

Astronomy (ASTR) and Astrophysics

Astronomy courses are offered by the Department of Astronomy and Physics (<http://www.ap.smu.ca>).

Chairperson	I. Short
Observatory Director	D. Turner
ICA Director	R. Deupree
Undergraduate Co-ordinator	A. Sarty
Graduate Co-ordinator	D. Guenther
Professors	D. Clarke, R. Deupree, D. Guenther, A. Sarty, D. Turner
Associate Professor	R. Austin, M. Sawicki, I. Short, R. Thacker
Assistant Professors	L. Gallo, R. Kanungo,
Adjunct Professor	P. Bennett
Professors Emeriti	W. Lonc, G. Mitchell, G. Welch

Note: This segment lists undergraduate courses in astronomy and programs in astrophysics only. Course and program descriptions for physics may be found in the Physics (PHYS) segment of Section 4 in this *Calendar* while graduate course descriptions and programs in astronomy may be found in the *Graduate Academic Calendar*.

History

Astronomy is an ancient science, with some of its first practitioners among the Minoans, Aztecs, Egyptians, and early Chinese. Throughout its long history, the discipline has gone through many revolutions having benefited from some of the greatest minds who ever lived: Aristotle, Copernicus, Galileo, Newton, and Einstein. In the late 1800's, George Hale proclaimed astrophysics-the joining of traditional astronomical techniques with the mathematical rigour of physics-as "the new astronomy for the twentieth century" and, within a generation, few astronomers could complete their training without a full background in physics. Today, astronomers design highly engineered observatories and detectors, are cognizant of chemistry and biochemistry as more and more complex molecules such as amino acids are detected in the cosmos, and must be competent mathematicians, physicists, and computer scientists to understand and interpret what is being observed. Of all pure scientists, astrophysicists are among the best qualified to pursue a wide variety of careers in both science and education.

Formal introductory courses in Astronomy were introduced to the Saint Mary's curriculum by Father Michael J. Burke-Gaffney S.J. in 1957. Fifteen years later, Burke-Gaffney convinced the University to build a small observatory on the roof of the 23-story Loyola residence to be used for both class activities and public tours. In recognition of Burke-Gaffney's seminal role in establishing Saint Mary's as the regional centre for astronomy, the observatory was named in his honour.

Between 1971 and 1974, three astronomers joined the Department of Physics who, in 1974, formed a separate

department and began offering an M.Sc. in Astronomy. This was the University's first Master's program in science as well as the first Astronomy program in the region. In 1989 and in cooperation with the Department of Physics, the Department of Astronomy began offering undergraduate programs in astrophysics to complement the M.Sc. in Astronomy and the B.Sc. in physics.

In 1993, the independent Departments of Physics and Astronomy were combined into a single department with eight faculty members and three staff. Given the University's status as the only institution in Atlantic Canada to offer full programs in Astronomy at either the undergraduate or graduate levels, the new department was called the Department of Astronomy and Physics. Building upon this strength, Saint Mary's made the strategic decision to allocate two of its six Canada Research Chairs to Astronomy and the Department used this opportunity to found the Institute for Computational Astrophysics (ICA) in 2001. With the addition of an NSERC University Research Fellow, the Department now has eleven full-time faculty and three faculty emeriti bringing more than \$350,000 annually to the University in external research funds.

In 2002, approval was granted to the University to offer a Ph.D. program in Astronomy, making it the first science Ph.D. program offered in Nova Scotia outside Dalhousie. With its emphasis on research as well as teaching, its status of offering the only full complement of university astronomy degrees east of Toronto, and its small, intimate, urban setting in one of the most charming cities on the continent, Saint Mary's University is truly a unique place to study astronomy and astrophysics at any level.

Degree Programs in Astrophysics

Because all modern-day astronomers are also physicists, no undergraduate degree in astronomy alone is offered. Instead, the Department offers two programs in *astrophysics*. The astrophysics major program is designed for those who want a solid foundation in modern physics and astronomy, but who are not necessarily planning to continue their education beyond the B.Sc. The astrophysics honours program is designed for those who intend to continue on to graduate school, and involves the preparation of an honours thesis (PHYS 4790) under the supervision of a faculty advisor in their fourth year. As listed below, these two programs are identical through the second year meaning students need not commit to the honours program until the third year of study. Note also, as listed, these programs conform to the requirements of the Science faculty as outlined in Section 3.

Note: The astrophysics programs demands a minimum grade of C in all physics and astronomy courses required for the degree. The program of study must be approved by the chairperson or the undergraduate coordinator. For undergraduate courses and programs in physics, please refer

to the Physics (PHYS) segment listed in Section 4 of this *Calendar*.

Astrophysics Major/Honours

Year 1

1. three (3) credit hours in science electives [CSCI 1226 recommended] and ASTR 1100
2. PHYS 1100 and 1101
3. ENGL 1205 and PHYS 1500
4. MATH 1210 and 1211
5. six (6) credit hours in science electives [CHEM 1210/1211 recommended]

Year 2

1. ASTR 2100 and 2400
2. PHYS 2300 and 2301
3. MATH 2311 [three (3) credit hours in science electives] and PHYS 2400
4. MATH 2301 and 2303 [six (6) credit hours in science electives]
5. three (3) credit hours in Humanities electives; and three (3) credit hours in Arts or ECON electives

Year 3 (Major)

1. either ASTR 3400 or 3500; and three (3) credit hours in Arts or ECON electives
2. PHYS 3200 and 3201
3. PHYS 3300 and three (3) credit hours in electives
4. PHYS 3500; and either PHYS 3350 or 3400
5. six (6) credit hours in Arts or ECON electives

Year 3 (Honours)

1. either ASTR 3400 or 3500; and either ASTR 4200 or 4600
2. PHYS 3200 and 3201
3. PHYS 3300 and 3210
4. PHYS 3500 and either PHYS 3350 or 3400
5. PHYS 3600 and three (3) credit hours in Arts or ECON electives

Year 4 (Major)

1. either ASTR 3400 or 3500; and either ASTR 4200 or 4600
2. PHYS 4500 and either PHYS 3350 or 3400
3. eighteen (18) credit hours in electives

Year 4 (Honours)

1. either ASTR 3400 or 3500; and either ASTR 4200 or 4600
2. three (3) credit hours in ASTR at the 5000 level and three (3) credit hours in arts/ECON electives
3. PHYS 4500 and either PHYS 3350 or 3400
4. three (3) additional credit hours in PHYS at the 4000 level and three (3) credit hours in Arts or ECON electives
5. PHYS 4790

Course Descriptions

The Department offers courses in astronomy, both undergraduate and graduate, to support its three degree programs in astronomy and astrophysics. Note that Astrophysics honours students are required to include at least one graduate level course in their program, and students should refer to the *Graduate Academic Calendar* for graduate course descriptions.

The Department also offers introductory astronomy courses for the non-specialist, including ASTR 1000, 1001, and 1010. Both ASTR 1000 and 1001 are suitable for science electives for all students, whereas ASTR 1010 is suitable for a science elective for non-science students only (but still may be taken as a general elective by science students).

IMPORTANT NOTE ON COURSE NUMBERING

In the 2008-09 academic year, courses were re-numbered. The first digit represents the year, the second digit indicates the subject area [0=general interest, 1=foundation, 2=techniques, 3=planets, 4=stars/ISM, 5=(extra)galactic], and the third and fourth digits number the course within a given subject area.

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 very clear on this matter:

Course # -2003	Course # 2004-07	Course # 2008-
AST 205	ASTR 1205	ASTR 1100
AST 206	ASTR 1206	ASTR 1101
AST 215	ASTR 1215	ASTR 1000
AST 216	ASTR 1216	ASTR 1001
AST 217	ASTR 1217	ASTR 1010
AST 312	ASTR 2312	ASTR 2100
AST 313	ASTR 2313	ASTR 2400
AST 412	ASTR 3412	ASTR 3400
AST 413	ASTR 3413	ASTR 3500
AST 435	ASTR 4435	ASTR 5220*
AST 445	ASTR 4445	ASTR 5300*

*formerly undergraduate courses, now offered as graduate courses; see the *Graduate Academic Calendar* for descriptions.

1000 The Sky and Planets
3 credit hours

This course provides an introduction to the Solar System for non-science students with little background in science and mathematics. Topics include: the celestial sphere and the night sky, locating astronomical objects, motions and phases of the moon, timekeeping and the calendar, history of astronomy, eclipses, telescopes and instruments, planets, asteroids, and comets. Homework consists of assignments and labs, some of which require the use of the Burke-Gaffney Observatory.

Classes 3 hrs. and lab/telescope observing 1 hr. per week

1001 Stars and Galaxies

3 credit hours

This course is an introduction to astronomy beyond the Solar System for non-science students with little background in science and mathematics. Topics include: the Sun as a star, stars and star clusters, stellar evolution, nebulae, the Milky Way, galaxies and galaxy clusters, quasars, active galaxies, cosmology. Homework consists of assignments and labs, some of which require the use of the Burke-Gaffney Observatory.

Classes 3 hrs. and lab/telescope observing 1 hr. per week

1010 Life in the Universe

3 credit hours

The possibility that life might exist elsewhere in the universe has fascinated human beings ever since our ancestors first gazed into the starry skies. Is life on Earth unique, or could there be other civilisations in the cosmos? This course examines the possibility of extraterrestrial life from astronomical, biological and sociological perspectives. Topics include planets, stars and galaxies, our place in the universe, the origin and evolution of life on Earth, searches for extraterrestrial life, the Anthropic Principle, UFOs, and more.

Note: This course is currently offered exclusively as a web-based course.

Note: Please note that this course may not be used by B. Sc. Students to satisfy the requirement of a science elective under regulations 3.e., 6.e., 10.c., and 12.b. for B.Sc. degrees.

1100 Introduction to Astrophysics

3 credit hours

Prerequisites: PHYS 1100 and Nova Scotia grade 12 math pre-calculus, or equivalent.

This course provides a mathematics-based and physics-based introduction to general and solar system astronomy for science students and astrophysics majors. Topics include: the celestial sphere and the night sky, development of astronomy as a science, orbits planets, time measurement, eclipses, telescopes and astronomical instruments, and the solar system. Homework consists of assignments and labs, some of which require the use of the Burke-Gaffney Observatory.

Classes 3 hrs. and lab/telescope observing 1 hr. per week; 1 semester.

2100 Foundations of Astrophysics

3 credit hours

Prerequisites: ASTR 1101; PHYS 1101; MATH 1211

The emphasis of this first course in *astrophysics* is on directly observable quantities such as the positions and motions of stars and the light they emit. Topics include a review of the celestial sphere, time in astronomy, astronomical catalogues, the two-body problem, dynamics of star clusters, stellar spectra including emission and absorption lines, and the operation of telescopes. Students

are assigned observing projects and trained to use the Burke-Gaffney Observatory.

Classes 3 hrs. per week and telescope observing session

2400 Physics of Stars

3 credit hours

Prerequisite: ASTR 2100.

One of the major scientific achievements of the 20th Century was the quantitative understanding of stars. This reviews these advances including the use of binary stars to determine stellar properties, spectral classification and the Boltzmann and Saha equations, radiative transfer and stellar atmospheres, the equations of stellar structure, and the interiors of hydrogen burning stars such as the Sun.

3400 Interstellar Matter and Stellar Evolution

3 credit hours

Prerequisite: ASTR 2400.

This course examines the nature of neutral and ionised interstellar clouds and the onset of star formation. Concepts introduced in ASTR 2400 are used to show how the initial mass of a "protostar" largely determines its place on the "main sequence" as a star, its internal structure and energy production, and the nature of its death, whether it be as a white dwarf, neutron star, or a black hole.

3500 Galaxies and Cosmology

3 credit hours

Prerequisite: ASTR 2400.

This course deals with an extremely broad area of astrophysics covering seven or eight orders of magnitude in length scale. Topics include the kinematic properties of nearby stars, galactic rotation, spiral structure, and the formation of the Milky Way. Extragalactic topics include the classification of galaxies, galactic evolution and interaction, galaxy clusters, large scale structure of the universe, and modern cosmology including observational tests of various cosmological models.

4200 Observational Astronomy

3 credit hours

Prerequisite: ASTR 2100

The principles of modern ground-based and space-based observational astronomy is discussed. Emphasis is on data acquisition (from observations and archives) and analysis, and on the statistical treatment of data. As much as practical, the Burke-Gaffney Observatory is used for student projects.

Classes 3 hrs. per week and telescope observing session.

4600 High-Energy Astrophysics

3 credit hours

Prerequisite: ASTR 2400, PHYS 2400, PHYS 3300.

This course discusses the astrophysical processes that create high-energy photons (x-rays and gamma-rays) as well as the emission created from very energetic electrons (synchrotron and inverse Compton). Topics include gas and radiative processes, high-energy detectors and telescopes, and

astrophysical processes from the solar system to black holes and gamma-ray bursts responsible for high-energy emission.

Atlantic Canada Studies (ACST)

Program Coordinator A. MacLeod, English

P. Twohig Canada Research Chair in Atlantic
Canada Studies

J. Ried Professor, History

R. Field Adjunct Professor

Atlantic Canada Studies is an interdisciplinary major, minor, honours, concentration, and certificate option in the Arts Faculty which has developed out of an increasing demand by students, faculty and the community generally, for a more organized study of this region.

Students who complete a major, minor, honours, concentration, or certificate in Atlantic Canada Studies will have helped to prepare themselves for a fuller and more meaningful participation in the life of Atlantic Canada, and will have acquired a useful background for careers in teaching, trade and industry, and the various bureaus of the provincial and federal civil services. Their attention is particularly drawn to the advantages, from a career point of view, of taking Atlantic Canada Studies as part of a double major or honours.

Students are required to choose their courses in consultation with a member of the Atlantic Canada Studies Committee, and are strongly urged to select one of its members to advise them for the duration of the program, and to provide the necessary liaison with the Committee.

Canada Research Chair in Atlantic Canada Studies

Dr. Peter L. Twohig holds the Canada Research Chair in Atlantic Canada Studies. He has an active program of research focusing on health in Atlantic Canada, and is particularly interested in interdisciplinary approaches to health care research and historical analyses of health and medicine. Undergraduate students interested in interview-based projects are encouraged to contact Dr. Twohig or visit the Gorsebrook Centre for New Media Qualitative Research.

Graduate Studies

For detailed information on the Master of Arts in Atlantic Canada Studies, refer to the *Graduate Academic Calendar*.

Major, Minor, Honours, Concentration, and Certificate programs.

The following are the regulations for the major, minor, concentration, and honours programs. Details concerning the Master of Arts in Atlantic Canada Studies degree are found in Section 3 of this *Calendar*.

Majors

To complete a major in Atlantic Canada Studies, a student must meet the usual University requirements for the Bachelor of Arts degree, and in particular, obtain forty-eight (48) credit hours from the courses listed below. At least twenty-four (24) of the forty-eight (48) credit hours must be at the 2000 level or above. Students are required to select courses in accordance with the following criteria:

1. The courses must include at least six (6) credit hours from each of three of Groups A, B, C, D and E.
2. The courses must include at least six (6) credit hours from each of three different academic disciplines. Interdisciplinary ACST courses do not count as a discipline for this purpose.
3. ACST 4411 and 4412 must be among the courses selected.
4. No more than eighteen (18) credit hours may be selected from Group E.
5. It is the responsibility of the student to ensure that all prerequisites have been fulfilled for the courses chosen.

Minors

A minor in Atlantic Canada Studies consists of twenty-four (24) credit hours chosen from the courses listed below and completed with a quality point average of at least 2.00. At least twelve (12) credit hours must be at the 2000 level or above, and the courses selected must include ACST 4411 and 4412. The courses must also include six (6) credit hours from each of three different academic disciplines, and no more than twelve (12) credit hours may be selected from Group E.

Honours

To complete an honours program in Atlantic Canada Studies, a student must meet the usual University requirements for the Bachelor of Arts (Honours) degree, and in particular, obtain sixty (60) credit hours from the courses listed below. At least forty-eight (48) of the sixty (60) credit hours must be at the 2000 level or above. Students are required to select courses in accordance with the following criteria:

1. The courses must include at least six (6) credit hours from each of four of Groups A, B, C, D, and E.
2. The courses must include at least six (6) credit hours from each of three different academic disciplines. Interdisciplinary ACST courses do not count as a discipline for this purpose.