

## 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](mailto: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**

Paul Harding, Ph.D.  
(University of Arizona)  
Observatory Manager

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**

Jeffrey 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.

\*\*\*\*\*

## BACHELOR OF SCIENCE IN ASTRONOMY DEGREE COURSES

### **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 hours required, up to 24 with Astronomy capstone (Class-Lab-Credit Hours)**

ASTR 151 Doing Astronomy *	(1-0-1)	* Suggested but Not Required For the Major
ASTR 221 Stars and Planets	(3-0-3)	
ASTR 222 Galaxies and Cosmology	(3-0-3)	
ASTR 306 Astronomical Techniques (SAGES Dept Seminar)	(3-0-3) <sup>a</sup>	
ASTR 309 Astrophysics Seminar I	(1-0-1)	
ASTR 310 Astrophysics Seminar II	(1-0-1)	
ASTR 311 Stellar Physics	(3-0-3) <sup>a</sup>	
ASTR 323 The Local Universe	(3-0-1) <sup>a</sup>	
ASTR 328 Cosmology and the Structure of the Universe	(3-0-3) <sup>a</sup>	
ASTR 351 SAGES Astronomy Capstone	(4-0-(3-4)) <sup>b</sup>	

<sup>a</sup>. ASTR 306,311,323 and 328 are taught every other year only.

<sup>b</sup>. 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 Astronomy Capstone requires 1 hour in the Senior Fall Semester and 2-3 hours in the Senior Spring Semester. If another Capstone is taken the number of hours may be different.

### **Physics Hours: 43**

PHYS 121 General Physics I - Mechanics	(4-0-4) <sup>c</sup>
--	----------------------

PHYS 122 General Physics II: Electricity & Magnetism ..(4-0-4) <sup>c</sup>
PHYS 203 Laboratory Physics .....(2-4-4)
PHYS 204 Advanced Instrumentation Lab .....(1-4-4)
PHYS 221 General Physics III: Modern Physics .....(3-0-3) <sup>c</sup>
PHYS 250 Mathematical Physics & Computing .....(3-0-3)
PHYS 310 Classical Mechanics .....(3-0-3)
PHYS 313 Thermodynamics & Statistical Mechanics ... (3-0-3)
PHYS 324 Electricity & Magnetism I .....(3-0-3)
PHYS 325 Electricity & Magnetism II .....(3-0-3)
PHYS 326 Physical Optics .....(3-0-3)
PHYS 331 Quantum Mechanics I .....(3-0-3)
PHYS 332 Quantum Mechanics II ..... (3-0-3)

c. Selected students may be invited to take PHYS 123, 124, 223 in place of 121, 122, 221.

**Math Hours: 14**

MATH 121 Calculus for Science & Engineering I .....(4-0-4)
or MATH 123 Calculus I .....(4-0-4)
MATH 122 Calculus for Science & Engineering II.....(4-0-4)
or MATH 124 Calculus II .....(4-0-4)
MATH 223 Calculus for Science & Engineering III.....(3-0-3)
or MATH 227 Calculus III .....(3-0-3)
MATH 224 Elementary Differential Equations .....(3-0-3)
or MATH 228 Differential Equations .....(3-0-3)

**ENGR/Computing Hours: 3**

ENGR 131 Elementary Computer Programming .....(3-0-3)
---

**Technical Electives Hours 9**

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

\*\*\*\*\*

**BACHELOR OF ARTS IN ASTRONOMY DEGREE COURSES**

**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: 17 required, up to 21 with Astronomy capstone**

### **(Class-Lab-Credit Hours)**

ASTR 151 Doing Astronomy*	(1-0-1)	* Suggested but Not Required For the Major
ASTR 221 Stars and Planets	(3-0-3)	
ASTR 222 Galaxies and Cosmology	(3-0-3)	
ASTR 306 Astronomical Techniques (SAGES Dept Seminar)	(3-0-3) <sup>a</sup>	
ASTR 309 Astrophysics Seminar I	(1-0-1)	
ASTR 310 Astrophysics Seminar II	(1-0-1)	
ASTR 311 Stellar Physics	(3-0-3) <sup>a</sup>	
ASTR 323 The Local Universe	(3-0-3) <sup>a</sup>	
ASTR 328 Cosmology and the Structure of the Universe	(3-0-3) <sup>a</sup>	
ASTR 351 SAGES Astronomy Capstone	(4-0-(3-4)) <sup>b</sup>	

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 Astronomy Capstone requires 1 hour in the Senior Fall Semester and 2-3 hours in the Senior Spring Semester. If another Capstone is taken the number of hours may be different.

## **Physics Hours: 29**

PHYS 121 General Physics I: Mechanics	(4-0-4)
PHYS 122 General Physics II: Electricity and Magnetism	(4-0-4)
PHYS 221 General Physics III: Modern Physics	(3-0-3)
PHYS 250 Mathematical Physics & Computing	(3-0-3)
PHYS 310 Classical Mechanics	(3-0-3)
PHYS 313 Thermodynamics & Statistical Mechanics	(3-0-3)
PHYS 324 Electricity & Magnetism I	(3-0-3)
PHYS 326 Contemporary Physical Optics	(3-0-3)
PHYS 331 Quantum Mechanics I	(3-0-3)

## **Math Hours: 14**

MATH 121 Calculus for Science & Engineering I	(4-0-4)
or MATH 123 Calculus I	(4-0-4)
MATH 122 Calculus for Science & Engineering II	(4-0-4)
or MATH 124 Calculus II	(4-0-4)
MATH 223 Calculus for Science & Engineering III	(3-0-3)
or MATH 227 Calculus III	(3-0-3)
MATH 224 Elementary Differential Equations	(3-0-3)
or MATH 228 Differential Equations	(3-0-3)

## **ENGR/Computing Hours: 3**

ENGR 131 Elementary Computer Programming	(3-0-3)
--	---------

## **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.

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

\*\*\*\*\*

MINOR IN ASTRONOMY DEGREE COURSES

*The requirements for the minor have been streamlined and are now as follows:*

**Astronomy minor requirements for all students except Physics majors: 17 Hours**

- PHYS 115 Introduction to mechanics (or equivalent-PHYS 121,123)..... (4)
- PHYS 116 Introduction to Electricity & Magnetism (or equivalent PHYS 122,124)..... (4)
- ASTR 221 Stars and Planets..... (3)
- ASTR 222 Galaxies and Cosmology..... (3)

one of the following:

- ASTR 306 Astronomical Techniques\*.....(3)
- ASTR 311 Stellar Physics\* ..... (3)
- ASTR 323 The Local Universe\*.....(3)
- ASTR 328 Cosmology and the Structure of the Universe\*..... (3)

(\*These courses are taught every other year only)

**Astronomy minor requirements for Physics majors: 15 hours**

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

- ASTR 221 Stars and Planets.....(3)
- ASTR 222 Galaxies and Cosmology.....(3)

**one** of the following:

- ASTR 306 Astronomical Techniques\*.....(3)
- ASTR 311 Stellar Physics\* .....(3)
- ASTR 323 The Local Universe\*.....(3)
- ASTR 328 Cosmology and the Structure of the Universe\*.....(3)

(\*These courses are taught every other year only)

**6 more credit** hours of Astronomy courses, taken from:

- ASTR 151 Doing Astronomy ..... (1)
- ASTR 306 Astronomical Techniques\*..... (3)
- ASTR 309 Astrophysics Seminars I..... (1)
- ASTR 310 Astrophysics Seminars II ..... (1)
- ASTR 311 Stellar Physics\* ..... (3)
- ASTR 323 The Local Universe\* ..... (3)
- ASTR 328 Cosmology and the Structure of the Universe\*..... (3)
- ASTR 351 Astronomy Capstone Project..... (3-4)
- ASTR 369 Undergraduate Research ..... (1-3)

(\*These courses are taught every other year only)

\*\*\*\*\*

## 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)<sup>c</sup>  
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)<sup>c</sup>  
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)<sup>c</sup>  
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)<sup>a</sup>  
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) <sup>a</sup>
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 Dept Seminar)...	(3-0-3) <sup>a</sup>
ASTR 309 Astrophysics 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) <sup>b</sup>
Technical Elective.....	(3-0-3)
Global and Cultural Diversity .....	(3-0-3)
Total: .....	17-0-17

### Spring

ASTR 310 Astrophysics Seminar II .....	(1-0-1)
ASTR 323 The Local Universe .....	(3-0-3) <sup>a</sup>
PHYS 332 Quantum Mechanics II .....	(3-0-3)
ASTR 351 SAGES Astronomy Capstone .....	(3-0-3) <sup>b</sup>
Social Science II .....	(3-0-3)
Technical Elective .....	(3-0-3)
Total: .....	16-0-16

## BACHELOR OF ARTS IN ASTRONOMY DEGREE

**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) <sup>a</sup>
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) <sup>a</sup>
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 Astronomical Techniques (SAGES Dept Seminar)	(3) <sup>a</sup>
ASTR 309 Astrophysics Seminar I.....	(1)
PHYS 331 Quantum Mechanics I.....	(3)
ASTR 351 SAGES Astronomy Capstone.....	(1) <sup>b</sup>
Global and Cultural Diversity.....	(3)
Total .....	(11)

### Spring

ASTR 310 Astrophysics Seminar II .....	(1)
ASTR 351 SAGES Astronomy Capstone.....	(3) <sup>b</sup>
Total .....	(4)