Handbook for Undergraduate Students in Astronomy 2025-2026

Department of Astronomy | University of Wisconsin-Madison | 475 North Charter Street | Madison, WI 53706-1582 | (608) 262-3071 | www.astro.wisc.edu

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University of Wisconsin-Madison

Department of Astronomy

Location:

University of Wisconsin-Madison
2532 Sterling Hall
475 N Charter Street
Madison WI 53706
http://www.astro.wisc.edu/

Department of Astronomy Directory http://www.astro.wisc.edu/our-people/directory/

Undergraduate Advising:

Not sure which courses you should take? Would you like to get involved in a research project? Do you have an academic problem that you need assistance with? Have you met the Astronomy Major course requirements and you are ready to declare a major?

Faculty Advisors

Prof. Juliette Becker
6th floor Sterling Hall, juliette.becker@wisc.edu
Prof. Ke Zhang
6th Floor Sterling Hall, ke.zhang@wisc.edu

Undergraduate Advisor

Evan Heintz
2320D Chamberlain Hall, 608-263-7450, eheintz@wisc.edu or make an appointment via Starfish

Department of Physics Undergraduate Website http://www.physics.wisc.edu

Welcome to the University of Wisconsin-Madison Department of Astronomy!

Department Chair: Dr. Amy Barger

The UW-Madison Astronomy Department's mission is to conduct cutting edge research and to offer students and postdocs the highest quality of education. We conduct research in diverse areas of astronomy, from the physics of stars to cosmology, in observation and theory, and through the construction of cutting-edge instruments for our complement of telescopes. We pride ourselves in an inclusive, diverse, and friendly scientific environment.

Research Universities like the UW-Madison offer undergraduate students the unique opportunity to become involved in forefront research at the cutting edge of science. Beyond developing technical and scientific writing skills, the immersion in a research program in the Astronomy Department at UW-Madison gives students the opportunity to develop a genuine understanding of the process and culture of modern science.

Apart from purely academic matters, we value your personal well- being. If there is anything you think we can help with, contact the department office, located on the second floor of Sterling Hall.

Diversity is a source of strength, creativity, and innovation for UW–Madison. We value the contributions of each person and respect the profound ways their identity, culture, background, experience, status, abilities, and opinion enrich the university community. We commit ourselves to the pursuit of excellence in teaching, research, outreach, and diversity as inextricably linked goals.

The University of Wisconsin–Madison fulfills its public mission by creating a welcoming and inclusive community for people from every background — people who as students, faculty, and staff serve Wisconsin and the world.

Department of Astronomy
UNIVERSITY OF WISCONSIN–MADISON

At present, we have seventeen faculty members in the Department, all of whom teach undergraduate courses and carry on programs of research. Wisconsin astronomy is famous for technological advances in instrumentation and major astronomical discoveries. Historically, Washburn Observatory, which opened on campus in 1878, pioneered the development of photoelectric astronomy. Later, Wisconsin led the nation into space astronomy, building the first Orbiting Astronomical Observatory and then the Wisconsin Ultraviolet Photo-Polarimeter Experiment (WUPPE), which flew aboard the Space Shuttle. Wisconsin astronomers also served on the teams responsible for four Hubble Space Telescope instruments, including the current Cosmic Origins Spectrograph. Today, UW is the lead institution in a major infrared survey of the Milky Way galaxy using the Spitzer Space Telescope.

Examples of Wisconsin's continuing technological innovation are the Wisconsin H-a Mapper (WHAM) that has discovered a new major component of the Milky Way Galaxy; the Star Tracker 5000 which has become the premier guidance system for astronomical rocket and balloon flights; and the Wide-field Imaging Spectro-Polarimeter, a rocket payload. The University of Wisconsin-Madison is also a major partner in both the WIYN and SALT observatories. The WIYN 3.5-meter telescope is located on Kitt Peak in Arizona and is fully operable by undergraduates in Sterling Hall. Wisconsin faculty and students are in the process of building fiber optic "integrated field units'' to advance WIYN spectroscopy. The Robert Stobie Spectrograph, the primary first-light instrument for SALT, an 11m telescope located outside Sutherland, South Africa, was designed and built in Chamberlain Hall. Currently, its sibling spectrograph for near-infrared observations is also being designed and built on campus. The Department recently established a 5-year partnership with IRAM (Institut de Radioastronomie Millimétrique) to obtain access to two radio telescopes: The Northern Extended Millimeter Array (NOEMA) in French Alps and the 30-m single-dish telescope in the south of Spain. In addition, the Department operates two 2.3-m Small Radio Telescopes (SRTs) for educational purposes. One SRT is located on the roof of Sterling Hall, while the second one is in Pine Bluff. Both are extensively used for undergraduate and graduate classes, as well as public outreach.

Wisconsin's research interests range from studies of the large-scale structure of the Universe through observations of galaxies and clusters of galaxies to work on the formation of stars and the interstellar medium out of which they form. We also carry out theoretical research into the dynamics of galaxies, the nature of interstellar gas and dust, the internal structure out to the winds of hot stars, and the origins of stars. The Department operates a powerful network of image processing workstations for the analysis and interpretation of astronomical data, using both national high-performance computing facilities and several large departmental computer clusters. Most importantly, undergraduates are welcome to join us in any of these research programs.

To understand the techniques and ideas of modern astronomy requires a thorough background in physics and mathematics. This is particularly important for the student who plans a career in astronomy. For this reason, the Astronomy Department offers the Astronomy-Physics major to provide undergraduates with the opportunity to develop an appreciation of our current understanding of the physical universe. The Astronomy-Physics major includes core courses in astronomy that are taken while the student obtains the necessary comprehensive background in physics and mathematics. This booklet describes the Astronomy-Physics major in greater detail.

We look forward to joining you in your adventure at the University of Wisconsin and are excited that you are interested in majoring in astronomy. If you have any questions, please don't hesitate to contact us.

Department of Astronomy & Associated Faculty

Amy Barger
Ph.D. University of Cambridge, 1997
Observational cosmology, distant galaxies and supermassive black holes, observations at X-ray, optical, near-infrared, submillimeter and radio wavelengths, star formation and accretion histories of the Universe.

Thomas Beatty
Ph.D. Ohio State University, 2014
Exoplanet atmospheres, detection, habitability, and formation; optical and infrared observations from the ground (WIYN) and space (JWST, HST, TESS)

Juliette Becker
Ph.D. University of Michigan, 2019
Solar system and exoplanet dynamics; planet formation; habitability and dynamical evolution of habitable planets; exoplanet discovery and characterization

Matthew A. Bershady
Ph.D. University Of Chicago, 1994
Extragalactic Astronomy and observational cosmology; galaxy kinematics, image structure, stellar populations; galaxy and quasar evolution; optical and IR observations and instrumentation.

Elena D'Onghia
Ph.D. University of Milan, 2003
Cosmology, nature of dark matter, large scale structure formation, dynamics and galaxy formation.

Sebastian Heinz
Ph.D. Univ. Of Colorado, Boulder 2000
Relativistic jets, black holes, AGN, X-ray binaries, galaxy clusters, gamma ray bursts, interstellar and intergalactic medium.

Catherine (Kate) Grier
Ph.D. Ohio State University, 2013
Active galactic nuclei, supermassive black hole masses, reverberation mapping, quasar/active galaxy variability, quasar outflows/broad absorption lines, ground-based observing, the Sloan Digital Sky Survey, optical/UV spectroscopy

Alex Lazarian
Ph.D. University Of Cambridge, 1995
Magnetohydrodynamic turbulence, magnetic reconnection, generation of magnetic field, new ways to study magnetic fields from observations, interstellar polarization, CMB foreground, cosmic ray physics, star formation

Michael Maseda
Ph.D. Heidelberg University 2015
Galaxy formation and evolution; multi-wavelength imaging and spectroscopic surveys; cosmic Reionization; extreme stellar populations.

Robert D. Mathieu
Ph.D. Univ. of California-Berkeley, 1983
Observational studies of binary stars and star clusters, with emphasis on the evolution of stars within binaries. Involves stellar radial-velocity surveys, high-resolution optical/near-infrared spectroscopy, multi-wavelength spectral energy distributions, photometric variability, and stellar evolution modeling.

Melinda Soares-Furtado, Assistant Professor
Ph.D. Princeton University, 2020
Optical spectroscopy and time-series photometry; numerical stellar evolution; observational studies of stellar clusters and young moving groups; stellar age-dating; star-planet interactions; exoplanet detection and characterization.

Snezana Stanimirovic
Ph.D. University of Western Sydney, 1999
Galactic disk/halos, dust properties in low-metallicity environments, physics of the ISM, radio techniques and applications.

Zoe Todd
Ph.D. Harvard University, 2020
Astrobiology, astrochemistry, prebiotic chemistry, origins of life, planetary environments.

Richard H. Townsend
Ph.D. University College London, 1997
Theoretical and computational stellar astrophysics; numerical stellar evolution and asteroseismology; rotation, magnetic fields, and mass-loss of massive stars

Christy Tremonti
Ph.D. Johns Hopkins University, 2003
Galaxy and AGN co-evolution, galactic chemical

Eric M. Wilcots
Ph.D. University of Washington, 1992
Radio astronomy; observations of H I in galaxies and dynamics of galaxies; galaxy evolution; H II regions.

Susanna Widicus Weaver
Ph.D. California Institute of Technology, 2005
Astrochemistry, star formation, planet formation, molecular spectroscopy

Ke Zhang
Ph.D. California Institute of Technology, 2015
Planet formation, extrasolar planets, astrochemistry.

Ellen Zweibel
Ph.D. Princeton University, 1977
Theoretical astrophysics, especially plasma astrophysics. Generation and evolution of astrophysical magnetic fields, interstellar astrophysics, star formation, stellar physics.

Associated Faculty

The Department works closely with the members of the Department of Physics. Active researchers and programs include Baha Balantekin, neutrino astrophysics; Daniel Chung and Peter Timbie, cosmology; Francis Halzen and the Ice Cube team, neutrino astronomy, cosmic rays and active galaxies; and Dan McCammon, X-ray astronomy, soft X-ray background, the hot interstellar medium.

Professor Emeriti on Campus

Edward B. Churchwell
Ph.D. University of Indiana, 1970
Radio and infrared observations of massive star formation regions; atomic abundances and chemical evolution of the galaxy; chemistry and structure of interstellar molecular clouds.

John S. Gallagher, III
Ph.D. University of Wisconsin, 1972
Multi-wavelength observational investigations of physical processes that shape galaxies; the evolutionary states of galactic stellar populations and interstellar matter; relationships between stellar populations and the interstellar medium in actively star-forming galaxies.

Kenneth Nordsieck
Ph.D. Univ. of California-Santa Cruz, 1972
Instrumental, observational, and analytical applications of astronomical polarimetry; optical studies of supergiants and the polarization that arises from scattering by interstellar dust.

Senior Scientists

Eric Hooper
Ph.D. University of Arizona, 1997
Galaxy and AGN evolution. WIYN Development Scientist

Marina Orio
Ph.D. Technion, Haifa, Israel, 1987
Transients' populations, interacting binaries, accreting and hydrogen burning white dwarfs.

Jeffrey W. Percival
Ph.D. University of Wisconsin, 1979
Instrument control software, telescope control systems, guidance and navigation for suborbital rockets.

Bart Wakker
Ph.D. Groningen, 1990
The interstellar medium in the Galactic halo, high-velocity clouds, nearby galaxies, circumgalactic and intergalactic medium, absorption-line spectroscopy, radio astronomy.

Marsha Wolf
Ph.D. University of Texas-Austin, 2005
Galaxy evolution, stellar populations in galaxies, merging galaxies, post-starburst galaxies, quasar host galaxies, and astronomical instrumentation.

Research Areas

Stars & Stellar Systems
Stellar astrophysics studies the building blocks of galaxies – stars – both individually and in associations ranging from binary systems up to clusters, in order to understand the complex lifecycle of these remarkable objects.

Galactic Astronomy
Galactic astronomy studies the composition and structure of the Milky Way Galaxy, including the statistical properties of its stellar populations, and the global properties of the interstellar medium.

Theory & Computation
Astrophysical theory attempts to understand the universe, or aspects thereof, through the methods of physics and mathematics. Computational astrophysics uses numerical simulation to test and develop theoretical models, taking the place of experiments.

Plasma Astrophysics
Plasma astrophysics studies how plasmas behave in order to understand the detailed birth, evolution, and death of the wide variety of structures we can see in the universe: from stars and planetary systems to galaxies and clusters of galaxies.

Extragalactic Astronomy & Cosmology
Extragalactic Astronomy studies the structure and evolution of other galaxies, including their stellar populations, active galactic nuclei, and interstellar media, and the clustering of galaxies. Cosmology studies the structure and evolution of the universe as a whole.

Observational Astronomy
Observational Astronomy studies the visible universe by detecting photons and particles. Depending on wavelength, observers use a wide range of detection methods and a broad variety of skills to extract quantitative information from images, spectra, and light curves of cosmic objects.

Interstellar & Intergalactic Media
The interstellar and intergalactic media consist of gas, dust, magnetic fields, interstellar radiation, and energetic cosmic rays. The UW-Madison Astronomy program has a long, pioneering history in ISM/IGM and continues to lead a rich array of research in this area.

High Energy Astrophysics
High energy astrophysics studies the universe at its most extreme. Its focus is the understanding of compact objects and the processes occurring in their vicinity, the properties of ionizing cosmic radiation, and the acceleration of non-thermal particle distributions.

Instrumentation
Astronomical Instrumentation constructs the cameras and spectrographs that collect the data astronomers use to analyze astrophysical processes and test theories. Instruments can be designed to provide high spatial, spectral or time resolution.

Prebiotic Astrochemistry
Our research draws from the forefronts of laboratory spectroscopy, observational astronomy, and chemical modeling.

Exoplanets and Planet Formation
We aim to understand the formation and evolution of our Solar System and planetary systems around other stars.

Astrophysics in Physics
The Physics department hosts a number of groups working actively on astrophysical topics, ranging from cosmology to high-energy astrophysics.

Note that if you are interested in joining a research group in the department, it is **strongly** recommended that you take ASTRON 202: Introduction to Astronomy Research. Please talk with the academic advisor, Evan Heintz, as soon as possible if you are interested in joining a research group, and he will discuss the process with you.

Astronomy Requirements for the Major

The major requires a minimum of 39 credits in the field of specialization, with at least 12 of these credits in astronomy and at least 25 credits in physics.

Before declaring the major, students must have a cumulative GPA of 2.5 and complete the first two of the three intro sequence physics classes: Physics 247, 248, and 249, or 207, 208, and 241, or Physics 201, 202, 235. We encourage students to declare their major as early as possible. In addition, the specific course requirements for the major are (these also count toward the 15 credits of upper-level courses as required by the College of Letters and Science):

Astronomy:

Introductory Astronomy:

200 The Physical Universe, 3cr.

At least three of the following:

1. 310 Stellar Astrophysics, 3 cr
2. 320 The Interstellar Medium, 3 cr
3. 330 Galaxies and Cosmology, 3 cr
4. 335 Cosmology, 3 cr
5. 340 Solar System Astronomy, 3 cr
6. 500 Techniques of Modern Observational Astrophysics, 3 cr
7. 540 Exoplanets, 3 cr
8. 620, Special Topics, 1-3 cr

Physics:

1. 247-248-249 A Modern Introduction to Physics (or 201-202-235; or 207-208-241) 13-14 cr
2. 311 Mechanics, 3 cr
3. 322 Electromagnetic Fields, 3 cr
4. 415 Thermal Physics, 3 cr
5. 448 Atomic and Quantum Physics or 531 Introduction to Quantum Mechanics, 3cr.

A 300-level or higher laboratory course must be taken; Astronomy 465 or Physics 307

Recommended Additional Courses:

MATH: Mathematics courses other than those required as prerequisites for physics courses are not required for the major, but the following courses are recommended:

1. Math 319 (Ordinary Differential Equations)
2. Math 340 (Matrix and Linear Algebra)
3. Math 321 (Applied Analysis)

Students may take Math 320 (Linear Algebra and Differential Equations) instead of Math 319/340 if they are behind on their math, but it is recommended that students take the honors version so as not to miss any material.

If a student plans to work toward the PhD degree the student should also take:

1. Math 322 (Applied Analysis)
2. Math 431 (Intro to the Theory of Probability)

Note: Additional math (or statistics) courses should be chosen after consultation with the undergraduate advisor.

Computing: Computers are fundamental to astronomical research. One or more courses in programming, or short courses run by the computing center should be considered. We strongly recommend CompSci 220: Data Science Programming I.

Chemistry: A college course in physical or organic chemistry is useful for astronomy students. Physical chemistry is particularly valuable for those interested in the interstellar medium, comets, and planets.

Statistics: A background in statistics is valuable, particularly for students interested in observational astronomy. Statistics 301, or Statistics 309/310 for a more solid foundation, are suggested.

Honors in the Major

Students wishing to receive Honors in the Major must satisfy the following requirements:

1. Completion of four 300 or higher-level astronomy courses with a minimum grade point average of 3.5 at UW-Madison at the time of graduation.
2. Completion of a Senior Honors Thesis (Astron 681/682) with a grade of AB or better (for a total of 6 credits)

Students wishing to pursue Honors in the Major should contact their major advisor to seek guidance about planning the Honors in the Major curriculum that best reflects their special interests.

Declaring a Major in Astronomy

There are no requirements for declaring the Astronomy major. Students interested in declaring should set up an appointment with Evan Heintz, the Undergraduate Advisor to start the process.

Regularly Check the Degree Audit Reporting System (DARS)

The Degree Audit Reporting System (DARS) is part of UW-Madison's commitment to academic advising. A DARS report is particularly helpful when combined with the wisdom of skilled advisors. Always review the DARS report with the transcript. DARS reports become increasingly important as a student first decides on a particular college, then determines a major or combination of majors, and finally approaches graduation. DARS shows which requirements have been completed and which remain unsatisfied. It can offer suggestions about appropriate courses that may be taken to meet specific requirements. DARS is not intended to replace contact with your academic advisors. Students can print their DARS report through My-UW. 'What If' DARS reports may be helpful in showing how completed or in-progress courses may be used in different degree programs.

Astronomy-Physics Undergraduate Catalog website:
https://guide.wisc.edu/undergraduate/letters-science/astronomy/astronomy-physics-bs/

Course Descriptions

Astronomy 103: The Evolving Universe. I, II; 3 cr (P-E). The universe is vast and ever changing. The topics covered in this course include lifecycles of stars; supernovae and creation of elements; white dwarfs, pulsars and black holes; the Milky Way and galaxies; distances of stars and galaxies; quasars; expansion of universe; open and closed universes; the big bang. *Pre-requisites:* QR-A.

Astronomy 104: Exploration of the Solar System. I, II; 3 cr (P-E). Humanity is linked to the solar system in countless ways. Topics covered in this course include the sky and celestial motions; ancient astronomy; the Copernican revolution; gravity, orbits, and interplanetary travel; formation of the solar system; a survey of the sun, planets and moons; asteroids, meteors and comets; origin of life, and exoplanets. *Pre-requisites*: QR-A

ASTRON 140 — EARTH 2.0: the exoplanet revolution; 3cr (P-E). Our Galaxy contains about 100 billion stars. Most of these stars have planets as diverse and as fascinating as the worlds in our own neighborhood, the solar system. Learn about the study of planets and exoplanets, probing some of the deepest questions science and philosophy grapple with. Explore the ways in which scientists search for and analyze planets orbiting distant stars, both in the classroom and in hands-on laboratory experiences. From moons to super-Jupiters, this course provides an engrossing introduction into the brand new science of exoplanet research.

Astronomy 150: Topics in Astronomy. I or II; 2 cr (P-E). This course will intensively study selected topics of modern astronomy. Examples include missions to the planets, formation of stars and planets, end states of stellar evolution (supernovae, white dwarfs, pulsars, black holes), origin and evolution of the universe. *Pre-requisites:* None

Astronomy 170: The Dark Side of the Universe; I or II; 2 cr (P-E). Some of the greatest mysteries of the cosmos reside in what astrophysicists call "the dark sector". This course explores the nature of black holes, dark matter, and dark energy, which show us nature at its most extreme, taking you from the warping of spacetime and the launching of plasma beams around black holes to the acceleration of the cosmos that indicates the presence of some yet unknown form of energy. Learn about the fundamental laws of nature that govern everything from GPS satellites that enable navigation apps on your cell phone to the birth and ultimate fate of the universe.. *Pre-requisites:* None

Astronomy 200: The Physical Universe. I, II; 1; 2 cr (P-E). Modern astrophysics involves applying physical principles to understand astronomical phenomena. Includes the solar system, stars, nebulae, galaxies, and cosmology, with emphasis on origins and evolution. Some nighttime observation with telescopes required. *Pre-requisites*: Math 222 or Physics 201/207/247

Astronomy 202: Introduction to Astronomy Research II; 1; 1 cr (P-E). Learn the basic tools necessary to conduct research in astronomy. Explore the programming techniques employed in astrophysical research, with a focus on the Python programming language and associated packages that are most often used in astronomy. *Pre-requisites*: ASTRON 103, 104, 200, or concurrent enrollment in ASTRON 103, 104, or 200

Astronomy 310: Stellar Astrophysics. I; 3 cr (P-I). Properties of normal and peculiar stars as found from an analysis of the radiation they emit; introduction to radiation transfer. Theory of stellar atmospheres, interiors, and evolution. *Pre-requisites:* Astron 200 and Physics 205, 241, or 249 (or concurrent enrollment)

Astronomy 320: The Interstellar Medium. Alt yrs; II; 3 cr (A). Properties of neutral and ionized interstellar gas, giant molecular clouds, the warm and hot inter-cloud medium, supernova remnants, and interstellar dust. Physical processes in low-density gases including radiation transfer, excitation and ionization of interstellar atoms and molecules, and the interaction between gas and dust. *Pre-requisites:* Astron 200 and Physics 205, 241, or 249 (or concurrent enrollment)

Astronomy 330: Galaxies: Alt yrs; II; 3 cr (A). Distribution of stars, gas, and dust within our Milky Way, and their motions. Nearby galaxies: our Local Group. Optical, radio, and other techniques for observing galaxies. Composition and motions of other galaxies; galaxies with active nuclei; galaxy formation. *Pre-requisites:* Astron 200 and Physics 205, 241, or 249 (or concurrent enrollment)

Astronomy 335: Cosmology: Alt yrs; II; 3 cr (A). Introduction to the study of our Universe as a whole. Distribution of matter on the largest scales. Equations for cosmic expansion; making observations in an expanding curved spacetime. Nucleosynthesis and other tests of the Big Bang hypothesis. Gravitational collapse and the growth of structure. *Pre-requisites:* Astron 200 and Physics 205, 241, or 249 (or concurrent enrollment)

Astronomy 340: Solar System Astrophysics: Alt yrs; I; 3 cr (P-I). Properties of solar system objects, solar atmospheric phenomena, physics of planetary atmospheres, results of recent planetary missions, comets, origin of the solar system. *Pre-requisites:* Astron 200 and Physics 205, 241, or 249 (or concurrent enrollment)

Astronomy 465: Observational Astronomy and Data Analysis: 3 cr.
A basic introduction into astronomical observations and data analysis techniques by undertaking observational projects with optical and radio telescopes. Topics covered include observation and data reduction, basic calibration of radio and optical telescopes, basics of data analysis and statistics, presenting scientific results, and basics of scientific ethics. Although specific to observational astrophysics, these methods are applicable to any of the physical sciences disciplines. *Pre-requisites:* Astron 200 and Physics 205, 241, or 249

Astronomy 500: Techniques of Modern Observational Astrophysics: I or II; 1; 3 cr (A). An introduction to astrophysics data collection. Students will be familiarized with the concepts, techniques, skills and resources needed to plan, obtain, reduce and interpret observations of astronomical objects. *Pre-requisites*: Graduate student or Astron 310 and instructor consent.

Astronomy 540: Exoplanets: I or II; 1; 3 cr (A). Over the past several decades, astronomers have discovered thousands of planets orbiting stars other than the Sun. Learn about the various methods (transits, radial velocities, microlensing, and direct imaging) used to detect these exoplanets, the inherent challenges and limitations of current methodologies (data quality, processing, and bias), and theories related to exoplanet formation, atmospheres, and habitability. *Pre-requisites*: Graduate student, Astron 310 or 320

4-Year Plan

Four Year Plan		Astro-Physics Degree	BS
Fall 1	**Credits**	**Spring 1**	**Credits**
Math 221 (QR-B)	5	Math 222	4
Biological Science	3	Biological Science	3
Humanities	3	Astronomy 200 (non-majors take 103)	3
Language	4	Language	4
		Comm A	2
Total	15	Total	16
Fall 2	**Credits**	**Spring 2**	**Credits**
Physics 247	5	Physics 248	5
Math 234	4	Literature	3
Social Science	3	Social Science	4
Language	4	Math 320 (or 319 and 340)	3
Total	16	Total	15
Fall 3	**Credits**	**Spring 3**	**Credits**
Physics 249	4	Physics 311	3
Astronomy 310	3	Astronomy 300 level	3
Math 321	3	Social Science	3
Comm B	3	Literature	3
		Math 322	3
Total	13	Total	15
Fall 4	**Credits**	**Spring 4**	**Credits**
Physics 322	3	Social Science	3
Physics 448	3	Physics 449	3
Ethnic Studies	3	Physics 415	3
Astro 510 (or any 300 level lab)	2	Humanities	3
Elective	4	Astro 300 level (optional)	3
	15		15
		Total	**120**

Students are strongly encouraged to consider doing a Senior Thesis research project during their senior year (Astro 691/692). It is recommended that you start exploring possible topics with faculty prior to the senior year.

Strategies for Choosing Math Courses

There are specific math courses listed as prerequisites for physics courses. (Math courses other than those required as prerequisites for physics courses are not required for the Astronomy major, but Math 321 and 322 are recommended. If you plan to work toward the PhD, you should also take Math 320 or 319 and 340.) Please consult with an advisor when choosing your Mathematics course.

1. **Math 221/222:** Standard Introductory calculus sequence. Math 221 is a prerequisite to Physics 247, 207 and 201.
2. **Math 234:** Calculus of Several Variables, typically taken to complete the sequence Math 221/222/234. This course could be taken simultaneously with Math 319.
3. **Math 319:** Techniques in Ordinary Differential Equations. You are strongly advised to take this or Math 320 before or with Physics 311 (Mechanics).
4. **Math 340:** Elementary Matrix and Linear Algebra. Many physics students find this course to be particularly useful and we strongly suggest taking it or Math 320 before Physics 311. Math 320 is a "light" version of Math 319 and 340 and can be taken as a one-semester alternative to those if you are short on time.
5. **Math 321:** Applied Mathematical Analysis. Techniques for solving problems in the physical sciences, engineering, and applied mathematics, using advanced calculus and analytic function theory. Has some vector calculus. It is recommended that Math 321 be taken before taking Physics 322.
6. **Math 322:** Applied Mathematical Analysis. Techniques for solving partial differential equations, with an emphasis on practical problems in the physical sciences. Also covers special functions, Fourier Transformations, etc. Useful for advanced quantum mechanics and students interested in pursuing a Ph.D.
7. **Math 431:** Introduction to the Theory of Probability. Axioms of probability, random variables, the most important discrete and continuous probability distributions, expectation and variance, moment generating functions, conditional probability and conditional expectations, multivariate distributions, Markov's and Chebyshev's inequalities, laws of large numbers, and the central limit theorem. Useful for Physics 415 and 448.

Physics Department Suggested Curricula

The appropriate program for your goals should be established with the help of your advisor. The introductory program consists of Physics 247-248-249. Students are encouraged to take this sequence.

Alternatively, 207-208-241 or 201-202-235 (or 241) may be substituted. 235 should really only be taken by certain engineering students. The remainder of the physics core for the Astronomy Major program is Physics 311, 322, 415, 448, 449 (531 may be substituted for the 448-449 sequence) and a 300-level or higher laboratory course (Astronomy 465 or Physics 307).

Also Math 221-222-234 or equivalents are necessary since they are prerequisites for other courses. It is possible to enter the core program in either semester since almost all physics courses (other than Physics 448 and 449) are offered each semester. Students are urged to start the recommended sequence of courses (247/248/249) as soon as they have the calculus prerequisite (Math 222 or concurrent enrollment). However, students are still on track to graduate if they begin the sequence their sophomore year.

Involvement & Awards

Undergrads are sometimes shy about attending events they see advertised, even though the subjects may sound quite interesting. Don't be— seminars and colloquia are open events and **we welcome you to attend**. The percentage of a talk that anyone will likely be able to understand varies widely from one seminar to another, and from one speaker to another. If the title sounds interesting, then there's a fair chance you'll be able to keep up for a while. (Keep in mind that most people there will not generally follow the whole talk.)

Undergraduate Lounge

We have a lounge JUST for undergraduate students to use, study, chat, have lunch, and relax. The undergraduate lounge for astronomy-physics majors is in room 3527 Sterling Hall. If you need access to the room, contact Steve Anderson, in room 2544 Sterling Hall.

Astronomy Club

Get involved: organize and host movies, talks, study groups, or anything you think is of interest. Visit their Facebook page: https://www.facebook.com/astroclubuw/

Astronomy Colloquium Information

The Astronomy Colloquia on Thursday at 3:30 PM in 4421 Sterling is highly recommended for our undergraduate majors. The event begins at 3:15 PM with a social period while enjoying coffee and cookies, allowing you to meet and converse with Astronomy Department faculty and graduate students. The talk is presented to a group with widely varying interests; therefore, the material is conveyed in a more general fashion, with questions encouraged. Those with astrophysical interests at all levels of experience can enjoy an informative and supportive interaction in an environment of academic inquiry.

Physics Colloquium Information

The Physics Department hosts a large number of colloquia and seminars each year. Check the web for Colloquium & Seminar Notices. The Physics Colloquium at 3:30 PM on Friday afternoon in 2241 Chamberlin Hall is intended to be a broad-based presentation that physicists in all subfields have a chance to enjoy. It is preceded by cookies and coffee at 3:15 PM.

Awards

Lowell Doherty Award for Excellence in Astronomy: This is awarded in recognition of a graduating senior's exceptional performance in astronomical research and in the classroom as an Astronomy-Physics major. The criteria are: graduating senior undergraduate student, outstanding academic performance, and outstanding research performance. Students are nominated by Astronomy faculty and research scientists, and the award decision is made by the Department's awards committee every spring.

Fay Ajzenberg-Selove Scholarship Fund: This fund supports undergraduate **women** majoring in or planning to major in astronomy or physics. The fund was established in May 1996 by Professor Ajzenberg-Selove. Professor Selove received her MS in 1949 and Ph.D. in 1952 in Physics, both from the University of Wisconsin. Interested students should apply at: https://www.physics.wisc.edu/awards

Bernice Durand Undergraduate Research Scholarship: Established in 2003, this undergraduate research scholarship will be giving preference to women or to ethnic minorities in Physics and Astronomy who show research potential, motivation and interest in the discipline. This award will typically be given to 1 student per year after the completion of the three-semester introductory classical and modern physics sequence or equivalent and will enable the student to work with the research group of her or his choice. The intent is that the amount of the award shall be at least one third of the coming academic year's resident full year tuition. Interested students should apply at: https://www.physics.wisc.edu/awards

Research stipends and internships: Students should consider applying for several UW and national scholarships and awards listed at:
https://research.wisc.edu/information-for-undergraduate-students/
The Sophomore Research and Hilldale Undergraduate Fellowship in particular provides a stipend for undergraduate research in collaboration with a faculty member.

In addition, the Wisconsin Space Grant Consortium provides several possibilities for fellowships, internships and scholarships:
https://spacegrant.carthage.edu/funding-programs/undergraduate/

Students should contact their undergraduate advisor for additional scholarship information.

Undergraduate Research Opportunities

Process for Finding Undergraduate Research

If you are interested in undergraduate research with a faculty member or scientist in the department, you should first make an appointment with Evan Heintz, the Undergraduate Advisor, to start the process. It is recommended to do this as soon as you are interested so that we can get you involved as soon as possible. Research is extremely important for undergraduates to participate in, especially if you intend to get a Ph.D. after graduation.

REU

REU (Research Experience for Undergraduates) programs are a way for undergraduates to get some research experience, make contacts and become more involved in their academic community. They're funded by the NSF (National Science Foundation) and sites are located all over the country, as well as some NSF-funded sites abroad.

There are programs in astronomy, physics and many other fields, Atmospheric Sciences, Engineering, etc., as well.

Any US citizen or permanent resident who has not graduated prior to the start of the REU program is eligible to apply. A few of the programs (NRAO and NOAO) accept recent graduates. Check with the individual programs about eligibility.

Applicants are traditionally Sophomores or Juniors, although Freshmen are welcome to apply to most programs. Applications are typically due at the end of January/beginning of February. It's a good idea to start working on them no later than early December (see the checklist).

University of Wisconsin Programs

The University of Wisconsin provost's office offers undergraduate research fellowships in a variety of fields. These fellowships will provide you with funding to do a research project with a UW faculty member.

Sophomore fellowship for sophomore students
Hilldale fellowship for juniors

The UW also sponsors an undergraduate symposium, which is a wonderful venue to get some experience presenting your research. Applications will be available through the Symposium website.

The Undergraduate Research Scholars Program has some projects in the physical sciences which provide opportunities for younger undergraduate students to do research with a faculty mentor.

Other Internships and Sources of Funding

The Wisconsin Space Grant Consortium offers research awards for undergraduate students, up to $5,000, to fund research related to space-studies.

NASA funds many summer schools and institutes to prepare undergraduates for careers in science.

The NASA Academy is a unique experience for people with not only an interest in astronomy, but also earth science, manned space flight, engineering, or space policy and administration. It is a prestigious program with a dedicated Alumni Association. The application deadline is in January.

Google is offering the Anita Borg Scholarship to women in computing and science fields.

The nucleus has many summer internships in physics, astronomy and other physical sciences (both domestic and abroad) listed on their website.

Conferences for Undergraduate Research

The UW's Undergraduate Symposium undergraduate symposium.
Society for Advancement of Chicanos/Hispanics & Native Americans in Science
National Society of Black Physicists
APS Conference for Undergraduate Women in Physics

Useful Links

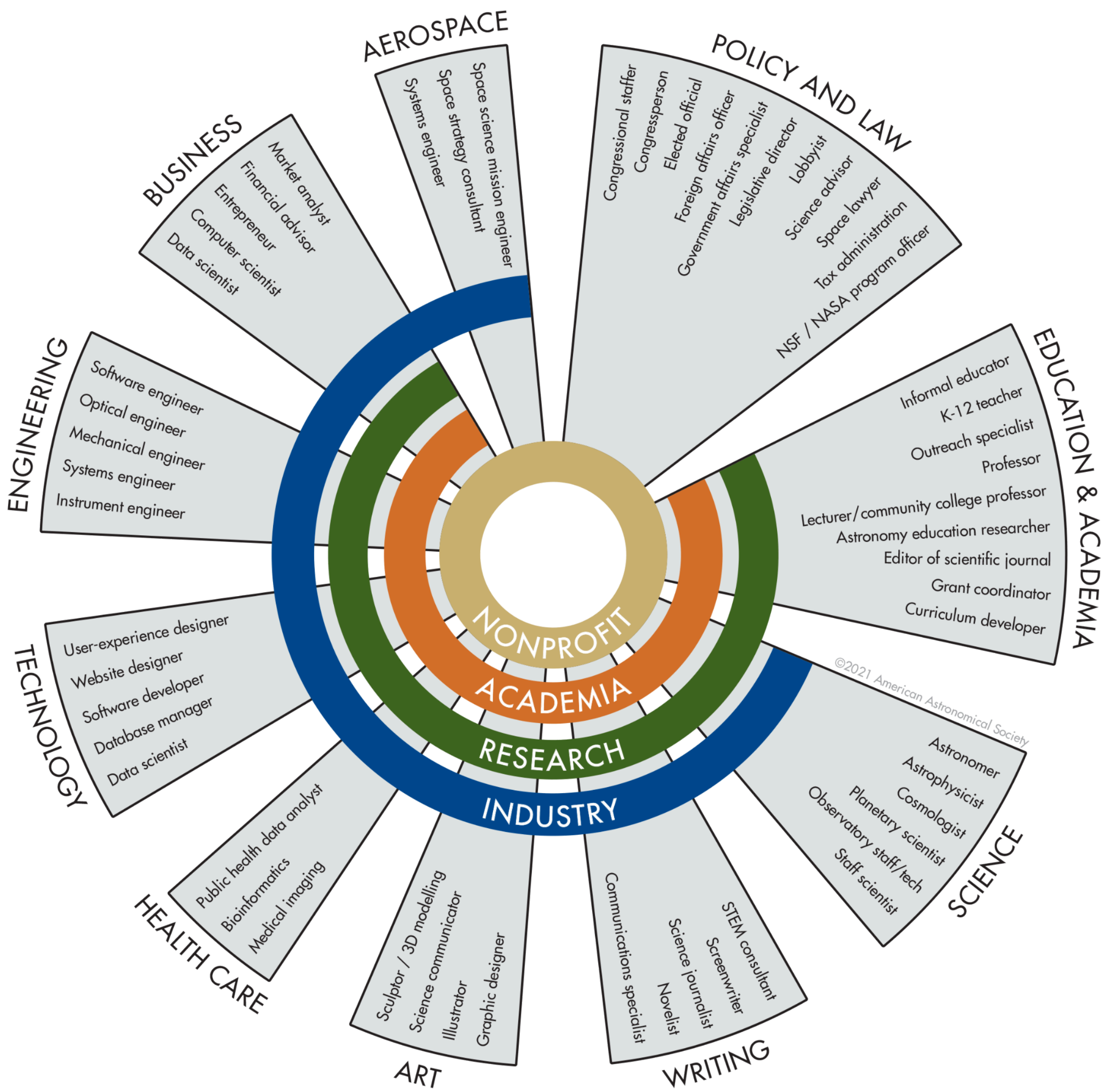
The AAS (American Astronomical Society) has a list of REU sites. If you scroll down, this has a good summary of application deadlines and program details. Note that the list is incomplete and there are more sites listed at the NSF REU page.

Final Notes

All of these opportunities can help you get a feel for what it's like to do research in the "real world" of academia and can really help you get your foot in the door. Not only will the contacts that you make help you in your future career, but you'll also have experiences which will speak well for you in job and graduate school applications.

Post-Degree Plans and Careers

The AAS Committee on Employment has created this Workforce Infographic you may find useful:



Further Reading:

- [The American Astronomical Society (AAS) Careers Hub]()
- [The AAS's "A New Universe to Explore: Careers in Astronomy"]()
- AAS Career Profiles: https://aas.org/careers/career-profiles
- [Bureau of Labor Statistics Report]()

What you can do with your ASTRONOMY-PHYSICS MAJOR

Major Skills:

Problem Solving & Critical Thinking
You learn how to define and analyze problems, identify factors that contribute to outcomes, analyze connections, and solve quantitative and qualitative problems proficiently.

Computational & Data Analysis
You learn to collect and organize quantitative and qualitative astronomical data; plan astronomical observations using scientific computing methods; test hypotheses; and properly conduct and interpret statistical analysis.

Teamwork
You collaborate inclusively with people from different local and global cultures.

Data Modeling
You build and interpret mathematical models of astronomical data using scientific computing methods.

Professional and Ethical Conduct
You demonstrate a professional demeanor, appropriately credit the contributions of others, and possess the ability to address a breakdown of professional ethics and standards if experienced or observed.

Communication
You communicate data, concepts and results with scientific peers and non-technical audiences in writing and through oral and visual presentations.

Supplement Your Skills With:

- Gain Experience: Research, Internships, & Part-Time Work
- Ethical Conduct in Data Analysis & Privacy
- Career & Self Development
- Learn Programming (eg. Python) and statistical analysis
- Experience Fostering Professional Equity & Inclusion
- Leadership On & Off Campus

Chart Your Path Forward

Activate Your Handshake Account for connections to jobs, internships, employer & alumni networking.

Explore Career Communities to discover a wide variety of fields where you can turn your major into success.

Get Career & Internship Advising from SuccessWorks to make a plan, whether you're a first-year student or about to graduate.

Get Started: successworks.wisc.edu

Put your Astronomy-Physics major to WORK

Common Alumni Job Titles:

- Software Engineer
- Professor
- Astronomer
- Chief Executive Officer
- Data Scientist
- Engineering Manager
- Software Developer
- Technical Services Manager
- Aerospace Engineer

Top Employers of Alumni:

- Amazon
- CDW
- Cerner Corporation
- Eastman Chemical Company
- Epic
- Google
- Intelsat
- John F. Kennedy Space Center
- Lockheed Martin
- MIT Lincoln Laboratory
- MMT Observatory
- NASA
- Oshkosh Corporation
- Space Telescope Science Institute
- Systems Engineering Group
- Uline
- University of Wisconsin-Madison
- US Marine Corps
- Waukesha Metal Products
- Wisconsin and Geological and Natural History Survey

Recent Grads' Career Plans:

59% Continuing Education or Grad School
38% Employment
3% Other

Where Alumni Live & Work:

37% Wisconsin
9% California
8% Illinois
6% Washington
39% Other

"My Astronomy-Physics major has given me a range of quantitative skills I've used in my roles as a data analyst, software engineer, and technical manager. At a basic level, the ability to think about and interpret data is essential. As a result, I was well-prepared to hit the ground running in my first job out of college. The emphasis on collaborative work helped prepare me for the modern workplace where the problems are too big to be tackled alone."

Alex Viana, 2007
VP of Data, Vercel
Chicago, IL

"A major in Astronomy-Physics is versatile and rewarding. I developed skills in software engineering and large-data management to work on advanced optical systems for the U.S. Department of Defense. Critical problem-solving skills and knowledge in a range of high-level topics helps me be successful in my professional career."

Jalyn Krause, 2021
Modeling and Analysis Assistant Staff, MIT Lincoln Laboratory
Lexington, MA

Career Communities for Astronomy-Physics Majors

SuccessWorks has eight Career Communities to connect you with career advising, resources, and programs. Here are a few suggestions on where Astronomy-Physics majors can start.

- **Technology, Data & Analytics**
- **Scientific Research & Development**
- **Government, Policy, International Affairs & Law**
- **Consulting, Finance, Management & Client Relations**

Not inspired by these options? Visit SuccessWorks to explore more widely.

successworks.wisc.edu