Graduate Programs: Science

The Faculty of Science offers five graduate programs in the areas of Astronomy, Applied Psychology, and Applied Science.

Graduate Programs in Astronomy

Program Coordinator, Professor	D. Guenther
Chairperson, Assistant Professor	I. Short
Director ICA, Professor	R. Deupree
Observatory Director, Professor	D. Turner
Undergraduate Coordinator, Professor	A. Sarty
Professors	D. Clarke
	B. Deupree
	D. Guenther
	A. Sarty
	D. Turner
Associate Professors	R. Austin
	I Short
	R. Thacker
Assistant Professors	L. Gallo
	R. Kanungo
	M. Sawicki
Adjunct Professors	K. Balaji
	P. Bennett,
	P. Noerdinger
Professor Emeritus	W. Lonc
	G. Mitchell

Saint Mary's University is the major centre for astronomical and astrophysical research in Atlantic Canada. It offers degree programs leading to the M.Sc. (Astronomy) and to the Ph.D. (Astronomy).

Admission Requirements

All students entering the Astronomy graduate program require a B.Sc. or equivalent, in Astronomy, Mathematics, or Physics. Students with a B.Sc. or equivalent intending to pursue a Ph.D. enter the Astronomy graduate program at the M.Sc. level. Students with an M.Sc. may enter the Astonomy graduate program at the Ph.D. level, and may be given course transfer credits for equivalent Saint Mary's University graduate level astronomy courses taken elsewhere.

Applications to the Astronomy graduate programs can be made at any time of the year. Highest priority for fall admission will be given to applications received by February 28th of the preceding winter. Applications may be obtained at http://fgsr.smu.ca/grad_pro_app.html, or by contacting the Faculty of Graduate Studies and Research (FGSR) directly. Prospective students who are in doubt about their qualifications should contact the graduate coordinator: graduate.coordinator@ap.smu.ca.

Students may apply for full-time or part-time status. Under special circumstances and subject to department approval, new or existing students may enrol in the program on a part-time basis. Admission and degree requirements for part-time students are the same as for full-time students, but part-time students are not guaranteed full financial support.

Financial Support

Full-time M.Sc. (thesis option) and Ph.D. students receive an annual stipend sufficient to meet the cost of living and tuition for one person in Halifax, provided they continue to meet the program requirements. Funding is guaranteed for up to four years in the Ph.D. program, providing satisfactory progress is being made.

Sources of funding include fellowships from federally funded faculty grants, University Graduate Fellowships, teaching assistantships, and named graduate scholarships. The latter include the Father Burke-Gaffney Memorial Scholarship (established by the Saint Mary's University Alumni Association),the John Depard deBlois Scholarship (established by Marcia Watts deBlois in memory of her husband, an NRC photographer and avid amateur astronomer), and the Reuben and Helen Hornstein Bursary (established in 1982 by Reuben Hornstein, a former meteorologist in Halifax and an honorary degree recipient of Saint Mary's). Students are encouraged to apply for external fellowships and awards (e.g., NSERC, ACEnet, etc.) and those who are successful can expect financial support higher than the normal minimum level.

Master of Science (Astronomy)

Overview

The Master Program offers both a thesis and a no-thesis option, and is normally of two years duration. Subject to departmental approval and normally after two years of study, students may choose to transfer to the Ph.D. program without formally completing their M.Sc.

Admission requirements

A B.Sc. (HONS) or equivalent in Astronomy, Physics or a related field, with a Grade Point Average (GPA) of 3.00 (B) or better is normally required for admission into the program.

Program Requirements

Students take thirty-six (36) credit hours, eighteen (18) credit hours per year for full-time students. For credit towards the degree, a student must attain a course grade of B- (2.67 GP) or better. A student must attain a GPA of at

least 3.00 (B) in the first eighteen (18) hours of course work to continue into the second year of study. A student's GPA over all courses satisfying degree requirements must be at least 3.00 (B) to be eligible for graduation.

Thesis Option

Note: **Students not registered in any course work but working on their Program/Thesis must register in Program Continuation (FGSR 9000) if their program was initiated after 1 September 2004 or Thesis Continuation (THES 9999) if their program was initiated prior to 1 September 2004 for every semester (including summer) in which they are in their graduate program.**

Students take ASTR 5900 (Graduate Seminar I, three (3) credit hours), ASTR 6900 (Graduate Seminar II, three (3) credit hours), ASTR 5980(Research project 1, three (3) credit hours), ASTR 6990 (Thesis, six (6) credit hours), at least four (twelve (12) credit hours) of the six "core courses" listed below, and three other courses, (nine(9) credit hours) drawn from the ASTR courses numbered 5000 and above (excluding the thesis courses), or graduate level courses in related disciplines from Saint Mary's or elsewhere, subject to University regulations on transfer credits for off-campus courses for credit and approval of the student's supervisor.

The Core Courses are:

5400 Stellar Astrophysics I
5410 Introduction to Stellar Atmospheres
5420 The Interstellar Medium
5500 Galactic Astronomy
5510 Extragalactic Astronomy
5600 Cosmology

The thesis is prepared under the supervision of a faculty supervisor and consists of original research performed by the student on a topic chosen and defined by the student and faculty supervisor. When complete, students defend their thesis in front of a Thesis Defence Committee normally scheduled near the end of the second year of study. The M.Sc. defence normally consists of a brief presentation by the student to the academic community, followed by a private oral examination with the Committee.

No-Thesis Option

Students pursuing this option may not be eligible for full financial support.

Students take ASTR 5900 and 6900 (Graduate Seminar I and II, six (6) credit hours), all six core courses (eighteen (18) credit hours) and four courses (twelve (12) credit hours) drawn from ASTR courses numbered 5000 or above (excluding thesis courses), or graduate level courses in related disciplines from Saint Mary's or elsewhere, subject to University regulations on transfer credits for off-campus courses and approval of the student's supervisor.

Doctor of Philosophy (Astronomy)

Overview

The Ph.D. program is a four year program including dissertation research for students who have already obtained an M.Sc. or equivalent in astronomy.

Admission Requirements

An M.Sc., or equivalent in Astronomy, Physics, or related field is normally required for admission into the program. Students completing the M.Sc. program at Saint Mary's who wish to continue in the Ph.D. program may do so with or without receiving the M.Sc. degree. Those who wish to obtain the M.Sc. degree must formally apply to FGSR for admission to the Ph.D. program during the second year of the program. Students who elect not to receive the M.Sc. degree may, with departmental approval, transfer to the Ph.D. program at the end of the second year of the graduate program without applying to FGSR for admission. Students must notify the graduate coordinator of that intention in writing six months prior to the intended transfer.

Program Requirements

Students take a total of twenty-four (24) credit hours of courses. Students must take six core courses (18 credit hours) and two courses (6 credit hours) drawn from ASTR courses numbered 5000 and above (excluding research, seminar, and thesis courses), or graduate level courses in astronomy or related disciplines from Saint Mary's University or elsewhere, subject to University regulations on transfer credits for off-campus courses and approval of the student's supervisor. All ASTR courses taken by students toward the M.Sc. degree at Saint Mary's (excluding research, seminar, and thesis courses) count towards Ph.D. course requirements. Students who have completed M.Sc. programs elsewhere may transfer courses taken at their former institution, subject to University regulations on transfer credits for off-campus courses and approval of the student's supervisor. Under special circumstances, upon approval by the graduate coordinator and the student's supervisor, a none core course may be substituted for a core course. Students wishing to take and receive credit for more than twenty-four (24) credit hours of graduate courses must obtain prior approval from their supervisors.

Students also participate in the Journal Club (taken by M.Sc. students as ASTR 5900 and 6900) every year they are enrolled in the program. Journal Club is normally led by senior Ph.D. students.

For credit towards the degree, a student must attain a course grade of B- or better. A student's CGPA over all courses satisfying degree requirements must be at least 3.00 (B) to be eligible for graduation.

Students are required to pass a comprehensive exam in which they present and defend their dissertation proposal followed by broader questioning by the examining committee to establish the general depth and comprehensive knowledge of the candidate in astronomy and astrophysics. Students must pass satisfactorily both the general astronomy knowledge and the dissertation proposal parts of the

comprehensive exam. Students are given a maximum of two attempts to pass the examination. If only one part of the examination is passed on the first attempt, the student does not need to retake that part again. Students who complete the M.Sc. program at Saint Mary's before commencing the Ph.D. program are encouraged to take the comprehensive exam during the second year of their M.Sc. program. The exam must be taken before the end of the second year of the Ph.D. program.

Students must submit a written dissertation proposal (normally not to exceed ten pages, single sided, double spaced) and present it to their Supervisory Committee at least two weeks prior to the comprehensive exam. Committee approval of the proposal is required before a student is permitted to pursue their dissertation research. Students should meet with the Supervisory Committee at least once a year to assess the student's progress.

Students enrol in AST 8990 the first year after approval of their dissertation proposal and in FGSR 9000 every year thereafter.

When the dissertation is complete, students defend their dissertation before their Dissertation Defence Committee, near the end of the student's program of study.

Voluntary Withdrawal

A student who wishes to withdraw from the Ph.D. program, who has not completed an M.Sc. program in Astronomy, may apply to the Department to use their progress to date towards the M.Sc. degree. If there are insufficient credits for the M.Sc. degree, the student may elect to transfer to the M.Sc. program to complete those requirements, provided notification is provided in writing to the graduate coordinator and approval is granted by the Department and the FGSR. Financial support for students who transfer from the Ph.D. program to the M.Sc. program is not guaranteed.

Graduate Courses (ASTR)

IMPORTANT

In the 2004-2005 academic year, courses were renumbered from three digits to four. A new digit was added to the front of the sequence to indicate the year of study in which a student would normally enrol in a course.

In the 2007-2008 academic year, all Astronomy and Physics courses were assigned new four digit numbers.

Students are urged to be extremely careful not to register again for a course for which they have already earned credit. Academic Regulation 17(b) is extremely important to this matter.

In the cases where courses have been renumbered, changed in level, or where a six (6) credit hour course (formerly referred to as "full course") has been split into two three (3) credit hour courses (formerly termed "half courses") or vice versa, a student who received credit recognition for the original course is not entitled to repeat the course in its new format or on its new level for additional credit recognition.

Previous Course #'s	2004-06 Course #'s	2007- Course #'s
AST 435	ASTR 4435	ASTR 5220
AST 445	ASTR 4445	ASTR 5300
AST 602	ASTR 5602	ASTR 5500
AST 604	ASTR 5604	ASTR 5420
AST 607	ASTR 6607	ASTR 5430
AST 608	ASTR 6608	ASTR 6800
AST 609	ASTR 5609	ASTR 5510
AST 611	ASTR 6611	ASTR 6810
AST 614	ASTR 5614	ASTR 5400
AST 615	ASTR 6615	ASTR 6400
AST 616	ASTR 6616	ASTR 5200
AST 619	ASTR 6619	ASTR 5600
AST 620	ASTR 6620	ASTR 5520
AST 622	ASTR 5622	ASTR 5710
AST 635	ASTR 5635	ASTR 5210
AST 637	ASTR 6637	ASTR 5700
	ASTR 6638	ASTR 5410
	ASTR 5690	ASTR 5980
	ASTR 6690	ASTR 5981
AST 695	ASTR 5695	ASTR 5900
AST 696	ASTR 6696	ASTR 6900
AST 697		
AST 698	ASTR 6698	ASTR 6990
AST 699	ASTR 8699	ASTR 8990

Graduate course offerings consist of formal lecture courses, six of which are designated as "core courses" (and indicated below with asterisks), research courses including Master's Thesis and Ph.D. Dissertation, and seminars such as "Journal Club".

5200 Astronomical Instruments and Techniques
3 credit hours
This course reviews current methods of collecting and interpreting electromagnetic information from the cosmos. It begins by discussing factors which limit the accuracy of light measurement from extremely energetic gamma radiation to decimetric radio waves. The following discussion of astronomical telescopes and detectors shows how those factors have influenced both hardware design and observing techniques. Special emphasis will be given to radio interferometry.

5210 Computational Methods
3 credit hours
This course introduces students to the details of computational numerical approaches used for solving theoretical problems in astrophysical research. The methods covered are those that students can expect to use for computationally-oriented modeling in theoretical astrophysics. Students should expect to obtain extensive "hands-on" experience and must be able to program in one or more scientific computing languages (preferably FORTRAN or C). Specific approaches discussed include Monte Carlo, finite element, finite difference, and smoothed particle hydrodynamics.

5220 Data Analysis in Astronomy
3 credit hours
The goal of this course is to instruct the student in the analysis of real astronomical data. Following a general

introduction to errors and data reduction, the bulk of the course will consist of the use of computers in data reduction. Student projects will include the analysis of images and spectral line maps.

5300 Solar System Astronomy
3 credit hours
Prerequisite: graduate standing or permission of the instructor.

Topics covered include fundamental data for planets and satellites, orbital mechanics, rocks and minerals, age dating of rocks by radioactive decay, meteorites and tektites, comets, asteroids, and remote sensing techniques, cosmogony and the early history of the solar system, planetary and satellite interiors, surfaces and atmospheres, and comparative planetology.

***5400 Stellar Astrophysics I**
3 credit hours
An introduction to the theory of stellar atmospheres and interiors. Topics include: the basic equations of stellar structure, nuclear processes, radiative transfer theory, pre-main-sequence evolution, white dwarfs, neutron stars, and black holes.

***5410 Introduction to Stellar Atmospheres**
3 credit hours
Prerequisite: graduating standing.

This course introduces the physics of stellar atmospheres and the application of atmospheric modeling to the determination of stellar properties. Topics include radiative transfer, gas phase and atomic physics, atmospheric conservation and equilibrium laws, and spectral line profiles. Computer programming in FORTRAN is required for some assignments.

***5420 The Interstellar Medium**
3 credit hours
Topics covered include: the phases of the interstellar medium, neutral clouds, ionized hydrogen regions, interstellar molecules, dust grains, shocks, gravitational collapse, bipolar outflows, and accretion disks.

5430 Binary and Variable Stars
3 credit hours
This course is devoted to the study of both binary stars and variable stars. Topics covered under binary stars include: fundamentals of orbital motion and the properties of binary star systems, analytical and practical techniques for studying visual, astrometric, spectroscopic, and eclipsing binaries, the mass-luminosity relation, and classification of close binaries by Roche-lobe filling. Topics covered under variable stars include: light curves and variable star classification, eclipsing variables, pulsating variables and pulsation theory, rotating variables, unique types, and the link between variability and stellar evolutionary stages.

***5500 Galactic Astronomy**
3 credit hours
This course describes the contents and structure of the Milky Way Galaxy. Topics covered include: historical highlights, reference frames and stellar astronomy, spectral classification, photometric systems, luminosity calibrations, clusters and associations, star counts and stellar density functions, the luminosity function, chemical composition variations in the Galaxy, solar motion, statistical and secular parallaxes, kinematic groups, galactic rotation and structure, spiral arms, and an introduction to galactic dynamics.

***5510 Extragalactic Astronomy**
3 credit hours
This course summarizes our understanding of nearby galaxies, and of how these galaxies evolved to the objects we see today. A review of our concept of the nebulae introduces the main topics, which include galaxy classification, the nature of the present stellar population and interstellar medium in galaxies, and galaxies as they were in the remote past. The presentation will reflect our growing awareness of the importance of interactions between and among galaxies as an agent of their evolution.

5520 Clusters of Galaxies
3 credit hours
Clusters of galaxies are the largest gravitationally bound objects in the universe, and their study has yielded valuable insights into such diverse topics as high energy astrophysics, galaxy formation and evolution and cosmology. This course introduces students to clusters of galaxies from both observational and theoretical perspectives. Topics discussed include galaxy populations, dark matters, the intracluster medium, gravitational lensing, and clusters as tracers of the large-scale structure of the universe.

***5600 Cosmology**
3 credit hours
Cosmology-the study of the large-scale structure and evolution of the universe-is one of the most exciting and active fields of astronomy today. This course presents a broad overview of observational and theoretical cosmology. Emphasis is on how basic physics, guided by observations, is used to construct a remarkably successful model of the universe. Topics include the Big Bang model, formation of galaxies and clusters of galaxies, the large-scale structure of the universe, quasars and radio galaxies, and dark matter.

5700 Magnetohydrodynamics
3 credit hours
An introduction to astrophysical fluids and plasmas. Topics covered include the Boltzmann and moment equations, the Navier-Stokes equations, turbulence, gas dynamics, the Vlasov Equation, and BBGKY hierarchy, basic magnetohydrodynamics, magnetic reconnection and dynamo theory, acoustic and Alfvén waves, instabilities, and shocks. Applications to astrophysical phenomena such as stellar winds, solar and stellar activity cycles, accretion, and jets are discussed.

5710 Astrophysical Dynamics
3 credit hours
Topics covered include: the dynamics of the solar system, the origin and evolution of planetary systems, the dynamics and evolution of star clusters, structure and dynamics of our Galaxy, the theory of spiral structure, and the formation and dynamical evolution of galaxies. The course includes an introduction to the dynamical modelling of planetary systems, star clusters, and galaxies.

5900 Graduate Seminar I
3 credit hours
Articles of interest from the current literature are discussed and critiqued. Students are expected to read articles chosen for discussion, contribute to the critiquing process, and make several presentations during the course. All graduate students must normally enrol in this course in the first year of the Master of Science program.

Seminar 11/2 hrs. a week. 2 semesters.

5980 Research Project I
3 credit hours
Prerequisite: graduating standing.

This course will introduce students in the M.Sc. Astronomy program to the basic principles and techniques of research. Students will be introduced to a research project (not necessarily related to their thesis topic), and perform the background work required before work on such a project could begin.

5981 Research Project II
3 credit hours
This course will continue the work begun in ASTR 5980. Students will now complete the research proposed as part of ASTR 5980 under the supervision of a faculty member. This research need not be related to their thesis project.

6400 Stellar Astrophysics II
3 credit hours
An introduction to current topics in stellar astrophysics. Topics include: variable stars and stellar pulsation theory, solar seismology, the solar neutrino problem, globular cluster ages, the theory of stellar rotation, novae, and supernovae.

6800 Selected Topics in Astronomy and Astrophysics
3 credit hours
One or more selected specialty areas in astronomy will be examined in greater detail than is possible within the broader scope of other courses. Topics will be chosen by the Department and made available to interested students prior to registration.

Seminar 3 hrs. a week.

6810 Directed Readings in Current Literature
3 credit hours
A topic of current interest in astronomy will be chosen in consultation with a faculty member. After a thorough study of recent work on the topic, a detailed written report with references will be submitted. Extensive use will be made of available research journals.

6900 Graduate Seminar II
3 credit hours
A continuation of ASTR 5695 normally taken by graduate students in the second year of the Master of Science program.

Seminar 1 1/2 hrs. a week. 2 semesters.

6990 M.Sc. Thesis
6 credit hours
Normally taken during the second year of enrolment in the Master of Science program after successful completion of the comprehensive oral examination. The research will be conducted under the supervision of a faculty member.

8990 Doctoral Dissertation
6 credit hours
The dissertation consists of an original research topic in astronomy undertaken by the student and prepared as a formal written treatment of their research, which is then defended publicly. The course is normally taken during the third through fifth years of enrolment in the doctoral program after successful completion of the Ph.D. written comprehensive examination and approval of the dissertation proposal. The research is conducted under the supervision of a faculty member. Registration must be approved by a Chair or Supervisor prior to registration and in writing.