How long will the Sun shine? When will we discover Earth-like planets among the many circling other stars? How did the universe begin and how has it evolved over its 13.7 billion year history? Astronomy is the science that asks and tries to answer questions like these. We have come a long way toward understanding what makes the sky appear as it does and how the Universe is fashioned. The Astronomy Department offers courses for anyone who is interested in learning about the Universe, and who would like to be able to follow new astronomical discoveries as they are made. All courses in Astronomy satisfy the Division III requirement. The Astrophysics major (administered jointly with the Physics Department) and the Astronomy major are described below.

The beginning astronomy courses are offered on two levels. Astronomy 101, 102, 104, and 330-range courses are intended primarily for non-science majors and have no prerequisite. Astronomy 111 is designed for students with some exposure to or interest in physics. It has a prerequisite of one year of high school physics or permission of the instructor, and a co-requisite of Mathematics 104 or equivalent background in calculus. Most of the astronomy courses take advantage of our observational and computational facilities including a 24-inch computer-controlled telescope with sensitive electronic detectors, and our own computer network for image processing and data analysis. The Astronomy Department homepage can be found at web.williams.edu/astronomy.

ASTROPHYSICS MAJOR

The Astrophysics major is designed for students who want a rigorous introduction to the field, and includes not only those who plan graduate study in astronomy, astrophysics, or a closely related area, but also those interested in a wide variety of careers. Alumni include not only astronomers but also computer scientists, geologists, teachers, doctors, lawyers, business school professors, and so on. In recent years, many astrophysics majors have had a second major in fields as wide ranging as mathematics, geosciences, economics, English, and art history. This major emphasizes the description of the Universe and its constituents in terms of physical processes. Potential Astrophysics majors should consult early with members of the Astronomy and Physics Departments to determine their most appropriate route through the major. An essential ingredient in such students' undergraduate training is experience in physics and mathematics. Therefore, the major normally will begin in the first year a student is at Williams with Physics 131, 141, or 151 and Mathematics 104 or 105 or 106 in the fall. Students with very good background placing them out of Physics 142 and/or Mathematics 104 may choose to take Physics 201 and Mathematics 105 or 106 instead. Astronomy 111 will often be taken in the fall of the sophomore year; however, many students take it in the fall of their first year at Williams, along with physics and math. Students who might place out of physics courses should read the section on placement under Physics; those who place out of Physics 131 or 141 into Physics 142 or 151 should particularly consider taking Astronomy 111 in the fall of their first year.

In addition to the major courses described below, other courses in geosciences, mathematics, and computer science may also be appropriate.

MAJOR REQUIREMENTS FOR ASTROPHYSICS

Astronomy 111 Introduction to Astrophysics

or

Astronomy 101 Stars: From Suns to Black Holes

and either

Astronomy 102 The Solar System—Our Planetary Home

or

Astronomy 104 The Milky Way Galaxy and the Universe Beyond

Three 400-level astronomy courses

or

Two 400-level astronomy courses and one of the following:

Astronomy 211 Astronomical Observing, Image Processing, and Analysis

Physics 302 Statistical Physics

Physics 402T Applications of Quantum Mechanics

Physics 405T Electromagnetic Theory

Physics 411T Classical Mechanics

Physics 418 Gravity

Physics 131 Particles and Waves

or

Physics 141 Particles and Waves—Enriched

or equivalent placement

Physics 142 Foundations of Modern Physics

or

Physics 151 Seminar on Modern Physics

Physics 201 Electricity and Magnetism

Physics 202 Waves and Optics

Physics/Mathematics 210 Mathematical Methods for Scientists

Physics 301 Introductory Quantum Physics

Mathematics 105 Multivariable Calculus

or

Mathematics 106 Multivariable Calculus

The total number of courses required for the Astrophysics major, an interdisciplinary major, is eleven. Students entering with Advanced Placement in physics and/or mathematics may obtain credit toward the major for the equivalent of Physics 141 and/or Mathematics 104 and/or 105 or 106 taken elsewhere, but at least 8 courses in astronomy, physics, and mathematics must be taken at Williams. There are some aspects of astrophysics that are closely related to chemistry or geosciences. In recognition of this relation, certain advanced courses in those departments can be accepted for credit toward the Astrophysics major on a two-for-one basis. It is not possible to double major in Astrophysics and Physics.

The information presented here is as of 10/26/2012.
THE DEGREE WITH HONORS IN ASTRONOMY

The honors degree in Astronomy will be awarded on the basis of a senior thesis presenting the results of an original observational, experimental, or theoretical investigation carried out by the student under the direction of a faculty member in Astronomy. There are no specific grade requirements (other than College-wide requirements for remaining in good academic standing) for entry into the thesis research program; however, a student wishing to do a thesis should have demonstrated both ability and motivation for independent work in previous courses and in any earlier research involvement. Students doing theses will normally choose a topic and an advisor early in the second semester of their junior year and usually begin their thesis work during the summer. During the senior year, those students whose proposals have been approved will elect two courses and a winter study project in addition to the minimum requirements for the major. Preparation for the thesis will occupy at least one course (Astronomy 493) and the winter study project (Astronomy 031). At the end of the winter study period, the department will decide, in consultation with each student, whether to admit that student to honors candidacy. Both a written thesis and an oral presentation to faculty and fellow students are required. The degree with honors will be awarded to those who meet these requirements with distinction.

The department will be flexible with regard to the number and timing of courses devoted to thesis research within the general guidelines of two courses and a winter study project over and above the minimum major requirements and the written and oral presentations, especially in cases of students with advanced standing and/or summer research experience. Students considering unusual requests are urged to consult with potential advisors or the department chair as early as possible.

Astronomy 101 Stars: From Suns to Black Holes

What makes a star shine? For how long will the Sun keep shining? What are black holes and how can they form? Astronomy 101, a non-major, general introduction to the part of contemporary astronomy that includes how stars form and how they end their existence, will provide answers to these questions and more. The course gives special attention to the exciting discoveries of the past few years. Topics include modern astronomical instruments such as the Hubble Space Telescope, the Chandra X-ray Observatory, the Herschel Space Telescope, the Kepler mission to discover extrasolar planets, the new generation of 8- and 10-meter mountain telescopes, and results from them; how astronomers interpret the light received from distant celestial objects; the Sun as a typical star (and how its future will affect ours); and our modern understanding of how stars work and how they change with time. We will also discuss how pulsars and black holes result from the evolution of normal, massive stars and how giant black holes are at the center of galaxies and quasars. We will discuss the discovery of planets around stars other than the Sun. We regularly discuss the latest news briefs and developments in astronomy and relate them to the topics covered in the course. This course is independent of and on the same level as Astronomy 102 and 104, and students who have taken those courses are welcome. Observing sessions will include use of the 24-inch telescope and other telescopes for observations of stars, star clusters, planets and their moons, nebulae, and galaxies, as well as daytime observations of the Sun.

Format: lecture (three hours per week), observing sessions (scattered throughout the semester), afternoon labs (five times per semester), and a planetarium demonstration. Evaluation will be based on two hour tests, a final exam, an observing portfolio, and laboratory reports. No prerequisites. Enrollment limit: 48 (expected: 48). Non-major course.


DEMIANSKI (lectures) SOUZA (labs)

Astronomy 102 The Solar System—Our Planetary Home

What makes Earth different from all the other planets? Did Mars ever have running water? What is Pluto? Will asteroids or comets collide with the Earth? What is a solar eclipse like? Astronomy 102, a non-major, general introduction to the part of contemporary astronomy that comprises the study of the solar system, will provide answers to these questions and more. We will cover the historical development of humanity’s understanding of the solar system, examining contributions by Aristotle, Ptolemy, Copernicus, Galileo, Newton, Einstein, and others. We will discuss the discovery of over 1000 exoplanets around stars other than the Sun. The course gives special attention to exciting discoveries of the past few years by space probes and by the Hubble Space and the Herschel Space Observatories. We regularly discuss the latest news briefs and developments in astronomy and relate them to the topics covered in the course. This course is independent of and on the same level as Astronomy 101 and 104, and students who have taken those courses are welcome. Observing sessions include use of the 24-inch telescope and other telescopes for observations of stars, star clusters, planets and their moons, nebulae, and galaxies, as well as daytime observations of the Sun.

Format: lecture (three hours per week), observing sessions (scattered throughout the semester), afternoon labs (five times per semester), and a planetarium demonstration. Evaluation will be based on two hour tests, a final exam, an observing portfolio, and laboratory reports. To be eligible for the Gaudino grade, which stipulates “intellectual presence,” a student must demonstrate commitment to engaging the course material in all its aspects: lectures, reading, labs, observing, homework, and exams.


PASACHOFF (lectures) SOUZA (labs)

Astronomy 104 The Milky Way Galaxy and the Universe Beyond

It has been less than a century since the Sun was discovered not to be at the center of the Milky Way Galaxy, and the Milky Way Galaxy was determined to be only one of countless "island universes" in space. A host of technological advances is enabling us to understand even more clearly our place in the universe and how the universe began. For example, the Hubble Space Telescope, the Herschel Space Observatory, and the Chandra X-ray Observatory bring clearer images and cover a wider range of the spectrum than has ever been obtainable before; they are speeding up progress on determining the past and future of the Universe. They are confirming and enlarging our understanding of the Big Bang. In addition, the Wilkinson Microwave Anisotropy Probe and Planck spacecraft’s study of the early Universe and large-scale mapping programs such as the Sloan Digital Sky Survey are giving clues into how the Universe’s currently observed structure arose. Astronomy 104, a non-major, general introduction to part of contemporary astronomy comprising the study of galaxies and the Universe, explores the answers to questions like: What is the Milky Way? Why are quasars so luminous? Is the Universe made largely of “dark matter” and “dark energy”? What determines the ultimate fate of the Universe? How have studies of Cepheid variables and distant supernovae with the Hubble Space Telescope determined that the Universe is 13.7 billion years old and indicated that the Universe’s expansion is accelerating. We regularly discuss the latest news briefs and developments in astronomy and relate them to the topics covered in the course. This course is independent of, and on the same level as Astronomy 101 and 102, and students who have taken those courses are welcome. Observing sessions will include use of the 24-inch telescope and other telescopes for observations of stars, star clusters, planets and their moons, nebulae, and galaxies, as well as daytime observations of the Sun.

Format: lecture (three hours per week), observing sessions (scattered throughout the semester), afternoon labs (five times per semester), and a planetarium demonstration. Evaluation will be based on two hour tests, a final exam, an observing portfolio, and laboratory reports. To be eligible for the Gaudino grade, which stipulates “intellectual presence,” a student must demonstrate commitment to engaging the course material in all its aspects: lectures, reading, labs, observing, homework, and exams.


PASACHOFF (lectures) SOUZA (labs)
ASTR 330 The Nature of the Universe (Not offered 2012-2013)
A journey through space and time from the first 10^43 seconds to the ultimate fate of the Universe billions of years in the future. Topics include inflation, conditions during the first three minutes, creation of the elements, stellar and giant black holes, the Big Bang and its remnant cosmic background radiation, relativity, galaxies and quasars, the large scale structure of the Universe, and current ideas about the future of the Universe and the end of time. In particular, we will explore the acceleration of the Universe's expansion, and the possible contributions string theory to our understanding.

Format: lecture/discussion, three hours per week. Evaluation will be based on two hour tests, a small observing portfolio, occasional homework, and a final exam. To be eligible for the Gaudino grade, which stipulates "intellectual presence," a student must demonstrate commitment to engaging the course material in all its aspects: lectures, reading, labs, observing, homework, and exams.

No prerequisites; open only to juniors and seniors; closed to students who have taken or are taking ASTR 104, and closed to Astronomy, Astrophysics, or Physics majors.
Non-major course. Courses in the 33X-sequence are meant as general-education courses for students in all majors. Enrollment limit: 48 (expected: 48).

KWITTER

ASTR 336(S) Science, Pseudoscience, and the Two Cultures (Same as HSCI 336) (W)
A famous dichotomy between the sciences and the humanities, and public understanding of them, was laid down by C. P. Snow and has been widely discussed, with ignorance of the second law of thermodynamics compared with ignorance of Shakespeare. In this seminar, we will consider several aspects of science and scientific culture, including how scientific and non-scientific knowledge is acquired. We will begin with a study of the claims of the modernist philosopher Thomas Kuhn and we will discuss the recent "Science Wars" over the validity of scientific ideas. We will consider the fundamental origins of modern science, including Tycho, Kepler, Galileo, and Newton, viewing their original works in the Chapin Library of rare books and comparing their interests in science with what we now call pseudoscience, like alchemy. We will review the history and philosophy of astrology and other pseudosciences. Building on the work of Martin Gardner in Fads and Fallacies in the Name of Science, we will consider from a scientific point of view what is now called alternative medicine, including both versions such as chiropractic, osteopathy, and homeopathy, and newer nonscientific practices. We will discuss the current global-climate-change deniers and their effects on policy. We consider such topics as GM (genetically modified) foods, the safety and regulation of dietary supplements, and the validity of government and other recommendations relevant to the roles of dietary salt and fat in health. We consider the search for extraterrestrial intelligence (SETI) and reports of UFO's and aliens. We consider the possible effects that pseudoscientific beliefs have on the general public's cooperation in vaccination programs and other consequences of superstition. We also consider the recently increased range of dramas that are based on scientific themes, such as Star Trek's "Aradia" and Michael Frayn's Copenhagen.

Format: seminar. Evaluation will be based on biweekly 5-page papers, participation in discussions, and a 15-page final paper.

No prerequisites. Enrollment limit: 12 (expected: 12). Preference will be given to juniors and seniors and to those with backgrounds in science, history of science, or philosophy.
Non-major course. Does not count toward the Astrophysics, Astronomy, or Physics major:

1:10–3:50 W

PASACHOFF

ASTR 338 The Progress of Astronomy: Galileo through the Hubble Space Telescope (Same as HSCI 338 and LEAD 338) (Not offered 2012-2013) (W)
Our capabilities of understanding the Universe have progressed over the 500 plus years since Copernicus moved the sun into the center. Galileo’s breakthrough observations of the sky with the new-fangled telescope led to hundreds of years of improving observations. In a seminar format, week by week, we will discuss each of the following topics (and look at original texts) in the context of the science and society at the time: Aristarchus, the "Copernican" discoveries; mapping the sky and constellations 1540 to the present through star atlases; William and Caroline Herschel and the discovery of a new planet; asteroids from 1 Ceres to 5100 Pasachoff and beyond; contemporary surveys, the extinction of the dinosaurs, and possible dangers to the Earth and its inhabitants; astronomy teaching from when Williams College students first built its Hopkins Observatory through the Committee of Ten to the Journal of Astronomy Education Research; planetariums from pasted stars to optomechanical and digital 21st-century projection; women’s roles in astronomy; the life stories of astronomer-greats; the remains of Venus from Horrocks and Capt. Cook through the 2004/2012 pair: the launch of Spintnik and the race to the moon; the formation of NASA and its transformation through space shuttles and the International Space Station; the past, present, and future of the Hubble Space Telescope; NASA’s “Great Observatories,” including not only Hubble but also the Chandra X-ray Observatory and the Spitzer Space Telescope; NASA’s “Vision” of sending astronauts to the Moon and Mars; advances in ground-based observatories and telescopes; mapping the Universe through projects like the Sloan Digital Sky Survey and 2dF; and the discovery that the Universe’s expansion is accelerating and its ramifications. We consider the role of individual leadership in the various topics.

Format: seminar, one three-hour meeting a week. Planetarium demonstration, with individual planetarium work on request. Evaluation will be based on two 10-page papers and participation in discussions.

No prerequisites. Enrollment limit: 19 (expected: 10). Preference will be given to juniors and seniors and to those with backgrounds in science, history of science, or philosophy.
Non-major course. Does not count toward the Astrophysics, Astronomy, or Physics major: Courses in the 33X-sequence are meant as general-education courses for students in all majors.

PASACHOFF

COURSES WITH PREREQUISITES

ASTR 111(F) Introduction to Astrophysics (Q)
How do stars work? This course is a survey of some of the main ideas in modern astrophysics, with an emphasis on the observed properties and evolution of stars; this course is the first in the Astrophysics and Astronomy major sequences. It is also appropriate for students planning to major in one of the other sciences or mathematics, and for others who would like a quantitative introduction that emphasizes the relationship of contemporary physics to astronomy. Topics include radiation laws and stellar spectra, astronomical instrumentation, physical characteristics of the Sun and other stars, star formation and evolution, nucleosynthesis, white dwarfs and planetary nebulae, pulsars and neutron stars, supernovae, relativity, and black holes. Observing sessions include use of the 24-inch and other telescopes for observations of stars, nebulae, planets and galaxies, as well as daytime observations of the Sun.

Format: lecture/discussion, observing sessions, and five labs per semester. Evaluation will be based on weekly problem sets, two hour tests, a final exam, lab reports, and an observing portfolio. To be eligible for the Gaudino grade, which stipulates "intellectual presence," a student must demonstrate commitment to engaging the course material in all its aspects: lectures, labs, observing, homework, and exams.

Prerequisites: a year of high school Physics, or concurrent college Physics, or permission of instructor, and Mathematics 104 or equivalent. Enrollment limit: 28 (expected: 20).
Hour: 11:20-12:35 TR Lab: 1-4 M,R KWITTER (lectures) SOUZA (labs)

ASTR 207(F) Extraterrestrial Life in the Galaxy: A Sure Thing, or a Snowball’s Chance? (W)
A focused investigation of the possibility of life arising elsewhere in the galaxy, and the chances of the existence of our detecting it. This course, pairs of students will explore the astronomical and bioscientific requirements for the development of Earth-like life. We will consider the conditions on other planets within our solar system as well as on newly-discovered planets circling other stars. We will also analyze the famous “Drake Equation,” which calculates the expected number of extraterrestrial civilizations, and attempt to evaluate its components. Finally, we will examine current efforts to detect signals from intelligent alien civilizations and contemplate humanity’s reactions to a positive detection.

Format: tutorial. Evaluation will be based on the student’s papers, responses to the partner’s papers, and evidence of growth in understanding over the semester.
Prerequisites: Astronomy 111 or Biology 101-102, Chemistry 101-102, or Geosciences 101 or equivalent science preparation. Enrollment limit: 10 (expected: 10). Instructor’s permission required. If overenrolled, preference given to students who have had Astronomy 111.

Tutorial meetings to be arranged.

KWITTER

ASTR 211 Observation and Data Reduction Techniques in Astronomy (Q) (Not offered 2012-2013)
This course will introduce techniques for obtaining and analyzing astronomical data. We will begin by learning about practical observation planning and move on to discussion of CCD detection, digital image reduction, and image processing. We will make use of data we obtain with our 24-inch telescope, as well as data from other optical ground-based observatories and archives. We also learn about and work with data from space-based non-optical observatories such as the Chandra X-Ray Observatory the Spitzer Space Telescope (infrared).

Format: lecture/discussion plus computer work and observing. Evaluation will be based on weekly problem sets, an hour exam and an observing project.

Prerequisites: Mathematics 105 or 106. Prior experience with Unix is helpful, but not required. Enrollment limit: 10 (expected: 6).

KWITTER

ASTR 402(S) Between the Stars: The Interstellar Medium (Q)
The matter between the stars—the interstellar medium—manifests itself in many interesting and unexpected ways, and, as the detritus of stars, its properties and behavior hold clues to the evolution of the universe itself. The stars are born in clouds of gas and dust, dispersed by the gravitational disruption of more massive stars; they are supported in dense molecular clouds, to the stellar winds they eject with varying ferocity as they evolve, to their final fates as they shed their outer layers, whether as planetary nebulae or dazzling supernovae. As these processes go on, they enrich the interstellar medium with the products of the stars’ nuclear fusion. The existence of life on Earth is eloquent evidence of this chemical enrichment.

In this course we will study the interstellar medium in its various forms. We will discuss many of the physical mechanisms that produce the radiation we observe from diffuse matter, including radiative ionization and recombination, collisional excitation of "forbidden" lines, collisional ionization, and synchrotron radiation. This course is observing-intensive. Throughout the semester students will work in small groups to design, carry out, analyze, and critique their own observations of the interstellar medium using the equipment on our observing deck.

Format: seminar/discussion, plus computer work and observing projects. Evaluation will be based on homework, class presentations/problem-solving, and observing projects.

Prerequisite: Physics 201. Enrollment limit: 10 (expected: 8).
Hour: 2:35-3:50 MR

KWITTER
The solar corona has recently been revealed as the connection between the Sun and the Earth. Observations from the 10 instruments on the Solar and Heliospheric Observatory (SOHO) now aloft are showing the flow of material from the Sun to the Earth in unprecedented detail. Further, data from total solar eclipses will be used to study the cause of the heating of the solar corona and will be linked to space observations from SOHO, TRACE, and Yohkoh solar satellites. We discuss theoretical aspects and observational techniques, and will make solar observations. Students will meet weekly with the professor in groups of two or three to discuss readings, solve problems, present short papers, and/or make observations.

Format: tutorial. Evaluation will be based on four 5-page papers, discussions, and presentations. Students will be expected to improve their writing throughout the course, with the aid of careful editing by and comments from the professor.

Enrollment limit: 19 (expected: 12). If overenrolled, preference will be given to Astronomy and Astrophysics majors. 

ASTR 493(F)-W31, W31-494(S) Senior Research in Astronomy

An original experimental or theoretical investigation is carried out under the direction of a faculty member in Astronomy, as discussed under the heading of the degree with honors in Astronomy above.

Prerequisites: permission of the department.

Hour: TBA

Members of the Astronomy Department

ASTR 493(F)-W31, W31-494(S) Senior Research in Astrophysics

An original experimental or theoretical investigation is carried out under the direction of a faculty member in Astronomy or Physics, as discussed under the heading of the degree with honors in Astrophysics above.

Prerequisites: permission of the department.

Hour: TBA

Members of the Astronomy and Physics Departments

ASTR 497(F), 498(S) Independent Study in Astronomy

ASTR 497(F), 498(S) Independent Study in Astrophysics

ASTR 499(F-S) Physics and Astronomy Colloquium (Same as Physics 499)

Physics and Astronomy researchers from around the country come to explain their research. Students of Physics and Astronomy at any level are welcome. This is not a for-credit course. Registration is not necessary to attend.

Hour: 2:35-3:50 F