

DEPARTMENT OF ASTRONOMY

567 Sears Library Building
http://astronomy.case.edu
Phone: 216-368-3728; Fax: 216-368-5406
J. Christopher Mihos, Chair
E-mail: mihos@case.edu

DEPARTMENT FACULTY

J. Christopher Mihos, Ph.D.
(University of Michigan)
Professor and Chair; Director of the Warner and Swasey Observatory
Galaxy evolution; interacting and merging galaxies; galaxy clusters; computational & observational astronomy

R. Earle Luck, Ph.D.
(University of Texas, Austin)
Worcester R. and Cornelia B. Warner Professor of Astronomy
Stellar and galactic chemical evolution; stellar spectrophotometry

Heather L. Morrison, Ph.D.
(Australian National University)
Professor
Galaxy formation via observational studies of the Milky Way and nearby galaxies; dark matter

Idit Zehavi, Ph.D.
(Racah Institute of Physics, Hebrew University of Jerusalem)
Assistant Professor
Cosmology and the large-scale structure of the universe; galaxy biasing; galaxy formation and evolution; structure formation; clustering of galaxies; cosmic flows.

Secondary Faculty

John Ruhl, Ph.D.
(Princeton University)
Professor of Physics
Experimental astrophysics and cosmology

Glenn D. Starkman, Ph.D.
(Stanford University)
Professor of Physics
Theoretical cosmology; particle physics; astrophysics

Adjunct Faculty

Jeffery R. Kriessler, Ph.D.
(Michigan State University)
Adjunct Assistant Professor

Two undergraduate degrees in astronomy are offered, a Bachelor of Science and a Bachelor of Arts. The primary difference between the two degrees is that the B.A. degree allows somewhat more flexibility in choice of courses. A broad and substantial background in physics and mathematics with introductory exposure to astronomy is emphasized in the astronomy curriculum. A faculty actively engaged in research provides first-rate instruction and opportunity for undergraduate involvement in research. The department

offers minor programs in astronomy for both the B.A. and the B.S.

A bachelor's degree in astronomy can prepare for graduate study in astronomy (about 50% of our graduates take this path), but the holder of this undergraduate degree who seeks employment in other fields can fill the same jobs as physics and computer science majors.

The department offers a graduate program leading to the degree of Doctor of Philosophy in astronomy. Current research provides opportunities in observational and theoretical studies of galaxy formation and evolution, galaxy cluster evolution, astronomical instrumentation, and cosmology. Prospective graduate students must submit scores on the Graduate Record Examination including the advanced physics test. Further information on the department's graduate programs, and details concerning financial aid, are available through the departmental office or Web site (<http://astronomy.case.edu>).

FACILITIES

The Department of Astronomy operates the Kitt Peak Station of the Warner and Swasey Observatory near Tucson, Arizona, home of the Burrell Schmidt telescope. This telescope is used for surveys and ultra-deep imaging with a large format CCD. The department is also a member of the Sloan Digital Sky Survey, which operates a 2.5m telescope with multi-object spectrographs and wide field imager at Apache Point, New Mexico. The third incarnation of this survey includes a Baryon Oscillation survey of the large-scale structure of the universe and a spectroscopic survey of the Milky Way galaxy. A 9.5-inch refractor permanently mounted on the roof of the A. W. Smith Building is available for use by students. The department also houses a research and instruction computer laboratory, including the Astronomy high-performance computing cluster.

UNDERGRADUATE PROGRAMS

Bachelor of Science in Astronomy Degree

Freshman Year (Class-Lab-Credit Hours)

Fall

MATH 121 Calculus for Science & Engineering I(4-0-4)
or MATH 123 Calculus I(4-0-4)
PHYS 121 General Physics I - Mechanics(4-0-4)^a
PHED 101 Physical Education Activities(0-3-0)
First Seminar(4-0-4)
Social Science I(3-0-3)
Total: 15-3-15

Spring

MATH 122 Calculus for Science & Engineering II(4-0-4)
or MATH 124 Calculus II(4-0-4)
PHYS 122 General Physics II: Electricity
& Magnetism(4-0-4)^a
PHED 102 Physical Education Activities(0-3-0)
ENGR 131 Elementary Computer Programming(3-0-3)
ASTR 151 Doing Astronomy*(1-0-1)
Arts & Humanities I(3-0-3)
Total: 15-3-15

* Suggested but Not Required For the Major

Sophomore Year

Fall

ASTR 221 Stars and Planets	(3-0-3)
MATH 223 Calculus for Science & Engineering III	(3-0-3)
or MATH 227 Calculus III	(3-0-3)
PHYS 221 General Physics III: Modern Physics	(3-0-3) ^a
PHYS 203 Laboratory Physics	(2-4-4)
University Seminar	(3-0-3)
Total:	14-4-19

Spring

ASTR 222 Galaxies and Cosmology	(3-0-3)
MATH 224 Elementary Differential Equations	(3-0-3)
or MATH 228 Differential Equations	(3-0-3)
PHYS 204 Advanced Instrumentation Lab	(1-4-4)
PHYS 250 Mathematical Physics & Computing	(3-0-3)
PHYS 310 Classical Mechanics	(3-0-3)
University Seminar	(3-0-3)
Total:	16-4-19

Junior Year

Fall

ASTR 311 Stellar Physics	(3-0-3) ^b
PHYS 313 Thermodynamics & Statistical Mechanics	(3-0-3)
Technical Elective	(3-0-3)
Arts & Humanities II	(3-0-3)
Social Sciences I	(3-0-3)
Total	15-0-15

Spring

ASTR 328 Cosmology and the Structure of the Universe	(3-0-3) ^b
PHYS 324 Electricity & Magnetism I	(3-0-3)
PHYS 326 Physical Optics	(3-0-3)
Quantitative Reasoning	(3-0-3)
Technical Elective	(3-0-3)
Total:	15-0-15

Senior Year

Fall

ASTR 306 Astronomical Techniques (SAGES)	(3-0-3) ^b
ASTR 309 Senior Seminar I	(1-0-1)
PHYS 325 Electricity & Magnetism II	(3-0-3)
PHYS 331 Quantum Mechanics I	(3-0-3)
ASTR 351 SAGES Astronomy Capstone	(1-0-1) ^c
Technical Elective	(3-0-3)
Global and Cultural Diversity	(3-0-3)
Total:	17-0-17

Spring

ASTR 310 Senior Seminar II	(1-0-1)
ASTR 323 The Local Universe	(3-0-3) ^b
PHYS 332 Quantum Mechanics II	(3-0-3)
ASTR 351 SAGES Astronomy Capstone	(3-0-3) ^c
Social Science II	(3-0-3)

Technical Elective(3-0-3)
Total: 16-0-16

Total Hours Required for Graduation: 122

Six hours of Mathematics and Natural Science (Physics) are double counted towards SAGES Breadth Requirement and 1 required math course is double counted towards the SAGES Quantitative Reasoning requirement.

Astronomy Hours: 20
Physics Hours: 43
Math Hours: 14
Technical Electives Hours 12

Technical Electives are additional courses in astronomy, chemistry, mathematics, statistics, physics, or geology which satisfy interests of the student but also fall within the science/mathematics objectives of the major. For a complete list of approved technical electives see advisor.

Approved Technical Electives - B. S. In Astronomy (This is not an exhaustive list)

GEOL 345 Planetary Materials
MATH 201 Introduction to Linear Algebra
MATH 345 Introduction to Applied Mathematics
PHYS 316 Introduction to Nuclear and Particle Physics
PHYS 349 Methods of Mathematical Physics I
PHYS 350 Methods of Mathematical Physics II

Astronomy minor requirements for all students except Physics majors:

- PHYS 115 (or equivalent)
- PHYS 116 (or equivalent)
- ASTR 221
- ASTR 222
- one of ASTR 306/311/323/328

University rules do not allow hours within the major department to count towards a minor; therefore, the requirements for Physics majors are different.

Astronomy minor requirements for Physics majors:

- ASTR 221
- ASTR 222
- one of ASTR 306/311/323/328
- 6 more credit hours of Astronomy courses, taken from:
 ASTR 151/306/309/310/311/323/328/351/369

- a. Selected students may be invited to take PHYS 123, 124, 223 in place of 121, 122, 221.
- b. ASTR 306,311,323 and 328 are taught every other year only.
- c. A SAGES Capstone Experience is required of all students. The Astronomy BS does *not* require the Astronomy Capstone but only that a Capstone be taken. The number of hours shown assumes the

Astronomy Capstone with 1 hour in the Senior Fall Semester and 3 hours in the Senior Spring Semester. If another Capstone is taken the number of hours may be different.

Bachelor of Arts Degree Major in Astronomy

Freshman Year(Credit Hours)

Fall

MATH 121 Calculus for Science & Engineering I.....	(4)
or MATH 123 Calculus I.....	(4)
PHYS 121 General Physics I: Mechanics.....	(4)
PHED 101 Physical Education Activities.....	(0)
First Seminar	(4)
Social Science I.....	(3)
Total.....	(15)

Spring

MATH 122 Calculus for Science & Engineering II.....	(4)
or MATH 124 Calculus II.....	(4)
PHYS 122 General Physics II: Electricity and Magnetism	(4)
PHED 102 Physical Education Activities.....	(0)
ENGR 131 Elementary Computer Programming	(3)
ASTR 151 Doing Astronomy*	(1)
Social Science II	(3)
Total.....	(15)

* Suggested but Not Required For the Major

Sophomore Year

Fall

ASTR 221 Stars and Planets	(3)
MATH 223 Calculus for Science & Engineering III	(3)
or MATH 227 Calculus III	(3)
PHYS 221 General Physics III: Modern Physics.....	(3)
University Seminar	(3)
Total.....	(15)

Spring

ASTR 222 Galaxies and Cosmology	(3)
MATH 224 Elementary Differential Equations.....	(3)
or MATH 228 Differential Equations.....	(3)
PHYS 250 Mathematical Physics & Computing	(3)
PHYS 310 Classical Mechanics.....	(3)
University Seminar	(3)
Total.....	(18)

Junior Year

Fall

ASTR 311 Stellar Physics.....	(3) ^a
PHYS 313 Thermodynamics & Statistical Mechanics	(3)
Arts & Humanities I.....	(3)
Arts & Humanities II	(3)

Technical Elective.....	(3)
Total	(15)

Spring

ASTR 328 Cosmology and the Structure of the Universe	(3) ^a
PHYS 324 Electricity & Magnetism I	(3)
PHYS 326 Contemporary Physical Optics	(3)
Quantitative Reasoning.....	(3)
Technical Elective.....	(3)
Total	(15)

Senior Year

Fall

ASTR 306 SAGES Departmental Seminar.....	(3) ^a
ASTR 309 Seminar I.....	(1)
PHYS 331 Quantum Mechanics I.....	(3)
ASTR 351 SAGES Astronomy Capstone	(1) ^b
Global and Cultural Diversity	(3)
Total	(11)

Spring

ASTR 310 Senior Seminar II.....	(1)
ASTR 351 SAGES Astronomy Capstone	(3) ^b
Total	(4)

Total Hours In Core and Departmental Requirements: 107

Open Electives to be added as appropriate to bring the total number of hours to the minimum of 120 needed for graduation with a B.A.

Six hours of Mathematics and Natural Science (Physics) double counted towards SAGES Breadth Requirement and 1 required math course double counted towards SAGES Quantitative Reasoning requirement.

Astronomy Hours:.....	18
Physics Hours:	29
Math Hours:	14
Technical Electives Hours:	6

Technical Electives are additional courses in astronomy, chemistry, mathematics, statistics, physics, or geology which satisfy interests of the student but also fall within the science / mathematics objectives of the major. For a complete list of approved technical electives see advisor.

Astronomy minor requirements for all students except Physics majors:

- PHYS 115 (or equivalent)
- PHYS 116 (or equivalent)
- ASTR 221
- ASTR 222
- one of ASTR 306/311/323/328

University rules do not allow hours within the major department to count towards a minor; therefore, the requirements for Physics majors are different.

Astronomy minor requirements for Physics majors:

- ASTR 221
- ASTR 222
- one of ASTR 306/311/323/328
- 6 more credit hours of Astronomy courses, taken from:
 ASTR 151/306/309/310/311/323/328/351/369

Approved Technical Electives - B. A. In Astronomy (This is not an exhaustive list):

CHEM 107 Properties and Structure of Matter I
CHEM 108 Properties and Structure of Matter II
PHYS 204 Advanced Instrumentation Lab
PHYS 316 Introduction to Nuclear and Particle Physics
PHYS 325 E&M II
PHYS 332 QM II

- a. 300 level Astronomy Courses: 3 of the following 4 are required: (ASTR 306, 311, 323, 328)
- b. A SAGES Capstone Experience is required of all students. The Astronomy BA does *not* require the Astronomy Capstone but only that a Capstone be taken. The number of hours shown assumes the Astronomy Capstone with 1 hour in the Senior Fall Semester and 3 hours in the Senior Spring Semester. If another Capstone is taken the number of hours may be different.

COURSE DESCRIPTIONS

Undergraduate Courses

ASTR 151. Doing Astronomy (1).

This course is intended to introduce students to how astronomy is done. The course will focus on the astronomy research process, the scientific community, and on career paths in astronomy. Course activities will include readings and class discussions focusing on various topics in modern astronomy, including ongoing research activity in the department.

ASTR 201. The Sun and its Planets (3)

An overview of the solar system; the planets and other objects that orbit about the sun and the sun itself as the dominant mass and the most important source of energy in the solar system. Concepts and the development of our knowledge will be emphasized. Not available for credit to astronomy majors.

ASTR 202. Stars, Galaxies, and the Universe (3)

Stellar structure, energy sources, and evolution, including red giants, white dwarfs, supernovae, pulsars, and black holes. Stellar populations in the Milky Way and external galaxies. The universe and its evolution. Not available to astronomy majors.

ASTR 203. Archaeoastronomy: Calendars, Barrows, and Megaliths (3)

To acquaint the student with the regular cycles of the Sun, Moon, planets, and stars. To show how ancient civilizations (and some not so ancient) have used those cycles to formulate calendars which are evidenced primarily by artifacts and ruins scattered over the entire Earth.

ASTR 204. Einstein's Universe (3)

This course is intended to introduce the non-scientist to the concepts of modern cosmology—the structure and evolution of the universe. No mathematical background beyond simple algebra is needed.

ASTR 205. The Scale of the Universe (3)

The solar system, stars, and galaxies. Our place in the Universe. Cosmology and the evolution of the Universe. The use of physical laws to study the Universe. The scientific method—predictions and tests of scientific theory.

ASTR 206. Life in the Universe (3).

This course is intended to introduce the non-scientist to the field of astrobiology – the interdisciplinary study of, and the search for, extraterrestrial life and the conditions for extraterrestrial life in the Universe.

ASTR 221. Stars and Planets (3)

Stellar structure and energy production. Formation and evolution of stars. Supernovae, neutron stars, and black holes. Star clusters. Planetary systems and the detection of extrasolar planets. The application of physical laws to the study of the universe. Prereq: MATH 122 or MATH 126.

ASTR 222. Galaxies and Cosmology (3)

The Milky Way Galaxy. Structure, dynamics, and evolution of galaxies. Galaxy clusters and large scale structure of the Universe. Physical cosmology and the Big Bang. Evolution of the Universe. Prereq: ASTR 221 or consent of department.

ASTR 306. Astronomical Techniques (3)

This course covers the techniques astronomers use to conduct research, including observations using ground- and space-based telescopes, computer simulations and other numerical methods, and statistical data mining of large on-line astronomical datasets. Prereq: ASTR 221 and ASTR 222.

ASTR 309. Senior Seminar I (1)

Selected topics in astronomy not covered ordinarily in courses. Presentation of talks by the students.

ASTR 310. Senior Seminar II (1)

Selected topics in astronomy not covered ordinarily in courses. Presentation of talks by students.

ASTR 311. Stellar Physics (3)

Radiative transfer, atomic and molecular opacities, and the observable properties of stars. Stellar interiors, nuclear processes, and energy generation. The evolution of stars of varying mass and production of the elements within supernovae explosions. Prereq: ASTR 222.

ASTR 323. The Local Universe (3)

The Milky Way Galaxy. Galaxy populations. Quantitative structure and dynamics of galaxies. The interstellar media of galaxies. Dark matter and stellar populations. The Local Group and Virgo cluster. Prereq: ASTR 222.

ASTR 328. Cosmology and the Structure of the Universe (3)

Distances to galaxies. The content of the distant universe. Large scale structure and galaxy clusters. Physical cosmology. Structure and galaxy formation and evolution. Testing cosmological models. Cross-listed as PHYS 328.

ASTR 351. Astronomy Capstone Project (Fall Semester 1 Hour and Spring Semester 2 or 3 Hours – Total Hours 3 or 4)

A two semester course (1 hour in the Fall Semester and either 2 or 3 hours in the Spring Semester) for students desiring a Capstone Experience in astronomy. Students pursue a project based on experimental, theoretical or teaching research under the supervision of an astronomy faculty member. A departmental Capstone Project Committee must approve all project proposals (by the end of the Fall Semester) and this

same committee will receive regular oral and written progress reports. Final results are presented at the end of the semester as a paper in a style suitable for publication in a professional journal as well as an oral report in a public symposium. (*approved SAGES capstone*) Prerequisites: ASTR 222 and consent of the department.

ASTR 369. Undergraduate Research (1-3)

Supervised research on topics of interest. Can be used as a thesis course if desired. Students may register more than once for a maximum of 9 credits overall (1-3 credits each semester). Prereq: Consent of department.

ASTR 396. Special Topics in Astronomy (1-3)

Open to astronomy majors only.

Graduate Courses

ASTR 409. Nucleosynthesis and Chemical Evolution (3)

Formation of the elements by stellar nucleosynthesis, especially within supernovae. The subsequent dispersal of this material into the interstellar medium and its incorporation into stars. The observable elemental content of stars and the relation of that content to the history and dynamics of the Galaxy. Prereq: Consent of department.

ASTR 411. Stellar Physics (3)

(See ASTR 311.)

ASTR 423. The Local Universe (3)

(See ASTR 323.)

ASTR 427. Dynamical Astronomy (3)

Gravitational dynamics of stars, star clusters, and galaxies. Dynamical evolution of gravitational systems. Dynamical equilibria, stability, and perturbation theory. Analytic and computational techniques. Prereq: Consent of department.

ASTR 428. Cosmology and the Structure of the Universe (3)

(See ASTR 328.) Cross-listed as PHYS 428.

ASTR 497. Special Topics in Astronomy (1-3)

Prereq: Consent of department.

ASTR 701. Dissertation Ph.D. (1-18)

(Credit as arranged.)