ASTRONOMY AND ASTROPHYSICS

Astrophysics deals with some of the most majestic themes known to science. Among these are the evolution of the universe from the Big Bang to the present day; the origin and evolution of planets, stars, galaxies, and the elements themselves; the unity of basic physical law; and the connection between the subatomic properties of nature and the observed macroscopic universe.

Three sequences of courses present the study of these topics in different scope and depth:

1. Several courses offered by the Department of Astronomy and Astrophysics satisfy the general education requirement in the physical sciences. Detailed course and sequence descriptions may be found on the Physical Sciences (collegecatalog.uchicago.edu/archives/2015-2016/thecollege/physicalsciences) page of this catalog.

2. For students seeking a more in-depth examination of selected astrophysical topics, astronomy courses numbered in the 18000s are offered, usually to be taken in their second year or later. These courses are intended for students from throughout the College.

3. For students considering graduate work in astrophysics, the Department of Astronomy and Astrophysics recommends the program leading to a degree of BA in Physics with Specialization in Astrophysics. For details, see the Physics (collegecatalog.uchicago.edu/archives/2015-2016/thecollege/physics) section of this catalog. Tutorial and research courses are available in addition to more informal opportunities for work and study in the Department of Astronomy and Astrophysics. Participation in a weekly seminar on current topics in astrophysical research is also recommended.

ASTRONOMY AND ASTROPHYSICS COURSES

ASTR 18100. The Milky Way. 100 Units.
The Sun and its planetary system is part of a larger hierarchical structure, a flattened disk of stars called the Milky Way that provides an environment for the birth of new stars, seeded by the deaths of other stars. The Milky Way is thus a dynamic system in several senses of the word. This course will survey the stellar and interstellar components of the Milky Way, the distribution in space and motions of the stars and the interstellar gas, how these components interact with each other, and how the whole system evolves. (L)
Instructor(s): N. Gnedin Terms Offered: Winter
Prerequisite(s): Any two-course 10000-level general education sequence in chemistry, geophysical sciences, physical sciences, or physics.
Equivalent Course(s): PHSC 18100
ASTR 18200. The Origin and Evolution of the Universe. 100 Units.
This course discusses how the laws of nature allow us to understand the origin, evolution, and large-scale structure of the universe. After a review of the history of cosmology, we see how discoveries in the twentieth century (i.e., the expansion of the universe and the cosmic background radiation) form the basis of the hot Big Bang model. Within the context of the Big Bang, we learn how our universe evolved from the primeval fireball.
Instructor(s): J. Frieman Terms Offered: Autumn
Prerequisite(s): Any two-course 10000-level general education sequence in chemistry, geophysical sciences, physical sciences, or physics.
Equivalent Course(s): PHSC 18200

ASTR 18300. Searching Between the Stars. 100 Units.
With the advent of modern observational techniques (e.g., radio, satellite astronomy), it has become possible to study free atoms, molecules, and dust in the vast space between the stars. The observation of interstellar matter provides information on the physical and chemical conditions of space and on the formation and evolution of stars.
Terms Offered: TBD
Prerequisite(s): Any two-course 10000-level general education sequence in chemistry, geophysical sciences, physical sciences, or physics.
Equivalent Course(s): PHSC 18300

ASTR 20000. Tutorial in Astronomy and Astrophysics. 100 Units.
Students in this tutorial read topics in astronomy and astrophysics under the supervision of a faculty member. Instructors meet with one to three students for approximately two hours each week to discuss readings on topics they choose together.
Terms Offered: Summer, Autumn, Winter, Spring
Prerequisite(s): Any 10000-level general education sequence in chemistry, geophysical sciences, physical sciences, or physics.
Note(s): Class limited to six students. Available for either quality grades or for P/F grading.

ASTR 24100. The Physics of Stars and Stellar Systems. 100 Units.
Building upon a student’s previous knowledge of physics, this course introduces the astrophysics of stars and stellar systems with an emphasis on the physical nature of stars. Topics include the tools of astronomy, both observational and theoretical Hertzsprung-Russell diagrams, structure and evolution of stars, binary stars, star clusters, and end states of stars (e.g., white dwarfs, neutron stars, black holes). L.
Instructor(s): R. Rosner Terms Offered: Autumn
Prerequisite(s): PHYS 23400 or consent of instructor.

ASTR 24200. The Physics of Galaxies and the Universe. 100 Units.
Physical laws are applied in the study of the structures and evolution of galaxies, quasars, clusters of galaxies, and the universe at large.
Instructor(s): W. Hu Terms Offered: Winter
Prerequisite(s): ASTR 24100 or consent of instructor.
ASTR 28200. Current Topics in Astrophysics. 100 Units.
This course explores in considerable detail an area of current research interest in astrophysics. The topic varies, but recent examples include the early universe, high-energy astrophysics, magneto-hydrodynamics in astrophysics, and observational cosmology.
Instructor(s): D. Fabrycky Terms Offered: Spring
Prerequisite(s): ASTR 24100 and 24200, or consent of instructor.

ASTR 29700. Participation in Research. 100 Units.
Students are assigned to work in the research group of a member of the faculty. Participation in research may take the form of independent work on a small project or assistance to an advanced graduate student or faculty member in his or her research.
Terms Offered: Summer, Autumn, Winter, Spring
Prerequisite(s): Third- or fourth-year standing and consent of instructor and departmental counselor.
Note(s): Students are required to submit the College Reading and Research Course Form. Available for either quality grades or for P/F grading. Students may register for this course for as many quarters as they wish; they need not work with the same faculty member each time.

OTHER COURSES OF INTEREST

PHSC 11902. The Secret Lives of Stars. 100 Units.
This course will explore the mystery that is hidden inside the heart of stars, which we have only recently begun to understand. For example, it will examine the physical processes that make stars the only objects in the Universe that can synthesize heavy elements, like all the atoms in your body. It will explain why some stars have winds, and why some stars retire to an old age of relaxation and cooling down while some of them blow up in the most spectacular manner. In order to do this, we will take as our starting point the diagram made in the early 20th century by Hertzsprung and Russell, which plotted the color of stars as a function of their brightness, and, through lectures and discussions, follow the subsequent developments in physics that helped us to unlock the secrets encoded therein.
Instructor(s): F. Catteneo Terms Offered: Summer
Note(s): This course fulfills the general education requirement in physical sciences for non-majors. Starting in Fall of 2015, PHSC 11900, 11902 and 12000 will no longer be offered. Students who have taken 11902 but have not taken 12000 may complete a two-quarter Physical Sciences requirement by taking PHSC 12600, 12610, 12710 or 12720, although 12710 is recommended as the best fit with 11902 among these options. This course may not be combined with PHSC 11900.
PHSC 12600. Matter, Energy, Space, and Time. 100 Units.
A comprehensive survey of how the physical world works, and how matter, energy, space, and time evolved from the beginning to the present. A brief survey of the historical development of mathematics, physics, and astronomy leads to a conceptual survey of the modern theory of the physical universe: space and time in relativity; the quantum theory of matter and energy; and the evolution of cosmic structure and composition. Systems such as black holes are used to illustrate the most extreme behaviors of nature, and systems such as stars are used to illustrate the explanatory power of physical reasoning. The major theme is understanding all of nature, from the prosaic to the exotic, using a powerful quantitative theory grounded in precise experiments. (L)
Instructor(s): D. Hooper Terms Offered: Autumn

PHSC 12610. Black Holes. 100 Units.
The Universe is a laboratory that reveals the behavior of matter and radiation under intense pressure, temperature, and density, far more extreme than can be replicated on Earth. Depending on its mass, a star ends its life as a spinning white dwarf, neutron star, or black hole. The strength of gravity near these compact dead stars is so high that we can observe consequences of the bending of space-time. This course will provide the physical framework necessary to understand the origin and properties of some of the most powerful and exotic phenomena known, such as supernovae, gamma-ray bursts, and quasars. (L)
Instructor(s): C. Hogan Terms Offered: Winter
Prerequisite(s): PHSC 12600 or PHSC 12700

PHSC 12620. The Big Bang. 100 Units.
The Big Bang model is a powerful framework for the interpretation of a wide range of observations and for making detailed and precise predictions for new experiments. The key motivating observations include the expansion of the Universe and how it has changed with time; the existence of radiation indicating a hot and dense early phase; the abundance of the light elements; and how matter is organized over a wide range of physical scales. The model naturally incorporates dark matter and dark energy, components that govern the growth of structure over time under the action of gravity. The course will explore the consequences of the model as it is applied to the earliest moments after the Big Bang, as well as to the fate of the Universe in the distant future. (L)
Instructor(s): E. Shirokoff Terms Offered: Spring
Prerequisite(s): PHSC 12600
PHSC 12700. Stars. 100 Units.
Elements such as carbon and oxygen are created at high temperatures and pressures in the deep interiors of stars, conditions that naturally arise in stars like the Sun. This course will outline the physical principles at work: how the theory of stellar interiors accounts for how stars shine, why they live for such long times, and how the heavy elements in their cores are dispersed to form a new generation of stars. Gravity assembles stars out of more diffuse material, a process that includes the formation of planetary systems. The course shows how, taken together, these physical processes naturally lead to the ingredients necessary for the emergence of life, namely elements like carbon, nitrogen, and oxygen, and planets in stable orbits around long-lived stars. (L)
Instructor(s): R. Kron Terms Offered: Autumn

PHSC 12710. Galaxies. 100 Units.
Galaxies have been called "island universes," places where stars are concentrated, where they are born, and where they die. Galaxies are dynamic systems in the sense that they change with time and in the sense that gravity shapes the orbit of each star within its galaxy. The Sun is one star among the 100 billion in the Milky Way, each moving on an orbit that reflects the distribution of all the other stars. This course will trace the modern picture for the formation of galaxies and the stars in them. It will also review aggregates of galaxies, how galaxies move on orbits around each other at this higher level of the hierarchy of structure, and how we arrive at the conclusion that most of the matter in the Universe is in an exotic form (dark matter). (L)
Instructor(s): M. Gladders Terms Offered: Winter
Prerequisite(s): PHSC 12600 or PHSC 12700

PHSC 12720. Exoplanets. 100 Units.
The past two decades have witnessed the discovery of planets in orbit around other stars and the characterization of extra-Solar (exo-) planetary systems. We are now able to place our Solar System into the context of other worlds: A challenging next step is to find planets as small as the Earth in orbit around stars like the Sun. The architecture of planetary systems reflects the formation of the parent star and its protoplanetary disk, and how these have changed with time. This course will review the techniques for discovery of planets around other stars, what we have learned so far about exoplanetary systems, and the driving questions for the future, including the quest for habitable environments elsewhere. (L)
Instructor(s): J. Bean Terms Offered: Spring
Prerequisite(s): PHSC 12700
PHSC 12800. European Astronomy and Astrophysics. 100 Units.
Modern astronomy was born in Europe in the sixteenth and seventeenth centuries, led by Nicolaus Copernicus of Poland, who simplified the description of the solar system by moving the Sun to the center of the Universe. The Italian, Galileo Galilei, first pointed a telescope at the sky in 1609 and discovered the moons of Jupiter, sunspots, the stellar composition of the Milky Way, and craters on the Moon. Tycho Brahe of Denmark studied planetary motions in great detail, allowing Johannes Kepler of Germany to define the principles of the orbits of the planets by 1615. Isaac Newton of England discovered the laws of gravity and of motion, and built the reflecting telescope later in the seventeenth century. By 1774, French astronomer Charles Messier began the explosion of our current knowledge of the Universe when he catalogued what are now known to be other galaxies. Building upon this history, this course also explores recent developments in European astronomical and astrophysical technology that allows a modern exploration of the deepest regions of the Universe using a wide range of telescopes.
Instructor(s): A. Olinto Terms Offered: Spring
Note(s): This course is offered only in Paris in Spring Quarter.

PHYS 29100-29200-29300. Bachelor’s Thesis.
This yearlong sequence of courses is designed to involve the student in current research. Over the course of the year, the student works on a research project in physics or a closely related field (e.g., astrophysics) leading to the writing of a bachelor’s thesis. A student who submits a satisfactory thesis, earns a grade of B or higher based on the project, and achieves a GPA of 3.0 or higher in the required undergraduate physics courses is eligible to receive a BA with honors. The project may be one suggested by the instructor or one proposed by the student and approved by the instructor. In either case, all phases of the project (including the literature search, design and construction of the experiments, and analysis) must be done by the student. The instructor, the faculty adviser, post-docs, and graduate students are, of course, available for consultation.
PHYS 29100. Bachelor’s Thesis. 100 Units.
This yearlong sequence of courses is designed to involve the student in current research. Over the course of the year, the student works on a research project in physics or a closely related field (e.g., astrophysics) leading to the writing of a bachelor’s thesis. A student who submits a satisfactory thesis, earns a grade of B or higher based on the project, and achieves a GPA of 3.0 or higher in the required undergraduate physics courses is eligible to receive a BA with honors. The project may be one suggested by the instructor or one proposed by the student and approved by the instructor. In either case, all phases of the project (including the literature search, design and construction of the experiments, and analysis) must be done by the student. The instructor, the faculty adviser, post-docs, and graduate students are, of course, available for consultation.
Terms Offered: Autumn
Prerequisite(s): Open to students who are majoring in Physics with fourth-year standing and consent of instructor.
Note(s): Students are required to submit the College Reading and Research Course Form in Autumn Quarter. Students receive a grade in each quarter of registration: P/F grading in Autumn and Winter Quarters, and a quality grade in Spring Quarter.

PHYS 29200. Bachelor’s Thesis. 100 Units.
No description available.
Terms Offered: Winter
Prerequisite(s): PHYS 29100
Note(s): Students are required to submit the College Reading and Research Course Form in Autumn Quarter. Students receive a grade in each quarter of registration: P/F grading in Autumn and Winter Quarters, and a quality grade in Spring Quarter.

PHYS 29300. Bachelor’s Thesis. 100 Units.
No description available.
Terms Offered: Spring
Prerequisite(s): PHYS 29200
Note(s): Students are required to submit the College Reading and Research Course Form in Autumn Quarter. Students receive a grade in each quarter of registration: P/F grading in Autumn and Winter Quarters, and a quality grade in Spring Quarter.

PHYS 29200. Bachelor’s Thesis. 100 Units.
No description available.
Terms Offered: Winter
Prerequisite(s): PHYS 29100
Note(s): Students are required to submit the College Reading and Research Course Form in Autumn Quarter. Students receive a grade in each quarter of registration: P/F grading in Autumn and Winter Quarters, and a quality grade in Spring Quarter.
PHYS 29300. Bachelor’s Thesis. 100 Units.
No description available.
Terms Offered: Spring
Prerequisite(s): PHYS 29200
Note(s): Students are required to submit the College Reading and Research Course Form in Autumn Quarter. Students receive a grade in each quarter of registration: P/F grading in Autumn and Winter Quarters, and a quality grade in Spring Quarter.