories, or academic/corporate cooperative institutes.
(b) to provide a teaching and research base for an ongoing series of collaborations that will improve exchange of knowledge and resources (both physical and human) between TAMU students and faculty, as well as other students and researchers from other Texas A&M University System units and the University of Texas system.

2. If the program design includes multiple curricula (concentrations, emphases, options, specializations, tracks, etc.), describe the educational objectives of each (Each of these curricula must be identified on the title page, including the Texas CIP code).

The program does not include multiple curricula.

B. Admission Standards

1. State admission requirements for the program (if there are different categories for admission, e.g. unconditional, probationary, etc., describe each).

Prospective students may apply to the Graduate Program in Astronomy through the TAMU Office of Graduate Studies. Students will be required to meet all requirements for admission to graduate studies at TAMU. Specifically, the overall graduate admission criteria are based on the entire record of the applicant and availability of departmental resources. Admission to the Graduate Program in Astronomy will be based upon the following criteria:
(1) Hold a four-year baccalaureate degree from a college or university of recognized standing (i.e., a degree recognized as equivalent to a baccalaureate degree from an accredited institution in the U.S.), overall transcript evaluation, and grade point ratio in the last 60 hours of coursework.

(2) Show promise of intellectual and academic ability, a minimum of three letters of recommendation from persons capable of judging the applicant's capabilities, and an evaluation of the Statement of Purpose essay.

(3) Submit, with application, scores on the General Test and the Physics Test of the Graduate Record Examination (GRE), which will be evaluated in a manner that complies with House Bill 1641.

(4) Additionally at the program level, an applicant from another country seeking admission to graduate studies must demonstrate the ability to read, write, speak, and understand the English language. Prospective students whose native language is not English must take the Test of English as a Foreign Language (TOEFL), which is administered by the Educational Testing Service in over 200 centers around the world. All applicants from non-English-speaking countries must present a computer-based TOEFL score of at least 213 to be admitted to graduate studies at the University.

Since the faculty anticipates initial acceptance of only 2 to 4 students into the program per year, standards of acceptance will be highly competitive. Students who enter the graduate degree program upon completion of their Bachelor of Science degree and plan to pursue a Doctor of Philosophy degree may elect to either complete a Master of Science degree first or go directly into the doctorate program.

C. Degree Requirements

1. In tabular form, indicate the semester credit hour (SCH) requirements in each of the following categories applicable to the proposed degree program; include the total SCH requirements for the degree:

The graduate curricula required of students in the Graduate Programs in Astronomy are outlined below. The degree requirements as shown in Tables 1-4 for each graduate degree in astronomy include four types of courses:

(a) foundation (prerequisite/leveling) courses as needed. All incoming students will be expected to have acquired an appropriate foundation in physics and mathematics as part of their undergraduate education, including (but not limited to) two semesters of quantum mechanics, one semester of statistical mechanics, senior-level electromagnetism and mechanics, the fundamentals of statistics and data analysis, differential equations, complex calculus, and linear algebra. The graduate program advisor will review the undergraduate transcript of all students admitted to the program and identify any deficiencies. These will be remedied by enrolling and obtaining a satisfactory grade (B or better) in the equivalent undergraduate courses taught by the Physics, Math & Statistics departments at TAMU.
(b) required (core) courses: all students must enroll and obtain a satisfactory grade (B or better) in six new courses covering the fundamental knowledge in astronomy. These courses will be designated as ASTR 601 through 606. A syllabus for each of these new courses is provided in Appendix B.

(c) directed electives: all students must enroll and obtain a satisfactory grade (B or better) in two courses selected from the list of core Physics PhD courses. The selection of the courses will be done in consultation with the graduate student advisor. A list of the current Physics core courses is presented in Appendix C. In addition, all students must enroll in ASTR 685 (Journal Club) for the first four semesters of their program, and will be expected to continue to attend the Journal Club for the remainder of their stay at TAMU.

(d) free electives: students may wish to enroll in additional courses that are suited to their individual needs or to the area of research of their dissertation. These may include (but are not limited to) courses in Physics, Computer Science, Statistics, Mathematics, or other fields. Enrollment in these courses should be approved by the graduate student advisor or the thesis research supervisor.

2. **Identify and describe special requirements for the program, e.g. clinicals, field experience, internships, practicum, thesis, etc.**

All students will be required to perform research in astronomy during their first two academic years in order to gain experience in the field. Following completion of the second academic year, students will undergo a comprehensive examination to determine if the student can be advanced to doctoral candidacy. The Curriculum/Program Committee will supervise this examination. Finally, following completion of an independent research project, doctoral candidates will be required to write a doctoral dissertation and to defend this dissertation to a faculty committee. The committee will be chosen from the Physics and Astronomy faculty, with additional external members as dictated by Texas A&M University requirements.

3. **If transfer students would be admitted to the program, list articulation agreements completed, in negotiation, or planned.**

No articulation agreements currently exist, or are planned. Special cases will be reviewed initially by the Recruiting/Admissions Committee and then by the Curriculum/Program Committee.
Table 1. Doctor of Philosophy in Astronomy (entering with a BS) Degree Requirements

<table>
<thead>
<tr>
<th>PhD in Astronomy (entering with a BS) Degree Requirements</th>
<th>SCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undergraduate Prerequisite/Leveling Courses: assigned on an individual basis as needed</td>
<td>0-12</td>
</tr>
<tr>
<td>Core Courses: (syllabi listed in Appendix B)</td>
<td></td>
</tr>
<tr>
<td>ASTR601 Extragalactic Astronomy</td>
<td>3</td>
</tr>
<tr>
<td>ASTR602 Astronomical Observational Techniques and Instrumentation</td>
<td>3</td>
</tr>
<tr>
<td>ASTR603 Stellar Astrophysics</td>
<td>3</td>
</tr>
<tr>
<td>ASTR604 Cosmology</td>
<td>3</td>
</tr>
<tr>
<td>ASTR605 Galactic Astronomy</td>
<td>3</td>
</tr>
<tr>
<td>ASTR606 Radiative Processes and the Interstellar Medium</td>
<td>3</td>
</tr>
<tr>
<td>Directed Electives</td>
<td>10-12</td>
</tr>
<tr>
<td>ASTR 681 Astronomy journal club (1 cr/semester x 4 semesters)</td>
<td>4</td>
</tr>
<tr>
<td>Two of PHYS core courses (listed in Appendix C)</td>
<td>6-8</td>
</tr>
<tr>
<td>Free Electives</td>
<td>66-68</td>
</tr>
<tr>
<td>ASTR691 Thesis research (approx. 3 full years @ 24 cr/year)</td>
<td>66-68</td>
</tr>
<tr>
<td><strong>Total SCH Required for Degree</strong></td>
<td><strong>96</strong></td>
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Table 2. Master of Science in Astronomy (with Thesis) Degree Requirements

<table>
<thead>
<tr>
<th>MS in Astronomy (with Thesis) Degree Requirements</th>
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<tbody>
<tr>
<td>Undergraduate Prerequisite/Leveling Courses: assigned on an individual basis as needed</td>
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</tr>
<tr>
<td>Core Courses (syllabi listed in Appendix B):</td>
<td></td>
</tr>
<tr>
<td>ASTR601 Extragalactic Astronomy</td>
<td>3</td>
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<tr>
<td>ASTR602 Astronomical Observational Techniques and Instrumentation</td>
<td>3</td>
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<tr>
<td>ASTR603 Stellar Astrophysics</td>
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</tr>
<tr>
<td>ASTR604 Cosmology</td>
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<tr>
<td>ASTR605 Galactic Astronomy</td>
<td>3</td>
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<tr>
<td>ASTR606 Radiative Processes and the Interstellar Medium</td>
<td>3</td>
</tr>
<tr>
<td>Directed Electives:</td>
<td>10-12</td>
</tr>
<tr>
<td>ASTR681 Astronomy journal club (1 cr/sem. x 4 semesters)</td>
<td>4</td>
</tr>
<tr>
<td>Two of PHYS core courses (listed in Appendix C)</td>
<td>6-8</td>
</tr>
<tr>
<td>Free Electives:</td>
<td>2-4</td>
</tr>
<tr>
<td>ASTR691 Thesis research (1 cr/sem. x 2-4 semesters)</td>
<td>2-4</td>
</tr>
<tr>
<td><strong>Total SCH Required for Degree</strong></td>
<td><strong>32</strong></td>
</tr>
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</table>
### Table 3. Master of Science (Non-Thesis) Degree Requirements

<table>
<thead>
<tr>
<th>MS (Non-Thesis) Degree Requirements</th>
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<tr>
<td>Undergraduate Prerequisite/Leveling Courses:</td>
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<tr>
<td>assigned on an individual basis as needed</td>
<td></td>
</tr>
<tr>
<td>Core Courses (syllabi listed in Appendix B):</td>
<td>18</td>
</tr>
<tr>
<td>ASTR601 Extragalactic Astronomy</td>
<td>3</td>
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<tr>
<td>ASTR602 Astronomical Observational Techniques and Instrumentation</td>
<td>3</td>
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<tr>
<td>ASTR603 Stellar Astrophysics</td>
<td>3</td>
</tr>
<tr>
<td>ASTR604 Cosmology</td>
<td>3</td>
</tr>
<tr>
<td>ASTR605 Galactic Astronomy</td>
<td>3</td>
</tr>
<tr>
<td>ASTR606 Radiative Processes and the Interstellar Medium</td>
<td>3</td>
</tr>
<tr>
<td>Directed Electives</td>
<td>10-12</td>
</tr>
<tr>
<td>ASTR681 Astronomy journal club (1 cr/sem. x 4 semesters)</td>
<td>4</td>
</tr>
<tr>
<td>Two of PHYS core courses (listed in Appendix C)</td>
<td>6-8</td>
</tr>
<tr>
<td>Free Electives</td>
<td>6-8</td>
</tr>
<tr>
<td>ASTR685 Directed studies (2 cr/sem. x 3-4 semesters)</td>
<td></td>
</tr>
<tr>
<td><strong>Total SCH Required for Degree</strong></td>
<td>36</td>
</tr>
</tbody>
</table>

### Table 4. Doctor of Philosophy in Astronomy (entering with a MS) Degree Requirements

<table>
<thead>
<tr>
<th>PhD in Astronomy (entering with a MS) Degree Requirements</th>
<th>SCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core Courses (syllabi listed in Appendix B):</td>
<td>0-18</td>
</tr>
<tr>
<td>assigned on an individual basis as needed to fulfill Table 1 requirements</td>
<td></td>
</tr>
<tr>
<td>Directed Electives</td>
<td>0-8</td>
</tr>
<tr>
<td>Two of PHYS core courses (listed in Appendix C)</td>
<td>0-8</td>
</tr>
<tr>
<td>assigned on an individual basis as needed to fulfill Table 1 requirements</td>
<td></td>
</tr>
<tr>
<td>Free Electives</td>
<td>64</td>
</tr>
<tr>
<td>ASTR691 Thesis research (approx. 2.5 full years @ 24 cr/year)</td>
<td>64</td>
</tr>
<tr>
<td><strong>Total SCH Required for Degree</strong></td>
<td>64</td>
</tr>
</tbody>
</table>
D. Curriculum

1. Identify by prefix, number, title, and description (including prerequisites) courses to be required or elected in the proposed program. (Identify with an asterisk (*) courses added during the last three academic years, and with two asterisks (**) courses to be added if the program is authorized.

**ASTR 601. Extragalactic Astronomy. Credit Hours: 3 (3-0).** An overview of the cosmic history of the Universe, focusing on the formation and evolution of galaxies. Topics include observations of galaxies, the Local Galactic Group, galaxy groups and clusters, the large-scale distribution of galaxies, the formation of structure in the Universe, evolution of galaxy stellar populations, luminosity functions, and radio galaxies and quasars.

**ASTR 602. Astronomical Observational Techniques and Instrumentation. Credit Hours: 3 (3-0).** The theory and practice of obtaining astronomical data and modern instrument design. Astrometric, photometric, spectroscopic, and interferometric measurements of astronomical sources. Photon detection techniques across the electromagnetic spectrum. Error analysis and signal-to-noise estimates. Introduction to model fitting, goodness-of-fit estimation, and applications of non-parametric statistical techniques.

**ASTR 603. Stellar Astrophysics. Credit Hours: 3 (3-0).** Theoretical and observational studies of the internal structure, atmospheres, and evolution of stars. Topics include: thermodynamic properties of stellar interiors, nuclear processes, energy transport, stellar evolutionary models, stellar stability and pulsations, and chemical enrichment processes.

**ASTR 604. Cosmology. Credit Hours: 3 (3-0).** An up-to-date summary of the study of the Universe. The course will discuss the physical processes that form the bases of modern cosmological research programs. A wide range of physical processes will be introduced: supernova explosions, the bending and lensing of light by gravitational field, the formation of large scale structures, and the nature of the cosmic microwave background.

**ASTR 605. Galactic Astronomy. Credit Hours: 3 (3-0).** An overview of the content and structure of our Milky Way Galaxy. The course will discuss the physical properties of stars and gas constituents of the Galaxy, the space distribution of stars and chemical elements, large-scale structure and kinematics, and formation scenarios. Comparison of formation models to modern observational results will also be included.

**ASTR 606. Radiative Processes and the Interstellar Medium. Credit Hours: 3 (3-0).** The theory and observation of low density plasmas in the interstellar medium, spectral line formation in active and normal galaxies, and the intergalactic medium. Thermodynamic and statistical mechanical description of the interstellar medium, The measurement of galactic chemical abundances. Study of supernovae, planetary nebulae, HII regions, and quasars. The evolution of the chemical elements and star formation in the Universe. X-ray and radio properties of galaxies and galaxy clusters.
**ASTR 681. Seminar in Astronomy Journal Club. Credit Hours: 1 (0-1).** Presentation and discussion of recently-published research in Astronomy and related areas.

**ASTR 685. Directed Studies in Astronomy. Credit Hours: 2 (0-2).** Directed studies consisting mainly of literature-based research, geared towards Master’s (Non-Thesis option) students.

**ASTR 691. Thesis Research. Credit Hours: 1 to 24 (0-1 to 24) Research leading to a Master’s or PhD Thesis.**

In addition, students will be required to enroll in two Physics courses, to be selected from the list presented in Appendix C.

2. *If the program design includes multiple curricula (concentrations, emphases, options, specializations, tracks, etc.), identify courses unique to each alternative.*

Multiple curricula are not planned.

3. *Provide a semester-by-semester projection for offering of the required and prescribed courses during the first 5 years.*

A projection of astronomy curriculum graduate offerings for the first five academic years of the program (anticipated start date in the Fall of 2010) is shown in Table 5. Courses will repeat roughly every two years. On the semesters where only one astronomy course is offered, students will be required to enroll in one of the Physics courses listed in Appendix C. These courses are offered every semester by the Department as part of the core curriculum for the Physics PhD.

**Table 5. Projected ASTR Course Offerings**

<table>
<thead>
<tr>
<th>Years:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fall</td>
<td>Spr</td>
<td>SS</td>
<td>Fall</td>
<td>Spr</td>
</tr>
<tr>
<td>ASTR 601**</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>ASTR 602**</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>ASTR 603**</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>ASTR 604**</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
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<tr>
<td>ASTR 605**</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>ASTR 606**</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

4. *Describe arrangements that would serve nontraditional students, e.g., non-traditionally scheduled classes, delivery of instruction by telecommunications and/or off-campus instruction sites, library services, student advisement, etc., if applicable.*

No programmatic arrangements for such instruction are planned as of yet.
5. If the general education/core curriculum component of the proposed program differs from that required for all or most other undergraduate programs at the institution, indicate how and why.

This does not apply to the proposed graduate program.

E. Supporting Fields.

1. Identify existing programs and support areas in your institution which would complement this program; describe the relationship of each to the proposed program.

TAMU currently offers two complementary graduate degrees (M.S. and Ph.D.) in Physics and Applied Physics in the same Department as the proposed program.

2. If the existing programs or supporting fields would require updating or expansion because of the new program, explain how and why.

No updating or expansion would be needed.

F. Effect on Existing Programs.

1. Describe how existing courses would be affected by enrollment generated in the proposed program, including but not limited to, the potential need for additional sections or increased class sizes, faculty, library resources, equipment, supplies, and/or space.

Since we will require our graduate students to take two Physics core courses, the sole change in these courses will be the additional enrollment of graduate students recruited into the program. This would constitute an enrollment increase of potentially 3 students or less per course per offering. No additional sections will be required. We will create six new graduate courses in Astronomy (described in D.1 above) to provide adequate training for Astronomy graduate students.

2. For a graduate program, describe how related undergraduate program would be affected by enrollment in the proposed program, including changes anticipated in the rank and/or credentials of faculty teaching in the undergraduate program, and use of graduate student Teaching Assistants, Graduate Assistants, Assistant Instructors, etc., and their credentials. Provide evidence that faculty (full-time, part-time or TA's) in the proposed program, or who would replace current faculty reassigned to the proposed program, would meet Southern Association minimum standards for credentials and experience.

There will be no impact on undergraduate instruction thanks to the recent increase in the number of faculty in Astronomy. In fact, the total number of sections in undergraduate astronomy courses has been steadily increasing every semester over the past two years and will continue to do so as additional faculty are recruited. All astronomy faculty members in
the Department hold graduate faculty status and exceed the Southern Association minimum standards (Master’s degree and expertise in the field). Graduate student Teaching Assistants will only be used in a supporting role for undergraduate courses (recitations, office hours and proctoring/grading of exams).

G. Accreditation.

1. If there is a professional program procedure in this field, attach current standards.

This is not applicable to the proposed program.

2. State intention regarding accreditation.

Accreditation will be through the Southern Association of Colleges and Schools (SACS) concomitant with the accreditation process that occurs every 10 years for Texas A&M University.

III. EVALUATION

A. Describe planned procedures for evaluation of this program and its effectiveness in the first five years of the program, including admission and retention rates, program outcomes, assessments, placement of graduates, changes of job market need/demand, ex-student/graduate survey, or other procedures. How would evaluations be carried out?

1. Student Progress Assessment
Close supervision of the progress of each graduate student admitted into the program is planned. This will be accomplished by assigning specific faculty members to monitor each student’s progress in coursework, research, attendance at journal club, colloquia, etc. There will also be an overall Graduate Advisor who will supervise the entire program. Astronomy faculty meetings will be held every semester specifically to discuss student progress and identify problems as early as possible.

2. Program Evaluations and Assessment
We will evaluate the success of the program by assessing the fraction of admitted students who obtain a PhD (typically high for Astronomy graduate programs) and close monitoring of future success and job placement of all program graduates. This will be minimal administrative effort, given the relatively small program size we anticipate. We note that 1-2 post-doctoral positions (each lasting 2-3 years) is typical in astronomy, so program evaluation will extend beyond five years.
IV. PROGRAM NEED/DEMAND

A. Identify similar programs.

1. At Texas public and independent universities
There are currently three other PhD programs in Texas that are similar to that proposed here. The University of Texas at Austin has an Astronomy Department that grants M.S. and Ph.D. degrees in Astronomy. Rice University also offers a PhD in Physics that can result from astronomical research activities. Texas Christian University offers a PhD in Astrophysics within the Department of Physics and Astronomy.

2. At out of state universities
There are approximately 50 programs in the United States that offer graduate degrees in Astronomy, Astrophysics, or Physics with Astronomy-related emphasis. Of these, the programs at Johns Hopkins, UCLA, Michigan State, Dartmouth, UNC-Chapel Hill, Minnesota, and SUNY Stony Brook most closely resemble the program we propose (a strong Astronomy program inside of a larger Physics & Astronomy Department).

B. Describe justification for the proposed program in terms of the following, as applicable:

1. Local, regional, national, and international needs (as appropriate)
Astronomy is a small professional field with wide public interest. Although there are only about 6,000 professional astronomers in North America, developments in the field regularly merit front-page mention in major newspapers, magazines, and other media outlets (for example, recently two of the Texas A&M astronomy faculty were mentioned in the New York Times). Popular level astronomy magazines (Sky & Telescope, Astronomy, Dark Sky) have paid subscriptions of more than 500,000 annually, more than nearly all other popular/hobby level science magazines combined. The small cadre of professional astronomers feed this interest at a minimal cost to society. Our goal is to create a program at Texas A&M that can contribute to the ranks of professional astronomers and help to enhance this interest at all levels.

2. The long-range academic plan of the institution
Texas A&M University has paid much attention to the idea of improving its status among the top tier of universities (Vision 2020) and, more importantly, the status of Texas in general as a top state in terms of higher education. Yet, every one of the top twenty universities in the United States has a degree-granting program in astronomy. Indeed, it is demonstrably true that all great universities in the United States have excellent astronomy research activities (Harvard, Yale, Princeton, MIT, Caltech, UC Berkeley, etc.). Thus, we expect that the establishment of a strong astronomy effort at Texas A&M will help to announce to the academic community the serious effort being made to achieve these long-range academic goals.

3. Demand from prospective students.
The pool of prospective students for an astronomy graduate program is roughly 250 students per year nationally. These students are typically of uniformly excellent quality,
achieving high grades, GRE scores, and high praise in recommendation letters. We expect to compete for these students with other astronomy programs by offering an excellent faculty, productive surroundings, interesting research possibilities, and competitive stipends and support.

4. Job market needs (identify specific potential employers and supply names, addresses and phone numbers where possible).
As noted earlier in this proposal, the number of professional astronomers in North America is approximately 6000. The job market for Astronomy PhD recipients is healthy, with a good balance between PhD production and vacant positions. In almost all cases, a graduating student will first be employed in a temporary post-doctoral position. The amount of time spent as a post-doc varies, but there is usually a minimum of three years and a maximum of six years before a more permanent position is attained. These are usually in academia (research university or college), or in a federally-funded (NASA, NSF, DoE, DoD) laboratory or observatory. Some graduates find astronomy-related employment in the private sector, either at optical or space sciences companies. Finally, as is the case with other physical sciences, the problem-solving abilities obtained as part of a PhD education are highly regarded by management consulting and investment firms. Hence, a small fraction of graduates find employment in the business sector.

Specific employers of Astronomy PhD recipients (supervised by current Texas A&M astronomy faculty) include the following institutions:

- The Observatories of the Carnegie Institution of Washington, Pasadena, CA 91101
- Fermi National Accelerator Laboratory, Batavia, IL 60510
- NASA Infrared Processing & Analysis Center, Caltech, Pasadena, CA 91125
- National Optical Astronomy Observatory, Tucson, AZ 85726
- Space Telescope Science Institute, Baltimore, MD 21218
- Vanderbilt University, Nashville, TN
- Harvard-Smithsonian Center for Astrophysics, Cambridge, MA
- University of Colorado, Boulder, CO

5. Educational and cultural needs of the community
Astronomy generates wide public interest and is well known as an excellent vehicle to stimulate science interest in K-12 students and the general public. We anticipate that the astronomy program will establish contacts in the Brazos Valley and the rest of Texas and develop public outreach activities in schools, community events, etc. Indeed, this process is already underway, with Texas A&M astronomy faculty scheduled to give many public talks next year at various Texas locations. We anticipate that astronomy graduate program participants will form an additional cadre of people capable of adding to this capability.
V. PROGRAM POTENTIAL

A. Estimate the cumulative headcount and full time equivalent (FTE) enrollment for each of the first five years (majors only, considering expected attrition and graduation) and indicate the number expected to be new to the institution each year.

<table>
<thead>
<tr>
<th>Table 6. First Five-Year Enrollment Projections for Master of Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yr1</td>
</tr>
<tr>
<td>Transfers from Other Graduate Programs</td>
</tr>
<tr>
<td>Returning Students from the Prior Year</td>
</tr>
<tr>
<td>New First-Year Students</td>
</tr>
<tr>
<td>Total Graduate Enrollment this Year</td>
</tr>
<tr>
<td>Attrition During this Year</td>
</tr>
<tr>
<td>Graduated During this Year</td>
</tr>
<tr>
<td>Total Students at Year End</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 7. First Five-Year Enrollment Projections for Doctor of Philosophy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yr1</td>
</tr>
<tr>
<td>Transfers from Other Graduate Programs</td>
</tr>
<tr>
<td>Returning Students from the Prior Year</td>
</tr>
<tr>
<td>New First-Year Students</td>
</tr>
<tr>
<td>Total Graduate Enrollment this Year</td>
</tr>
<tr>
<td>Attrition During this Year</td>
</tr>
<tr>
<td>Graduated During this Year</td>
</tr>
<tr>
<td>Total Students at Year End</td>
</tr>
</tbody>
</table>

B. Explain assumptions used in making these estimates.

We assume that we will recruit an elite group of students each year into the Graduate Program in Astronomy, without becoming a drain on students from existing programs.

Several assumptions have been used to make the estimates reflected in Tables 6 and 7:

1. All admitted students are full time.
2. MS students will typically finish their program in two years
3. PhD students will typically finish in 5 years.
4. When the program reaches a steady state, an average of 3 new PhD students and 1 new MS student will be admitted annually.
VI. RESOURCES

A. Personnel

1. Describe any personnel additions or changes in the past three years made in anticipation of the program.
The Faculty Reinvestment Plan, with a goal of recruiting some 400 new faculty members to Texas A&M University included seven astronomers hired into the Department of Physics. All will be involved in the proposed graduate program.

2. Indicate for the first five years the cumulative number of FTE personnel who would be involved in delivery of the program in each of the following categories.
With the adoption of the proposed program, administrative, IT and clerical FTEs will be required for delivery of the program. The addition of ASTR 601 through 606 will require faculty FTEs to teach these astronomy core courses. The average class enrollments are expected to be a minimum of six students (all first and second year astronomy students) with some additional Physics PhD students taking the courses as electives. It is expected that there will be no need for additional sections of existing courses or additional faculty and only a modest need for increases in supplies and materials. With these expectations in mind, the following personnel needs are expected.

   a. release time for administration and other services, 0.625 FTE
   b. full-time faculty, 4.875 FTE
   c. part-time faculty, none
   d. graduate teaching assistants (support for undergraduate courses), 18 FTE
   e. clerical/IT support staff, 10 FTE
   f. others: student workers for clerical support: 5 FTE

The proposed program will annually award about 9 graduate teaching assistantships to qualified students who have been admitted to the graduate program. These will be nominally reserved for 1st, 2nd and 3rd year students who will serve as TAs for ASTR 101. The program will additionally award graduate assistantship non-teaching (GANT), or graduate assistantship research (GAR) positions.

Headcounts and the annual numbers used to calculate the five-year cumulative numbers of FTE personnel who will be involved in the delivery of the proposed program as listed above are shown below in Tables 8 and 9.
### Table 8. Projected Headcounts of Personnel Assignments, Years 1-5

<table>
<thead>
<tr>
<th></th>
<th>Yr1</th>
<th>Yr2</th>
<th>Yr3</th>
<th>Yr4</th>
<th>Yr5</th>
<th>Total</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Released time for Administration</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>Graduate advisor</td>
</tr>
<tr>
<td>Full-Time Faculty</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Professor</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>For ASTR 601-606</td>
</tr>
<tr>
<td>Associate Professor</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>For ASTR 601-606</td>
</tr>
<tr>
<td>Assistant Professor</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>8</td>
<td>GATs for ASTR 101</td>
</tr>
<tr>
<td>Lecturer</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Coordinator &amp; IT support</td>
</tr>
<tr>
<td>Part-Time Faculty</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Graduate Student Assistants</td>
<td>3</td>
<td>6</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>36</td>
<td>GATs for ASTR 101</td>
</tr>
<tr>
<td>Clerical/Support Staff</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>10</td>
<td>Coordinator &amp; IT support</td>
</tr>
<tr>
<td>Other: Student Workers</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>10</td>
<td>Clerical support</td>
</tr>
</tbody>
</table>

### Table 9. Projected Full-Time Equivalent (FTE) Personnel Assignments, Years 1-5

<table>
<thead>
<tr>
<th></th>
<th>Yr1</th>
<th>Yr2</th>
<th>Yr3</th>
<th>Yr4</th>
<th>Yr5</th>
<th>Total</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Released Time for Administration</td>
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<td>0.125</td>
<td>0.125</td>
<td>0.125</td>
<td>0.125</td>
<td>0.625</td>
<td>adv. = .125</td>
</tr>
<tr>
<td>Full-Time Faculty</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Professor</td>
<td>0.375</td>
<td>0.375</td>
<td>0.375</td>
<td>0.375</td>
<td>0.375</td>
<td>1.875</td>
<td>each = .375 *</td>
</tr>
<tr>
<td>Associate Professor</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Assistant Professor</td>
<td>0.375</td>
<td>0.750</td>
<td>0.750</td>
<td>0.375</td>
<td>0.750</td>
<td>3.000</td>
<td>each = .375 *</td>
</tr>
<tr>
<td>Lecturer</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Part-Time Faculty</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Graduate Student Assistants</td>
<td>1.500</td>
<td>3.000</td>
<td>4.500</td>
<td>4.500</td>
<td>4.500</td>
<td>18.000</td>
<td>each = .5</td>
</tr>
<tr>
<td>Clerical/Support Staff</td>
<td>2.000</td>
<td>2.000</td>
<td>2.000</td>
<td>2.000</td>
<td>2.000</td>
<td>2.000</td>
<td>each = 1</td>
</tr>
<tr>
<td>Other: Student Workers</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
<td>5.000</td>
<td>each = .5</td>
</tr>
<tr>
<td>Total FTE per year</td>
<td>5.375</td>
<td>7.250</td>
<td>8.750</td>
<td>8.375</td>
<td>8.750</td>
<td>38.500</td>
<td></td>
</tr>
</tbody>
</table>

* half-time for nine months rather than 12 months
3. List current faculty members, indicating highest earned degree/institution, field of study, current teaching and research assignments, dates of appointment, and anticipated contribution to the program. Specify course(s) each faculty member would teach.

- **Nicholas Suntzeff**: PhD, University of California at Santa Cruz  
  - Field of study: Supernovae and Cosmology  
  - Current teaching assignment: ASTR 101  
  - Date of appointment: March 2006  
  - Program contribution: Graduate teaching & research supervision  
  - Courses to teach: ASTR 101, 314, 605, 606

- **Darren DePoy**: PhD, University of Hawaii at Manoa  
  - Field of study: Astronomical instrumentation and Cosmology  
  - Current teaching assignment: ASTR 101  
  - Date of appointment: July 2008  
  - Program contribution: Graduate teaching & research supervision  
  - Courses to teach: ASTR 101, 314, 602, 605

- **Kevin Krisiunas**: PhD, University of Washington at Seattle  
  - Field of study: Supernovae and Cosmology  
  - Current teaching assignment: ASTR 101  
  - Date of appointment: November 2006  
  - Program contribution: Undergraduate teaching & research supervision  
  - Courses to teach: ASTR 101, 314, 606

- **Lucas Macri**: PhD, Harvard University  
  - Field of study: Stellar populations, distance indicators & Cosmology  
  - Current teaching assignment: ASTR 101  
  - Date of appointment: June 2008  
  - Program contribution: Graduate teaching & research supervision  
  - Courses to teach: ASTR 101, 314, 603, 605

- **Casey Papovich**: PhD, Johns Hopkins University  
  - Field of study: Galaxy evolution and Cosmology  
  - Current teaching assignment: ASTR 314  
  - Date of appointment: April 2008  
  - Program contribution: Graduate teaching & research supervision  
  - Courses to teach: ASTR 101, 314, 601, 604

- **Kim-Vy Tran**: PhD, University of California at Santa Cruz  
  - Field of study: Galaxy evolution and Cosmology  
  - Current teaching assignment: ASTR 101  
  - Date of appointment: January 2009  
  - Program contribution: Graduate teaching & research supervision  
  - Courses to teach: ASTR 101, 314, 601, 604

- **Lifan Wang**: PhD, University of Science and Technology of China  
  - Field of study: Supernovae and Cosmology  
  - Current teaching assignment: PHYS 689  
  - Date of appointment: June 2006  
  - Program contribution: Graduate teaching & research supervision  
  - Courses to teach: ASTR 101, 314, 601, 605
B. Library

1. List any library holdings added in the past three years in anticipation of this program.
The Texas A&M University Libraries added over 1,453 items to their resources in support of astronomy/astrophysics over the past 3 years. This includes both print and electronic resources, both books and journals. The astronomy collection grew at a rate of 24% during this time period.

2. Describe library holdings relevant to the proposed program, noting strengths and weaknesses. If there are guidelines for the discipline, do current holdings meet or exceed standards. Describe planned actions that would maintain strengths and/or remedy weaknesses.
The Texas A&M University Libraries has a very strong collection of resources relevant to astronomy. In addition to the numbers given below for core subject area, there are considerable resources available in physics and chemistry that are also relevant to the program.

Table 10. Call Number Range Count of Print Titles Relevant to the Proposed Astronomy Graduate Program Held by the Texas Libraries, Fall 2009

<table>
<thead>
<tr>
<th>Classification Number (Schedule)</th>
<th>Subject Description</th>
<th>Number of Titles</th>
</tr>
</thead>
<tbody>
<tr>
<td>QB (Library of Congress)</td>
<td>Astronomy and Astrophysics</td>
<td>7,488 (books and journals)</td>
</tr>
<tr>
<td></td>
<td>Astronomy Total Titles:</td>
<td>7,488</td>
</tr>
</tbody>
</table>

There are also substantial electronic resources (both monographs and journals) readily available in full text via the Internet from the University Libraries’ website. The items counted above include only those classified in the core areas of astronomy and astrophysics. Students will also have access to the other 3.7+ million items held by the libraries. The libraries also subscribe to over 50,000 print and electronic journals.

A comparison of the Texas A&M University Libraries astronomy collections with its peers in the Association of Research Libraries puts TAMU in the top third of research libraries nationwide for astronomy collections. Well-supported collection budgets have allowed the Texas A&M University Libraries to continue expanding and developing collections. Texas A&M University Libraries has become a leader in delivering full text electronic resources to their users.

3. Describe cooperative library arrangements that would be available to students in this program.
The Texas A&M University Libraries belong to several consortia that benefit students in advanced degree programs. The larger of these is the Big 12 Plus. This consortium has at present 30 member universities. Recently, Arizona, Arizona State, Oregon, Oregon State, Southern California, Washington and Washington State have joined the Big 12 Plus. These additions along with the traditional Big 12 universities make this a major consortium.
The Libraries belong to several interlibrary loan consortia that help faculty and students acquire materials not available on campus. In particular, TexShare is a group of Texas academic and public libraries share holdings via interlibrary loan and permit the exchange of borrowing privileges. Finally the active participation of the libraries in Internet communications with other libraries insures that astronomy students can locate and use materials from institutions and agencies around the world.

4. **Provide library director’s assessment of library resources necessary for the proposed program.**
   A letter of support from Dr. Colleen Cook, Dean of Libraries, is included in Appendix E.

**VII. COSTS**

On the attached forms, provide estimates of new costs to the institution related to the proposed program(s) and provide information regarding sources of the funding that will defray those costs.
COSTS TO THE INSTITUTION OF THE PROGRAM/ADMINISTRATIVE CHANGE

*Note:* Use this chart to indicate the dollar costs to the institution that are anticipated from the change requested.

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Cost Sub-Category</th>
<th>before approval year</th>
<th>1st year</th>
<th>2nd year</th>
<th>3rd year</th>
<th>4th year</th>
<th>5th year</th>
<th>TOTALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty Salaries for ASTR 601-606</td>
<td>New</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(2 or 3 faculty at 1/2 time each for 9</td>
<td>Reallocated</td>
<td>122,364</td>
<td>84,023</td>
<td>129,816</td>
<td>133,710</td>
<td>91,815</td>
<td>141,853</td>
<td>703,582</td>
</tr>
<tr>
<td>Program Administration: Graduate advisor</td>
<td>New</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>(1/8 time for 12 mos. = 0.125 FTE)</td>
<td>Reallocated</td>
<td>13,596</td>
<td>14,004</td>
<td>14,424</td>
<td>14,857</td>
<td>15,302</td>
<td>15,761</td>
<td>87,945</td>
</tr>
<tr>
<td>Graduate Assistants (1/2 time for 9 months; 3-9 per year; see Table 8)</td>
<td>New</td>
<td>0</td>
<td>72,069</td>
<td>148,462</td>
<td>229,374</td>
<td>236,255</td>
<td>243,343</td>
<td>999,474</td>
</tr>
<tr>
<td></td>
<td>Reallocated</td>
<td>69,970</td>
<td>72,069</td>
<td>148,462</td>
<td>229,374</td>
<td>236,255</td>
<td>243,343</td>
<td>999,474</td>
</tr>
<tr>
<td>Staff: Program coordinator (1.0 FTE)</td>
<td>New</td>
<td>0</td>
<td>60,000</td>
<td>61,800</td>
<td>63,654</td>
<td>65,564</td>
<td>67,531</td>
<td>318,548</td>
</tr>
<tr>
<td>IT support staff (0.5 FTE)</td>
<td>New</td>
<td>0</td>
<td>50,000</td>
<td>51,500</td>
<td>53,045</td>
<td>54,636</td>
<td>56,275</td>
<td>265,456</td>
</tr>
<tr>
<td>Student workers (1.0 FTE)</td>
<td>New</td>
<td>0</td>
<td>17,810</td>
<td>18,344</td>
<td>18,895</td>
<td>19,461</td>
<td>20,045</td>
<td>94,556</td>
</tr>
<tr>
<td></td>
<td>Reallocated</td>
<td>10,000</td>
<td>10,000</td>
<td>10,300</td>
<td>10,600</td>
<td>10,900</td>
<td>11,250</td>
<td>63,050</td>
</tr>
<tr>
<td>Supplies &amp; Materials</td>
<td>Reallocated</td>
<td>0</td>
<td>10,000</td>
<td>20,000</td>
<td>30,000</td>
<td>31,000</td>
<td>32,000</td>
<td>120,000</td>
</tr>
<tr>
<td>Library &amp; IT Resources</td>
<td>Reallocated</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Equipment</td>
<td>None</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other:</td>
<td>None</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TOTALS</td>
<td>New</td>
<td>0</td>
<td>127,810</td>
<td>131,644</td>
<td>135,594</td>
<td>139,661</td>
<td>143,851</td>
<td>678,561</td>
</tr>
<tr>
<td></td>
<td>Reallocated</td>
<td>215,930</td>
<td>190,096</td>
<td>323,002</td>
<td>418,541</td>
<td>384,272</td>
<td>442,208</td>
<td>1,974,050</td>
</tr>
</tbody>
</table>

Explanations: 1 FTE = 100% employment for 12 months. Assumed rate of inflation: 3%
ANTICIPATED SOURCES OF FUNDING

Note: Use this chart to indicate the dollar amounts anticipated from various sources. Use the reverse side of this form to specify as completely as possible each non-formula funding source.

*For more information, please refer to the accompanying Anticipated Sources of Funding:
Explanatory Notes and Examples.

<table>
<thead>
<tr>
<th>Funding Category</th>
<th>1st Year</th>
<th>2nd Year</th>
<th>3rd Year</th>
<th>4th Year</th>
<th>5th Year</th>
<th>Five-Year Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Formula Income</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>II. Other State Funding</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>III. Reallocation of Existing Resources*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV. Federal Funding (In-hand only)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V. Other Funding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TOTALS**
**NON-FORMULA SOURCES OF FUNDING**

*Note:* Use this form to specify as completely as possible each of the non-formula funding sources for the dollar amounts listed on the reverse side of this form.

<table>
<thead>
<tr>
<th>Funding Category</th>
<th>Non-Formula Funding Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>II. Other State Funding*</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>III. Reallocation of Existing Resources*</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>IV. Federal Funding*</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>V. Other Funding*</td>
<td></td>
</tr>
</tbody>
</table>

*For more information, please refer to the accompanying *Anticipated Sources of Funding: Explanatory Notes and Examples*
APPENDIX A

Visiting Committee Report To Establish A Research Area in Astronomy

October 17, 2003

There has never been a more interesting time in the history of cosmology and astrophysics than the present.

(1) Texas A&M currently has no program in the area of astronomy, cosmology, and astrophysics. It is unimaginable that Texas A&M will become a "top ten" public university without such a program. In the strategic plan for Texas A&M University, the proposed program in observational cosmology and astronomy should therefore be one of the top priorities.

(2) To build a program in this area will require strong support from the university. There is now intense competition for the best people, since there is a widespread perception that cosmology/astronomy is currently an extraordinarily exciting area of science.

(3) Two well-endowed chairs may be sufficient, but a total of four positions is not. A more desirable number of positions is eight, consistent with other present initiatives (e.g. Stanford University).

(4) Undertaking some initiatives immediately is crucial. A program of visitors, lectures, conferences, and other activities will help to start the program.

(5) There are three possible models for how a strong program might be started.

Model 1: Use endowed positions and other resources to recruit outstanding people who are, e.g., current or potential members of the National Academy of Sciences. To attract such people will require perhaps $10 million for endowed chairs and start-up money. This is consistent with other initiatives, such as that of the Kavli Institute.

Model 2: Seek out targets of opportunity at both the junior and senior level. Younger people may take a decade to develop mature research programs, but they may be more movable from their current institutions. There are a wide variety of exciting projects currently being planned that will pay off on the time scale of a decade, with obvious examples being the James Webb Space Telescope (JWST) and the Supernova Acceleration Probe (SNAP).

Model 3: Become a major player by buying into a new facility, e.g. the 20 meter telescope currently being built by the Carnegie Observatories. This would cost of the order of perhaps $50 million.

(6) Interactions involving a "Texas astronomy triangle" (with Rice and especially the University of Texas at Austin) are strongly encouraged. Texas A&M astronomers will be welcome to use the McDonald Observatory (and may even be legally entitled to use this facility). Interactions with
NASA are also encouraged, and there is a natural connection with JPL through the Texas A&M Aerospace Department.

(7) One option worth noting is the possibility of building an instrument (e.g. an infrared camera or spectrograph) as the Texas A&M contribution to a larger project, perhaps in collaboration with the College of Engineering. Such an instrument for a 20-30 m telescope might cost several tens of millions of dollars, but would be a major contribution on the part of the university with major impact. Another possibility is a role in a relatively small but innovative telescope like that used in the Sloan Digital Sky Survey, or an automated observatory for transient objects such as gamma ray bursters, which might fit in a campus parking lot and yet observe these brightest of all objects across cosmological distances.

(8) Despite the very competitive climate for hiring the best people in this area, some teams are fairly large, and there are indications that some people may be movable with enough incentives. In particular, there may be young people who would like to move to positions of leadership, or to university positions.

(9) The connection with the Mitchell Institute for Fundamental Physics and Stephen Hawking is very valuable, and the eight positions envisioned above should include observationally oriented theorists. These theorists can span the gap between the abstract theories of Hawking and the current group in superstring theory, on the one hand, and the theoretical interpretation of the observations, on the other. The new theorists should be people with vision and ideas, and not just data analysts. Many universities, including the University of Pennsylvania, the University of California at Davis, Stanford University, and the University of Texas at Austin, have initiated new programs in astronomy and cosmology with the hiring of such theorists, and this might well be appropriate for Texas A&M also.

(10) Texas A&M already has a strong group in optics, and optical techniques (including infrared etc.) are very important in observational cosmology and astronomy. Texas A&M also has a strong high-energy group, whose experimentalists have helped to create a good infrastructure (machine and electronics shops, high bay area with crane, etc.). Interactions between the existing physics programs and the new astronomy/cosmology program are encouraged.

(11) The committee does not recommend any particular area, since there are there are many exciting possibilities and emerging programs. In the words of one panelist, "This is a target-rich environment".

(12) An astronomy program is not just a way to put the university on the map as a top research institution. Astronomy is also of great interest to the public and is a wonderful way to interest young people in science. The people who are recruited for this program will teach astronomy to a large number of Texas A&M undergraduate students. The program thus fits in perfectly with all of the university's main priorities.
APPENDIX B

Astronomy Course Syllabi

Short descriptions of each course (suitable for course catalog) are presented first, followed by full syllabi for each course.

Astronomy 601: Extragalactic Astronomy
Description
This course gives an overview of the cosmic history of the Universe, focusing on the formation and evolution of galaxies. Topics include observations of galaxies, the Local Galactic Group, galaxy groups and clusters, the large-scale distribution of galaxies, the formation of structure in the Universe, evolution of galaxy stellar populations, luminosity functions, and radio galaxies and quasars.

Course Information
Credit Hours: 3
Lab Hours: 0
Prerequisites: Approval of the instructor

Astronomy 602: Astronomical Observing Techniques and Instrumentation
Description

Course Information
Credit Hours: 3
Lab Hours: 0
Prerequisites: Approval of the instructor

Astronomy 603: Stellar Astrophysics
Description
Stars are studied from both theoretical and observational points of view to understand their internal structure, atmospheres, and evolution. Topics include: thermodynamic properties of stellar interiors, nuclear processes, energy transport, stellar evolutionary models, stellar stability and pulsations, and chemical enrichment processes.

Course Information
Credit Hours: 3
Lab Hours: 0
Prerequisites: Approval of the instructor
Astronomy 604: Cosmology  
*Description*  
This course will give an up-to-date summary of the forefront of modern cosmology. As one of the most exciting scientific area, Cosmology is rapidly advancing and producing amazing discoveries that are revolutionizing our view of the Universe. The most recent examples include the discovery of the presence of dark matter and dark energy in the Universe. Even greater advancement is expected as several major experimental programs are being planned in the coming years, which attempt to more precisely measure the mass and energy content of the Universe. This course will discuss the physical processes that form the bases of these programs. A wide range of physical processes will be introduced: supernova explosions, the bending and lensing of light by gravitational field, the formation of large scale structures, and the nature of the cosmic microwave background.

*Course Information*  
Credit Hours: 3  
Lab Hours: 0  
Prerequisites: Approval of the instructor

Astronomy 605: Galactic Astronomy  
*Description*  
An overview of the content and structure of our Milky Way Galaxy. The course will discuss the physical properties of stars and gas constituents of the Galaxy, the space distribution of stars and chemical elements, large-scale structure and kinematics, and formation scenarios. Comparison of formation models to modern observational results will also be included.

*Course Information*  
Credit Hours: 3  
Lab Hours: 0  
Prerequisites: Approval of the instructor

Astronomy 606: Radiative Processes in the Interstellar Medium  
*Description*  
The theory and observation of low density plasmas in the interstellar medium, spectral line formation in active and normal galaxies, and the intergalactic medium; thermodynamic and statistical mechanical description of the ISM; the measurement of galactic chemical abundances; supernovae, planetary nebulae, HII regions, quasars; evolution of the chemical elements and star formation in the Universe; X-ray and radio properties of galaxies and galaxy clusters.

*Course Information*  
Credit Hours: 3  
Lab Hours: 0  
Prerequisites: Approval of the instructor
Astronomy 601: Extragalactic Astronomy

Purpose
This course provides an overview of observations of galaxies in the Universe. The overview will concentrate on our understanding of the formation and evolution of galaxies and large-scale structures in the Universe both from a theoretical and observational perspective.

Course Description
Specific topics will include the history of extragalactic astronomy, the formation of structure in the early Universe, and the formation and evolution of galaxies. The course will discuss the distribution of the galaxy properties, including galaxy number counts and luminosity functions, and how these relate to galaxy evolution. There will be a discussion of the evolution of galaxy stellar populations, both within galaxies and over time. The course will discuss galaxy groups and galaxy clusters, and the effects of these environments on galaxy evolution. There will be a discussion of understanding the physical conditions in galaxies using spectroscopy. The course will also include an overview of active galaxies (radio galaxies, quasars, other AGN) and their relationship to galaxies and galaxy evolution.

Course Materials
The course will use primarily review articles from the literature, as well as seminal literature articles. Course handouts and notes will also be available.

Course Grade
The course grade will be assigned on the basis of exam performance (60%), assigned homework (30%), and in class participation (10%).

Exams
There will be two in-class exams (mid-term and final) over material presented in the course lectures. Each will contain short-answer, essay questions, and problems that will require calculation and quantitative estimates.

Homework
There will be homework problems assigned throughout the semester.

ADA Policy
The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring special accommodation, please contact the Department of Student Life, Services for Students with Disabilities, in Room 126 of the Koldus Building or call 845-1637.
Honor Code
Texas A&M University assumes that all students enroll in its programs with a serious learning purpose and expects them to be responsible individuals who demand of themselves high standards of honesty and personal conduct. All students are expected to behave at all times with respect and courtesy toward their fellow students and instructors and are to have the highest standards of honesty and integrity in their academic performance. Any behavior which disrupts the classroom learning environment or any attempt to present work that the student has not actually prepared as their own work, or to pass an examination by improper means, is regarded as a serious offense. The minimum penalty for such an offense is a failing grade for this course. Aiding and abetting the above behavior is also considered a serious offense resulting in equally severe penalties.

I consider it a privilege to work with students of such character as that of Aggies. The Honor Code sets Texas A&M apart from other universities, and you should be proud of the standard this sets. I expect that you will abide by the Aggie Code of Honor:

The Aggie Honor Code: An Aggie does not lie, cheat or steal, or tolerate those who do

Further information regarding the Honor Council Rules and Procedures may be found on the web at http://www.tamu.edu/aggiehonor

Course Outline


Weeks 3-4: Composition of galaxies, stars, gas, and dust. Observations and analysis of data. Evolution of galaxy stellar populations.

Weeks 5-6: Star formation rate indicators, starburst galaxies, luminous infrared and ultraluminous infrared galaxies. The galactic interstellar medium. Interactions and mergers. Environmental effects on galaxies.

Weeks 7-9: Dark matter in galaxies, the Hubble constant and the extragalactic distance scale. Galaxy groups and galaxy clusters, and other large-scale structures, and galaxy biasing. Redshift surveys. X-ray galaxy clusters, the intergalactic medium.


Weeks 13-14: Active galactic nuclei. Quasars, radio galaxies, and the effects of AGN on galaxies and galaxy evolution. Reionization.

Astronomy 602: Astronomical Observing Techniques and Instrumentation

Purpose
This course provides an opportunity for the students to acquaint themselves with the basic techniques of how to obtain meaningful astronomical data and the principles of astronomical instrumentation. It will introduce analysis tools (IRAF, IDL, AIPS, etc.) and statistical techniques (correlation, regression, $\chi^2$, non-parametric) that are commonly used in astronomical research. Course participants will also learn to use a telescope and modern astronomical detector systems in a night-time research setting.

Course Description
This course covers the theory and practice of obtaining astronomical data. Specific topics include the astrometric, photometric, spectroscopic, and interferometric measurement of astronomical sources across the electromagnetic spectrum. There is an introduction to statistical analysis of astronomical data that includes signal detection, signal-to-noise estimates, model fitting, good-of-fit estimation, and non-parametric techniques. There is discussion of the techniques and practices of the design, fabrication, assembly, test, deployment, and use of modern astronomical instruments.

Course Materials
Course handouts and notes will also be available.

Course Grade
The course grade will be assigned on the basis of exam performance (33%), assigned homework (33%), and an oral presentation describing some astronomical instrumentation system (33%).

Exams
There will be two in-class exams (mid-term and final) over material presented in the course lectures. Each will contain short-answer and essay questions that will require calculation and quantitative estimates.

Homework
There will be homework problems assigned throughout the semester. Each problem will require the student to investigate an aspect of instrument design (throughput, resolution, bandpass, etc.).

Presentation
Each student will prepare a written report and give an oral presentation on an existing or planned astronomical instrument (telescope, satellite, etc.).

ADA Policy
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Course Outline

Weeks 1-2: Introduction and Positional Astronomy (coordinate systems, spherical geometry, precession, time, right ascension and declination). Detection of a signal (signal-to-noise ratio). Statistics (sample and parent population, mean and variance, Poisson and Gaussian distributions, regression, correlation, χ², etc.)

Weeks 3-4: Non-parametric statistics: non-Gaussian distribution functions (exponential, Cauchy, beta, Student’s t, Pareto) and appropriate applications, mean and variance, non-parametric tests (Pearson’s χ², Kolmogorov-Smirnov, von Mises, Anderson-Darling, Mann-Whitney U, Spearman’s Rank, Kendall’s τ, etc.) and appropriate application. Multivariate analysis (principal component, discriminant, clustering, etc.). Time series analysis. Bayes’ theorem and examples. Fisher matrices and joint probability.

Weeks 5-6: Photon detectors (semiconductors, photodiodes, CCDs, infrared arrays, bolometers, heterodyne mixing, antenna theory). Instrumental signatures and noise sources (dark current, Johnson noise, electronic noise sources, pixel-to-pixel variations in quantum efficiency, etc.). Image analysis and data processing (IRAF, IDL, etc.). Signal-to-noise estimates and predictions.

Weeks 7-8: Optics (geometric optics, telescope design, aberrations, physical optics, elementary optical design). Atmospheric effects (refraction, seeing, observatory sites and selection criteria, extinction and
emission, adaptive optics). Practical considerations in instrumentation design (finite element and flexure analysis, cryogenic systems and cooling design, scattered and stray light analysis and control, calibration unit design, etc.)

**Weeks 9-11:** Photometry (photometric and radiometric concepts, magnitudes, photometric systems, absolute calibration, signal-to-noise calculation, etc.). Definition and design of filters. Photometry from a photographic plate. Design of a photometer (photomultiplier tubes, field lens, stops, readout electronics). Design of an imaging system (CCDs, optics, structural analysis, cryogenics, etc.).

**Weeks 12-14:** Spectroscopy: design of a slit spectrometer, dispersers (prisms, gratings, grisms, volume-phase holographic gratings), and other practical considerations. Analysis of spectroscopic data and removal of instrumental effects. Spectroscopy in the infrared. Other assorted spectroscopic techniques (Fourier transform spectroscopy, heterodyne techniques, Fabry-Perot interference, etc.). Design considerations for multi-object spectrographs (fibers, slit masks, etc.). Signal-to-noise calculations.

**Week 15:** Special topics: Radio, sub-mm, and x-ray astronomy; space astronomy and satellite design, etc. Neutrino and Gravitational Wave astronomy.
Astronomy 603: Stellar Astrophysics

**Purpose**
This course will give the students a thorough introduction to stellar astrophysics at a graduate level. It will cover the physical processes that take place in all layers of a star, from the core to the atmosphere. It will explore the temporal evolution of stars, from protostellar cores to core burning and beyond. It will discuss the stability of stellar atmospheres and pulsation mechanisms.

**Course Description**
This course covers the theoretical and observational aspects of stellar astrophysics. Specific topics include: thermodynamic properties of stellar interiors, energy sources, nuclear processes and burning stages, convective and radiative energy transport, evolutionary models, atmospheres, stability and pulsations, chemical enrichment processes and population synthesis.

**Course Materials**
Course handouts and notes will also be available.

**Course Grade**
The course grade will be assigned on the basis of exam performance (25%), assigned homework (50%), and an oral presentation (25%).

**Exams**
There will be two in-class exams (mid-term and final) over material presented in the course lectures. Each will contain short-answer and essay questions that will require calculation and quantitative estimates.

**Homework**
There will be homework problems assigned throughout the semester. Some problems will require the students to write computer programs to simulate astrophysical process associated with stars.

**Presentation**
Each student will prepare a 30-minute presentation on one of the topics covered during the course. These presentations will take place at the end of the semester.

**ADA Policy**
The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring special accommodation, please contact the Department of Student Life, Services for Students with Disabilities, in Room 126 of the Koldus Building or call 845-1637.
Honor Code
Texas A&M University assumes that all students enroll in its programs with a serious learning purpose and expects them to be responsible individuals who demand of themselves high standards of honesty and personal conduct. All students are expected to behave at all times with respect and courtesy toward their fellow students and instructors and are to have the highest standards of honesty and integrity in their academic performance. Any behavior which disrupts the classroom learning environment or any attempt to present work that the student has not actually prepared as their own work, or to pass an examination by improper means, is regarded as a serious offense. The minimum penalty for such an offense is a failing grade for this course. Aiding and abetting the above behavior is also considered a serious offense resulting in equally severe penalties.

I consider it a privilege to work with students of such character as that of Aggies. The Honor Code sets Texas A&M apart from other universities, and you should be proud of the standard this sets. I expect that you will abide by the Aggie Code of Honor:

The Aggie Honor Code: An Aggie does not lie, cheat or steal, or tolerate those who do

Further information regarding the Honor Council Rules and Procedures may be found on the web at http://www.tamu.edu/aggiehonor

Course Outline

Weeks 1-2:
Introduction and overview. Observations and techniques. HR diagram, spectroscopy, dynamics, seismology. Star formation and YSOs. Main sequence stars. Late stages of evolution. Binary systems.

Weeks 3-4:
Thermodynamic properties: ideal gas with radiation; ionized real gas; degenerate matter; equation of state. Nuclear processes and burning stages.

Weeks 5-6:
Energy transport: radiative transfer, convection

Weeks 7-8:

Weeks 9-10:
Stellar models: structure and evolution of low- and high-mass stars.

Weeks 11-12:
Stellar pulsations: radial and non-radial oscillations, helio- and astero-seismology.

Weeks 13-14: Chemical enrichment and population synthesis. Student presentations. Review for final exam.
Astronomy 604: Cosmology

Purpose
This course provides an opportunity for the students to get familiar with modern cosmological results and research. In particular, we will derive the basic equations that govern the evolution of the Universe and describe current and future experiments that aim to measure the parameters of the equations.

Course Description
This course will give an up-to-date summary of the forefront of modern cosmology. As one of the most exciting scientific area, Cosmology is rapidly advancing and producing amazing discoveries that are revolutionizing our view of the Universe. The most recent examples include the discovery of the present of dark matter and dark energy in the Universe. Even greater advancement is expected as several major experimental programs are being planned in the coming years, which attempt to more precisely measure the mass and energy content of the Universe. This course will discuss the physical processes that form the bases of these programs. A wide range of physical processes will be introduced: supernova explosions, the bending and lensing of light by gravitational fields, the formation of large scale structures, and the nature of the cosmic microwave background.

Course Materials
In-class lecture notes and handouts.

Course Grade
The course grade will be assigned on the basis of exam performance (33%), assigned homework (33%), and an oral presentation (33%).

Exams
There will be two in-class exams (mid-term and final) over material presented in the course lectures. Each will contain short-answer and essay questions that will require calculation and quantitative estimates.

Homework
There will be homework problems assigned throughout the semester.

Presentation
Each student will prepare a 30-minute presentation on a topic related to cosmology.

ADA Policy
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Honor Code
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Course Outline

Weeks 1-3: The beginning of observational cosmology: Astronomical Observations and the discovery of the expansion of the Universe.

Weeks 4-7: Basic cosmological equations: A mathematical framework is needed to describe space and time. Modern cosmology is based on Einstein's theory of general relativity. The basic theories of modern cosmology, from the Big Bang Theory, Cosmic Inflation, to perturbations that lead to the formation of the galaxies in the Universe will be introduced.

Weeks 8-9: The missing mass and the nature of dark matter.

Weeks 10-11: The Accelerated expansion of the Universe and the dark energy of the Universe.

Weeks 12-13: Methods of precision cosmology: Supernovae, Baryon Acoustic Oscillation, Weak gravitational lensing, Cosmic Microwave Background.


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Astronomy 605: Galactic Astronomy

Purpose
This course gives the students an opportunity to discuss the basic nature and structure of the constituents of our Milky Way galaxy. The distribution and motions of stars and gas in the Milky Way will be described and the implications for the formation of the Galaxy discussed. The large scale distribution of chemical abundances and the patterns seen in different kinematic populations will also be presented; the original and evolution of the observed chemical abundance patterns will also be investigated. Various models of galaxy formation will also be discussed and the implications of modern observations presented.

Course Description
An overview of the content and structure of our Milky Way Galaxy. The course will discuss the physical properties of stars and gas constituents of the Galaxy, the space distribution of stars and chemical elements, large-scale structure and kinematics, and formation scenarios. Comparison of formation models to modern observational results will also be included.

Course Materials
Course handouts and notes will also be available.

Course Grade
The course grade will be assigned on the basis of exam performance (25%), assigned homework (50%), and an oral presentation on a topic covered by the course (25%)

Exams
There will be one final exam over material presented in the course lectures. The exam will contain short-answer and essay questions that will require calculation and quantitative estimates.

Homework
There will be homework problems assigned throughout the semester.

Presentation
Each student will prepare a 30-minute presentation on a topic related to current research on Galactic astronomy.

ADA Policy
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Honor Code
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Course Outline

Weeks 1-2: Overview of the Milky Way. The historical growth of our conception of our Galaxy.

Weeks 3-4: Measurements of stars that help us understand the nature of the Milky Way: positions and coordinate systems, proper motions, parallax, radial velocities, stellar spectra, magnitudes and colors, absolute energy distributions, and a survey of astronomical catalogues and atlases.

Weeks 5-6: The physical properties of stars and the gaseous constituents of the Milky Way: stellar distances, masses and radii, analysis of stellar spectra, the systematic differences between stellar populations (spiral arms and disk populations versus halo populations), and interstellar absorption.

Weeks 7-9: The space distribution of stars and chemical elements in the Milky Way: the apparent distribution of stars, star-count analysis, the distribution of stars and the chemical elements, and the difference between stellar populations.

Weeks 10-12: Stellar kinematics: the motion of the Sun in the Milky Way, motions of disk stars, motions of halo stars, rotation kinematics of the Milky Way and other galaxies, dark matter halos.

Weeks 13-14: The large-scale distribution of gas in the Milky Way and other galaxies: neutral hydrogen, molecular clouds, the Galactic Center, mass in-fall due to collisions.

Week 15: Models of the formation of the Milky Way and other galaxies: classic monolithic collapse, hierarchical formation and accretion, observational evidence for either scenario.
Astronomy 606: Radiative Processes in the Interstellar Medium

**Purpose**
This course gives the students a thorough overview of radiative processes that take place in an astronomical setting, presents the properties of the interstellar medium, and discusses the interaction between them.

**Course Description**
The theory and observation of low density plasmas in the interstellar medium, spectral line formation in active and normal galaxies, and the intergalactic medium; thermodynamic and statistical mechanical description of the ISM; the measurement of galactic chemical abundances; supernovae remnants; planetary nebulae; HII regions; quasars; evolution of the chemical elements and star formation in the Universe; X-ray and radio properties of galaxies and galaxy clusters.

**Course Materials**
ISBN 0471827592
Course handouts and notes will also be available.

**Course Grade**
The course grade will be assigned on the basis of exam performance (50%) and assigned homework (50%).

**Exams**
There will be two in-class exams (mid-term and final) over material presented in the course lectures. Each will contain short-answer and essay questions that will require calculation and quantitative estimates.

**Homework**
There will be homework problems assigned throughout the semester.

**ADA Policy**
The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring special accommodation, please contact the Department of Student Life, Services for Students with Disabilities, in Room 126 of the Koldus Building or call 845-1637.

**Honor Code**
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Course Outline


Weeks 3-4: Radiation from moving charges. Relativistic covariance and kinematics.


Weeks 9-10: Modern view of the ISM. Overview of kinetic equilibrium.

Weeks 11-12: Interaction of photons and stellar winds with the ISM. HII regions.

Week 13-14: Intergalactic medium. The ISM at z>0
APPENDIX C

Physics Core Courses

Astronomy students (either MS or PhD) will be required to enroll in two of the following six courses and obtain a grade of “B” or better. Students must have taken the pre-requisite courses as part of their previous undergraduate or MS education; otherwise, they will need to take the pre-requisites at TAMU.

PHYS 601 Analytical Mechanics (3 SCH): Lagrange, Hamilton, and Hamilton-Jacobi approaches to dynamics; canonical transformation and variational techniques; central force and rigid body motions; the mechanics of small oscillations and continuous systems. Pre-requisites: PHYS 302 or equivalent; MATH 311 and 412 or equivalent; concurrent registration in PHYS 615.

PHYS 603 Electromagnetic Theory I (3 SCH): Boundary-value problems in electrostatics; basic magnetostatics; multipoles; elementary treatment of ponderable media; Maxwell’s equations for time-varying fields; energy and momentum of electromagnetic field; Poynting’s theorem; gauge transformations. Pre-requisites: PHYS 304 or equivalent; PHYS 615.

PHYS 606 Quantum Mechanics I (4 SCH): Schrödinger equation, bound states of simple systems, collision theory, representation and expansion theory, matrix formulation, perturbation theory. Pre-requisites: PHYS 412 or equivalent; MATH 311 and 412 or equivalent; concurrent registration in PHYS 615.

PHYS 607 Statistical Mechanics (4 SCH): Classical statistical mechanics, Maxwell-Boltzmann distribution, and equipartition theorem; quantum statistical mechanics, Bose-Einstein distribution, and Fermi-Dirac distribution; applications such as polyatomic gases, blackbody radiation, free electron model for metals, Debye model of vibrations in solids, ideal quantum mechanical gases, and Bose-Einstein condensation; if time permits, phase transitions and nonequilibrium statistical mechanics. Pre-requisites: PHYS 408 and 412 or equivalent; PHYS 615.

PHYS 615 Methods of Theoretical Physics I (4 SCH): Orthogonal eigenfunctions with operator and matrix methods applied to solutions of the differential and integral equations of mathematical physics; contour integration, asymptotic expansions of Fourier transforms, the method of stationary phase, and generalized functions applied to problems in quantum mechanics. Pre-requisites: MATH 311, 407 and 412 or equivalent.

APPENDIX D

Guidelines for Graduate Faculty Membership

This document presents University policies and practices which Department Heads should use in nominating members to the Graduate Faculty of Texas A&M University. Departments and colleges may have additional requirements that must be satisfied by individuals wishing to be recommended for appointment to the Graduate Faculty. Additional requirements are subject to the review and approval of the Executive Vice President and Provost. The following sections discuss the various categories of Graduate Faculty. The final section discusses current policy for assigning titles to members of the Graduate Faculty in the Graduate Catalog.

General Description of Graduate Faculty
The Graduate Faculty at Texas A&M University consists of the President, the Vice President for Academic Affairs, the Associate Provosts, the Dean of Graduate Studies, the Deans of all subject-matter colleges, selected Directors, and properly qualified academic groups appointed by the Dean of Graduate Studies. Appointees to the Graduate Faculty participate in the graduate degree programs of the University by serving on student advisory committees and teaching graduate courses. Individuals who have not been appointed to the Graduate Faculty may not teach graduate courses or serve on student advisory committees unless special approval is granted by the Dean of the Office of Graduate Studies.

The Graduate Faculty is composed of Members, Associate Members, Adjunct Members, and Special Appointments. Members and Associate Members are selected from qualified individuals of the academic staff of Texas A&M University, from the staff of other parts of the University, from The Texas A&M University System, and from affiliated research organizations (such as USDA) located in College Station, Texas.

Nomination for membership on the Graduate Faculty is always initiated by the head of the appropriate academic department of Texas A&M University in College Station and is processed as discussed in the following sections.

Appointment to membership on the Graduate Faculty, although considered an honor, serves functional purposes and must be earned. Appointment to membership is not for the purpose of conferring recognition upon an individual, but is designed to assure competence in the directing and counseling of graduate students and in the teaching of graduate courses. Such competence is, in part, a function of experience and knowledge of operational procedure; it is also characterized by ability and motivation.

Membership on the Graduate Faculty is maintained only by participating in the graduate program by teaching, by directing or administering graduate work, by doing research and publication, or by other direct and substantial contributions to the graduate programs of the University, such as by service on a Graduate Instruction Committee or by administrative assignments in graduate education. The Graduate Council expects that all Deans and Department Heads will regularly review the Graduate Faculty under their direction and will recommend withdrawal of the appointments of any members who no longer merit membership on the Graduate Faculty on the basis of their lack of contribution to graduate education. The Department Head shall notify any faculty member who is non-voluntarily
removed from the roles of the Graduate Faculty, and the faculty member has the right to appeal his/her removal through the PPM 2.3.2.6 (Faculty Grievance Procedures).

A graduate student at Texas A&M University may not be a member of the Graduate Faculty. Membership on the Graduate Faculty of any faculty or staff member of Texas A&M University or The Texas A&M University System and affiliated research organizations is forfeited upon a faculty or staff member's admission to a graduate program at Texas A&M University. The four categories of membership are: 1) Member, 2) Associate Member, 3) Adjunct Member, and 4) Special Appointment.

Members
Eligibility
Tenure track and tenured faculty members of Texas A&M University are eligible to participate as Members of the Graduate Faculty under criteria and guidelines as established by each college or department on the College Station campus. Appointment of an individual as a Member is accomplished by a letter of nomination from the head of a department on the College Station campus to the Dean of Graduate Studies. In some cases, additional approval is required by the Dean or the Graduate Instruction Committee of the individual's college.

A non-tenure-track individual employed by Texas A&M University, TAES, TAEX, TEES, TEEX, or TTI with professorial rank is eligible to participate as a Member of the Graduate Faculty. A person holding the title of Lecturer or Senior Lecturer may not normally be considered for Member status on the Graduate Faculty. Exceptions to this will be acceptable only if the person concerned has an unusual or unique contribution to make to the graduate program of Texas A&M University and approval is granted by the department, college, and Office of Graduate Studies. A non-tenure-track individual is nominated by the head of the appropriate academic department in College Station who must present evidence that (a) the nominee (1) has taught a graduate class, or (2) has actively served on a graduate student's advisory committee, or (3) has held a definite administrative assignment in the graduate program of a university; and that (b) the nominee has published a scholarly work as primary author (or, in the case of a professional discipline, has exhibited appropriate evidence of professional accomplishment). Recognized scholars and authorities whose merits are clearly established need not be measured by standard criteria. Appointment of these individuals is accomplished by use of the Personal Record Form, initiated by the head of the academic department in College Station, through the College Graduate Instruction Committee and the College Dean to the Executive Director of the Office of Graduate Studies.

Privileges
A Member of the Graduate Faculty, located at College Station, may teach graduate courses and serve as member, co-chair or chair of a graduate student's Advisory Committee. Members located at the Texas A&M University Galveston Campus, the Texas A&M Temple Campus, or Texas A&M's Institute of Biosciences and Technology-Houston may teach graduate courses and serve as a member, co-chair or chair of a graduate student's Advisory Committee. Other Members of the Graduate Faculty located off-campus may teach graduate courses and serve as a member or co-chair (but not chair), with a Member as the other co-chair, of a graduate student's Advisory Committee.

Associate Members
Eligibility
Any faculty member (including Instructors and Lecturers, if permitted by the department or college's policy) or professional staff employed by Texas A&M University, TAES, TAEX, TEES, TEEX, or
TTI who holds the highest earned degree common to that person's discipline may be granted Associate Member status on the Graduate Faculty of Texas A&M University provided that the individual's appointment as an Associate Member of the Graduate Faculty will be beneficial to the department's graduate program. In addition, employees of federal and state agencies located in the College Station area are eligible for Associate Member status. It is expected that a nominee for Associate Member status has published a scholarly work as primary author (or, in the case of a professional discipline, has exhibited appropriate evidence of professional accomplishment). Recognized scholars and authorities whose merits are clearly established need not be measured by standard criteria.

Appointment to Associate Member status is accomplished by use of the Personal Record Form, initiated by the head of the academic department at College Station through the College Graduate Instruction Committee and the College Dean to the Executive Director of the Office of Graduate Studies. A non-tenure-track individual is nominated by the head of the appropriate academic department at College Station who must present evidence that (a) the nominee (1) has taught a graduate class, or (2) has actively served on a graduate student's advisory committee, or (3) has held a definite administrative assignment in the graduate program of a university; and that (b) the nominee has published a scholarly work as primary author (or, in the case of a professional discipline, has exhibited appropriate evidence of professional accomplishment). Recognized scholars and authorities whose merits are clearly established need not be measured by standard criteria. Appointment of these individuals is accomplished by use of the Personal Record Form, initiated by the head of the academic department at College Station through the College Graduate Instruction Committee and the College Dean to the Executive Director of the Office of Graduate Studies.

Privileges
An Associate Member of the Graduate Faculty of Texas A&M University may teach graduate courses and serve as member or co-chair (but not as chair) with a Member as the other co-chair of a graduate student's Advisory Committee.

Adjunct Members
Eligibility
Recognized scholars who do not hold a permanent appointment to the faculty (including visiting and adjunct academic appointments) of this University, but who otherwise meet the basic requirements for the status of Member of the Graduate Faculty, as described previously, may be eligible for appointment to Adjunct Member status. In addition, individuals not located in College Station and not employed by Texas A&M University may be considered for Adjunct Member status on the Graduate Faculty provided they are employed by another agency of the Texas A&M University System or are qualified staff of federal or state agencies. Such nominations should be made in those cases in which there is an apparent need, and justification can be presented by the head of an academic department in College Station.

Appointment of an Adjunct Member is accomplished by use of the Personal Record Form, initiated by the head of the academic department at College Station through the College Graduate Instruction Committee and the College Dean to the Executive Director of the Office of Graduate Studies. A non-tenure-track individual is nominated by the head of the appropriate academic department in College Station who must present evidence that (a) the nominee (1) has taught a graduate class, or (2) has actively served on a graduate student's advisory committee, or (3) has held a definite administrative
assignment in the graduate program of a university; and that (b) the nominee has published a scholarly work as primary author (or, in the case of a professional discipline, has exhibited appropriate evidence of professional accomplishment). Recognized scholars and authorities whose merits are clearly established need not be measured by standard criteria. Appointment of these individuals is accomplished by use of the Personal Record Form, initiated by the head of the academic department at College Station through the College Graduate Instruction Committee and the College Dean to the Executive Director of the Office of Graduate Studies.

Privileges
An Adjunct Member of the Graduate Faculty may teach graduate courses and serve as a member or co-chair (but not chair) with a Member as the other co-chair of a graduate student's Advisory Committee.

Special Appointment
There may be times when the head of an academic department in College Station wishes to have qualified individuals teach a graduate course or serve on a student's Advisory Committee without being permanently on the Graduate Faculty as either a Member, Associate Member, or Adjunct Member. In addition, qualified individuals from other universities, government or industry may be appointed in special cases to teach a graduate course or to serve on a student's Advisory Committee. These appointments are accomplished by a letter of request from the head of an academic department in College Station to the Executive Director of the Office of Graduate Studies with the individual's resume attached. In the letter of request, the department head should indicate if the Special Appointment status is to be limited to the one specified committee, to one specified teaching assignment, or to a fixed length of time (e.g., for one or two years).

A qualified individual from another university, government or industry who holds Special Appointment status to the graduate faculty and who serves on a Graduate Advisory Committee is not counted toward the minimum number of graduate faculty necessary to form the committee.

Procedural Guidelines
1. Research staff who are on the Graduate Faculty of Texas A&M University and who hold payroll titles equivalent to the "Scientist" titles will be assigned by the Executive Director of the Office of Graduate Studies, for the purpose of listing in the Graduate Catalog, the equivalent "Scientist" title. (Example: A person holding the payroll title of "Associate Research Engineer" will be assigned the title of "Associate Research Scientist".)

2. Extension Service personnel on the Graduate Faculty of Texas A&M University will be identified in the Graduate Catalog by the title "Extension Specialist".

3. USDA personnel on the Graduate Faculty of Texas A&M University will be identified in the Graduate Catalog by the title "USDA Scientist".

4. Individuals in the Member, Associate Member, and Adjunct Member categories will be listed in the Graduate Faculty section of the Graduate Catalog.

5. Only names of individuals in the Member category of the Graduate Faculty will be listed under the respective departmental headings in the Graduate Catalog.
APPENDIX E

Letter of Support from Dean of Libraries

UNIVERSITY LIBRARIES
Office of the Dean

January 7, 2009

Dr. Edward S. Fry
Professor and Department Head
Physics Department
Texas A&M University
4242 TAMU
College Station, TX 77843-4242

Dear Dr. Fry:

The Texas A&M University Libraries can readily support the proposal for a Ph.D. program in Astronomy. The proposed Ph.D. in Astronomy will require no additional library resources initially, because the library has been steadily acquiring materials in Astronomy and related fields as part of its aggressive growth campaign.

The Library maintains standing orders for the major astronomy journals and provides online access to the important indexes and abstracts. The University Libraries’ collection of over 51,000 serials and over 3.7 million volumes can provide adequate support for a Ph.D. program in Astronomy. The libraries historically have collected extensively in the physical sciences, including chemistry, physics, and astronomy. Several of the long time physics faculty have helped us build an excellent astronomy collection. The new astronomy faculty are continuing this tradition of active participation in the development of the library collection. The depth of the collection reflects their interest.

Membership of the Texas A&M University Libraries in the Greater Western Alliance (GWLA) allows access to the holdings of research libraries in Arizona, California, Oregon and Washington, besides the traditional Big 12 schools. This membership allows the University Libraries to negotiate consortium agreements that benefit research in astronomy. Membership in the Center for Research Libraries provides access to another five million volumes.

To summarize, the Texas A&M University Libraries is committed to continuing support for programs in the physical sciences, including astronomy. The strength of our collections in these areas will provide good support for a new Ph.D. program in Astronomy.

Sincerely yours,

[Signature]

Dr. Colleen Cook
Dean
Sterling C. Evans Endowed Chair

cc: Dr. H. Joseph Newton
    Dr. Roland E. Allen

5000 TAMU
College Station, TX 77843-5000
Tel. 979.845.8111 Fax. 979.845.6238
www.libraries.tamu.edu
APPENDIX F

Biographical Sketches


