

Astronomy and Astrophysics

*Graduate Student Adviser: Kyle M. Cudworth, Yerkes Observatory,
262-245-5555*

Student Affairs Assistant: Melissa Gorman, AAC 120, 702-9808

Departmental Secretary: Dana Nassau, AAC 118, 702-8203

Web: astro.uchicago.edu/

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) PHSC 11900-12000-12700 is a two- or three-quarter sequence that satisfies the general education requirements in the physical sciences. The first two quarters cover the formation and evolution of stars, the galaxy, and the extragalactic universe; and the third quarter deals with the solar system. NTSC 10100-10200-10300-10400 is a four-quarter sequence that satisfies the general education requirements in physical sciences and biological sciences. NTSC 10200 deals with the evolution of the universe.

(2) For those seeking a more in-depth examination of selected astrophysical topics, astronomy courses numbered in the 18000s are offered, usually to be taken in the sophomore 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 B.A. in Physics with Specialization in Astrophysics. For details, see the 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.

Faculty

J. Carlstrom, J. Cronin, K. Cudworth, S. Dodelson, J. Frieman, D. Harper, Jr., L. Hobbs, W. Hu, S. Kent, E. Kibblewhite, E. Kolb, A. Königl, A. Kravtsov, R. Kron, D. Lamb, Jr., S. Meyer, T. Oka, A. Olinto, P. Palmer, C. Pryke, R. Rosner, N. Swerdlow, S. Swordy, J. Truran, M. Turner, P. Vandervoort, D. York

Courses

18100. The Milky Way. (=PHSC 18100) *PQ: Any 10000-level general education sequence in chemistry, geophysical sciences, physical sciences, or physics.* For course description, see Physical Sciences. *K. Cudworth. L. E. Kibblewhite. Spring. Offered 2002-03; not offered 2003-04.*

18200. The Origin and Evolution of the Universe. (=PHSC 18200) *PQ:*

Any 10000-level general education sequence in chemistry, geophysical sciences, physical sciences, or physics. For course description, see Physical Sciences. A. Olinto. Winter.

18300. Searching Between the Stars. (=PHSC 18300) *PQ: Any 10000-level general education sequence in chemistry, geophysical sciences, physical sciences, or physics.* For course description, see Physical Sciences. D. Harper. Autumn.

18500. The Lives and Deaths of Stars. (=PHSC 18500) *PQ: Any 10000-level general education sequence in chemistry, geophysical sciences, physical sciences, or physics.* For course description, see Physical Sciences. Offered 2003-04; not offered 2002-03.

19000. Telescope and Image Processing-Based Astronomy. *PQ: Any 10000-level general education sequence in chemistry, geophysical sciences, physical sciences, or physics; or consent of instructor.* This course models the exciting process of scientific inquiry through investigation of the properties of the sun, stars, and the Milky Way galaxy based on projects done by teams of students. Students work with small telescopes to take images with CCD cameras and filters, and then use image-processing software to analyze those images and others obtained by professional astronomers. Students gain skill in understanding data and measurement error in terms general enough to apply not only to astronomy but also to any other data encountered in academic or personal settings. D. Duncan. Summer. L.

20000. Tutorial in Astronomy and Astrophysics. *PQ: Any 10000-level general education sequence in chemistry, geophysical sciences, physical sciences, or physics. Class limited to six students. May be taken either for a letter grade or for P/N or P/F.* Students in this tutorial read topics in astronomy and astrophysics under the supervision of a faculty member. Students meet with the instructor in groups of one to three for approximately two hours per week to discuss readings on mutually agreed-upon topics. Summer, Autumn, Winter, Spring.

21300. Origin and Evolution of the Solar System. (=GEOS 21300) *PQ: Consent of instructor. Knowledge of physical chemistry helpful.* For course description, see Geophysical Sciences. L. Grossman. Winter. L.

22800. Cosmic Explosions. *PQ: PHYS 12300, 13300, or 14300; and consent of instructor.* Gamma-ray bursts and supernovae are the most violent and energetic events in the Universe. Yet much about them remains a mystery. Recent discoveries suggest that the two phenomena are linked, and that gamma-ray bursts may signal the creation of stellar-sized black holes. Astronomers are using both as probes of the early universe. Novae and X-ray bursts are, by comparison, much less energetic, but they have much to tell us about the fundamental properties of white dwarfs and neutron stars. This course takes an in-depth look at these cosmic explosions, and at the implications they have for life and for the ultimate fate of the Universe. D. Lamb. Autumn. Offered 2002-03; not offered 2003-04.

24100. The Physics of Stars and Stellar Systems. *PQ: PHYS 23400 or consent of instructor.* 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 such as white dwarfs, neutron stars, and black holes. *J. Truran. L: P. Palmer. Autumn.*

24200. The Physics of Galaxies and the Universe. *PQ: ASTR 24100 or consent of instructor.* Physical laws are applied in attempts to understand the structures and evolution of galaxies, quasars, clusters of galaxies, and the universe at large. *S. Dodelson. Winter.*

28000. Current Topics in Astrophysics. *PQ: ASTR 24100 and 24200, or consent of instructor.* An area of current research interest in astrophysics is explored in considerable detail. The topic varies, but some examples include the early universe, high energy astrophysics, magneto-hydrodynamics in astrophysics, observational cosmology, and cosmic microwave background. The current topic is the new cosmology, concentrating on recent developments. *M. Turner. Spring.*

29900. Participation in Research. *PQ: Third- or fourth-year standing and consent of instructor and departmental counselor. Available for either Pass or letter grading. Students are required to submit the College Reading and Research Course Form. Students may register for this course for as many quarters as they wish; they need not work with the same faculty member each time.* 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. *Summer, Autumn, Winter, Spring. L.*

Students with adequate preparation may register for the following graduate-level courses with the consent of the instructor:

30100-30200-30300-30400. Astrophysics I, II, III, IV. *PQ: Consent of instructor and a minimum of one year of physics. (Normally students should have completed or be enrolled concurrently in PHYS 33000-32200 or 34100-34200.)* This course is designed to provide a firm foundation in the principles of astrophysics (e.g., hydrostatic equilibrium of a self-gravitating object, radiative transfer, radiation from a diffuse gas) needed to carry out modern astrophysical research. Many astrophysical topics are discussed, but the emphasis is on elucidating general principles rather than attempting to survey the field. *Weekly seminar on current topics in astrophysical research required. Autumn, Winter, Spring.*

30500. Radiative Processes in Astrophysics. *PQ: Open to concentrators with advanced standing. ASTR 24200 and PHYS 22700, or consent of instructor.* The course deals with the fundamentals of radiative transfer. The basic physics of radiation fields is studied and applied to astrophysical systems. Emission and scattering processes and the theory of radiative transfer are discussed in the context of model stellar atmospheres. Radiation processes important to astrophysics, such as Bremsstrahlung, cyclotron and synchrotron radiation, Compton scattering, and atomic and molecular transitions are covered, with an emphasis on their observational manifestations (e.g., spectra, polarization properties). *A. Königl. Autumn.*

30600. Radiation Measurements and Instrumentation in Astrophysics.

PQ: Consent of instructor. Topics discussed include radiation as a random process, optical coherence, and signal analysis in spatial and temporal domains, along with the detection and measurement of radiation with astronomical instruments. *E. Kibblewhite. Winter.*

31300. Extragalactic Studies.

PQ: Consent of instructor. Topics include galaxies and intergalactic space, determination of Hubble's law, and peculiar extragalactic objects such as radio galaxies, Seyfert galaxies, and quasars. *S. Kent. Autumn. Offered 2002-03; not offered 2003-04.*

31500. Dynamics I (Fluids).

PQ: Consent of instructor. This course examines the principles of hydrodynamics and hydromagnetics. Topics also include equilibrium and stability of fluid systems in astrophysics, waves, shocks, and turbulence. *A. Königl. Winter. Offered 2002-03; not offered 2003-04.*

31600. Dynamics II (Particles).

PQ: Consent of instructor. This course examines the dynamics of collisionless plasmas and stellar systems. Stochastic processes and kinetic equations, dynamics of galaxies and star clusters, and astrophysical plasmas are explored. *Offered 2003-04; not offered 2002-03.*

32000. Relativistic Astrophysics.

PQ: Consent of instructor. This course covers topics in special relativity, including the general theory of relativity and its experimental tests, and applications to astrophysical problems such as super-massive stars, black holes, relativistic star clusters, and gravitational radiation. *E. Kolb. Spring. Offered 2002-03; not offered 2003-04.*

32100. Cosmology.

PQ: Consent of instructor. The standard Big Bang cosmological model, together with its tests and a discussion of nonstandard models, is covered. Topics include the Robertson-Walker metric, the 3K background, Big Bang nucleosynthesis, the determination of the age of the universe, and galaxy formation, as well as other current problems in cosmology. *W. Hu. Winter. Offered 2002-03; not offered 2003-04.*

34000. Statistical Methods in Astrophysics.

PQ: Consent of instructor. This course explores the variety of statistical methods used in modern astrophysics. *Offered 2003-04; not offered 2002-03.*

36100. Interstellar Medium.

PQ: Consent of instructor. Topics covered include the physics of interstellar gas, emission nebulae, HI regions, interstellar grains and molecules, and cosmic rays and the interstellar magnetic field. *Offered 2003-04; not offered 2002-03.*

38900. Kepler's Astronomy. (=CFSC 38900, HIPS 28900)

PQ: Consent of instructor. This course is a detailed exploration of the astronomical work of Kepler. *N. Swerdlow. Winter.*

Other courses of interest:

PHSC 11900-12000-12700. Introduction to Astrophysics. *Autumn, Winter, Spring.*

PHYS 29100-29200-29300. Bachelor's Thesis. *PQ: Open to concentrators*

with fourth-year standing and consent of instructor. This yearlong sequence is designed to involve the student in current research. The student works on a research project in physics or a closely related field, such as astrophysics, leading to the writing of a bachelor's thesis. The project may be one suggested by the instructor, or one proposed by the student and approved by the instructor. *Autumn, Winter, Spring.*