ASTRONOMY–PHYSICS, B.A.

ASTRONOMY

Astronomy, the oldest of the sciences, originated in the human urge to understand the mysterious lights we see in the sky above us—the Sun, the Moon, the planets and the stars. Over the centuries, new tools have become available to study these cosmic icons—telescopes that allow us to see further and fainter, detectors that are sensitive to electromagnetic signals at non-visible wavelengths, and satellites that can observe from outside the confines of the Earth's atmosphere. These tools have answered many questions, but raised even more. How did the Universe begin, and how did the stars and galaxies within it form? How will it end? Are there habitable planets around other stars—and has life emerged on these planets?

WHY STUDY ASTRONOMY?

- Because it's fascinating: Astronomy speaks directly to our natural urge to better understand our place in the cosmos.
- Because it's challenging: Astronomy studies objects that are distant beyond simple conception.
- Because it's adaptable: Astronomy utilizes a broad set of transferable skills, from a foundation in logical and quantitative reasoning through to data analysis, programming, and visualization.

The UW–Madison Astronomy–Physics program builds on a foundation of classical and modern physics, to embark on a comprehensive study of the observable Universe at scales extending from planets and stars, through to galaxies and the cosmic web.

A BACHELORS DEGREE FROM THIS STEM PROGRAM CAN:

- Prepare you for graduate studies for master's or doctoral degrees in experimental or theoretical Astronomy, Astrophysics or Physics.
- Prepare you for employment in industrial or governmental laboratories.
- Provide a broad background for further work in other sciences, such as materials sciences, aerospace, computer science, geophysics, meteorology, radiology, medicine, biophysics, engineering, and environmental studies.
- Provide a science-oriented liberal education. This training can be useful in some areas of business administration, public policy, law, or other fields where a basic knowledge of science is useful.
- Provide part of the preparation you need to teach Astronomy and Physics. To teach these subjects in high school, you will also take education courses to become certified. You will need a doctoral degree to become a college or university professor.

Students who intend to continue astronomy in a graduate program are strongly encouraged to get involved in research early. To learn about research opportunities in the department, please meet with faculty advisors. In addition, leading or co-authoring a professional journal publication, or doing a Senior Thesis ASTRON 691/ASTRON 692 or Senior Honors Thesis ASTRON 681/ASTRON 682, is highly encouraged. The experience of actual research and of writing a major paper develop both technical and writing skills.

HOW TO GET IN

Students are encouraged to declare their major as early as possible. Before declaring the major, students must complete the first two of the three classes in the Introductory PHYSICS sequence.

Introductory Physics sequences are:
Sequence 1: PHYSICS 247, PHYSICS 248, and PHYSICS 249
Sequence 2: PHYSICS 201, PHYSICS 202, and PHYSICS 205
Sequence 3: PHYSICS 207, PHYSICS 208, and PHYSICS 241

REQUIREMENTS

UNIVERSITY GENERAL EDUCATION REQUIREMENTS

All undergraduate students at the University of Wisconsin–Madison are required to fulfill a minimum set of common university general education requirements to ensure that every graduate acquires the essential core of an undergraduate education. This core establishes a foundation for living a productive life, being a citizen of the world, appreciating aesthetic values, and engaging in lifelong learning in a continually changing world. Various schools and colleges will have requirements in addition to the requirements listed below. Consult your advisor for assistance, as needed. For additional information, see the university Undergraduate General Education Requirements (http://guide.wisc.edu/undergraduate/#requirementsforundergraduatestudytext) section of the *Guide*.

General Education	• Breadth—Humanities/Literature/Arts: 6 credits • Breadth—Natural Science: 4 to 6 credits, consisting of one 4- or 5-credit course with a laboratory component; or two courses providing a total of 6 credits • Breadth—Social Studies: 3 credits • Communication Part A & Part B * • Ethnic Studies * • Quantitative Reasoning Part A & Part B *

* The mortarboard symbol appears before the title of any course that fulfills one of the Communication Part A or Part B, Ethnic Studies, or Quantitative Reasoning Part A or Part B requirements.

COLLEGE OF LETTERS & SCIENCE DEGREE REQUIREMENTS: BACHELOR OF ARTS (B.A.)

Students pursuing a bachelor of arts degree in the College of Letters & Science must complete all of the requirements below. The College of Letters & Science allows this major to be paired with either a bachelor of arts or a bachelor of science curriculum.

BACHELOR OF ARTS DEGREE REQUIREMENTS

Mathematics	Complete the University General Education Requirements for Quantitative Reasoning A (QR-A) and Quantitative Reasoning B (QR-B) coursework.

Foreign Language	• Complete the fourth unit of a foreign language; OR • Complete the third unit of a foreign language and the second unit of an additional foreign language.
L&S Breadth	• 12 credits of Humanities, which must include 6 credits of literature; and • 12 credits of Social Science; and • 12 credits of Natural Science, which must include one 3+ credit Biological Science course and one 3+ credit Physical Science course.
Liberal Arts and Science Coursework	Complete at least 108 credits.
Depth of Intermediate/Advanced work	Complete at least 60 credits at the intermediate or advanced level.
Major	Declare and complete at least one major.
Total Credits	Complete at least 120 credits.
UW-Madison Experience	• 30 credits in residence, overall; and • 30 credits in residence after the 86th credit.
Quality of Work	• 2.000 in all coursework at UW–Madison • 2.000 in Intermediate/Advanced level coursework at UW–Madison

NON–L&S STUDENTS PURSUING AN L&S MAJOR

Non–L&S students who have permission from their school/college to pursue an additional major within L&S only need to fulfill the major requirements. They do not need to complete the L&S Degree Requirements above.

REQUIREMENTS FOR THE MAJOR

The major requires a minimum of 34 credits in the field of specialization, with at least 6 of these credits in ASTRON and at least 28 credits in PHYSICS.

COURSE REQUIREMENTS FOR THE MAJOR ARE:

Code	Title	Credits
Astronomy [1]		
Complete at least two of the following:		*6*
ASTRON 310	Stellar Astrophysics [2]	
ASTRON 320	The Interstellar Medium	
ASTRON 330	Galaxies [2]	
ASTRON 335	Cosmology [2]	
ASTRON 340	Solar System Astrophysics	
ASTRON 500	Techniques of Modern Observational Astrophysics [2]	
Physics		
Complete one of the following sequences for Introductory Physics: [3]		*28*
Sequence 1:		
PHYSICS 247 & PHYSICS 248 & PHYSICS 249	A Modern Introduction to Physics and A Modern Introduction to Physics and A Modern Introduction to Physics	
Sequence 2:		
PHYSICS 201 & PHYSICS 202 & PHYSICS 205	General Physics and General Physics and Modern Physics for Engineers	
Sequence 3:		
PHYSICS 207 & PHYSICS 208 & PHYSICS 241	General Physics and General Physics and Introduction to Modern Physics	
Mechanics, Electromagnetic Fields, & Thermal Physics (complete all):		
PHYSICS 311	Mechanics	
PHYSICS 322	Electromagnetic Fields	
PHYSICS 415	Thermal Physics	
Atomic & Quantum Physics (complete either):		
PHYSICS 448 & PHYSICS 449	Atomic and Quantum Physics and Atomic and Quantum Physics	
or		
PHYSICS 531	Introduction to Quantum Mechanics	
Complete one 300-level or higher laboratory course:		
PHYSICS 307	Intermediate Laboratory-Mechanics and Modern Physics	
PHYSICS 321	Electric Circuits and Electronics	
PHYSICS 407	Advanced Laboratory	
Additional PHYSICS to reach minimum of 28 credits		
Total Credits		**34**

RESIDENCE AND QUALITY OF WORK

- 2.000 GPA in all ASTRON, all PHYSICS, and all major courses
- 2.000 GPA on 15 upper-level major credits in residence[4]
- 15 credits in ASTRON and PHYSICS, taken on campus

HONORS IN THE MAJOR

Students may declare Honors in the Major in consultation with the Astronomy–Physics undergraduate advisor(s).

HONORS IN THE MAJOR REQUIREMENTS

To earn Honors in the Major, students must satisfy both the requirements for the major (above) and the following additional requirements:

- Earn a 3.300 University GPA
- Earn a 3.500 GPA for all ASTRON and PHYSICS courses, and all courses accepted in the major, at the 300 level or higher
- Complete the following coursework:
  - Four 300-level or higher ASTRON courses, with a 3.500 GPA
  - A two-semester Senior Honors Thesis in ASTRON 681 and ASTRON 682, with a grade of AB or better (for a total of 6 credits).

DISTINCTION IN THE MAJOR

Distinction in the Major requires no declaration,and is awarded at the time of graduation. Students may *not* receive Distinction and Honors in

the same major. To receive Distinction in the Major, students must have met the following requirements:

- Earn a 3.300 University GPA
- Earn a 3.300 GPA in all major and major subject courses
- Complete 6 additional credits in advanced-level Astronomy beyond the minimum required for the major.

FOOTNOTES

[1] ASTRON 103 and ASTRON 104 are not required for majors.

[2] ASTRON 310 is a prerequisite for ASTRON 330, ASTRON 335, and ASTRON 500.

[3] E M A 201, E M A 202, and M E 240 count toward the 28 credits of PHYSICS requirement. E M A 201 & E M A 202, or E M A 201 & M E 240 count as a first semester, introductory course (e.g., PHYSICS 247, PHYSICS 201, PHYSICS 207).

[4] ASTRON 300-699 and PHYSICS 300-699 are upper-level in the major.

UNIVERSITY DEGREE REQUIREMENTS

Total Degree	To receive a bachelor's degree from UW–Madison, students must earn a minimum of 120 degree credits. The requirements for some programs may exceed 120 degree credits. Students should consult with their college or department advisor for information on specific credit requirements.
Residency	Degree candidates are required to earn a minimum of 30 credits in residence at UW–Madison. "In residence" means on the UW–Madison campus with an undergraduate degree classification. “In residence” credit also includes UW–Madison courses offered in distance or online formats and credits earned in UW–Madison Study Abroad/Study Away programs.
Quality of Work	Undergraduate students must maintain the minimum grade point average specified by the school, college, or academic program to remain in good academic standing. Students whose academic performance drops below these minimum thresholds will be placed on academic probation.

LEARNING OUTCOMES

1. Learn how astronomical observations are made and how astronomical data are analyzed. Become acquainted with basic principles of astronomical imaging and spectroscopy, detectors, and interferometry. Apply simple statistical concepts learned previously in required laboratory courses to astronomical data. Use simple scientific computing methods to plan astronomical observations and analyze astronomical data.
2. Become familiar with current astrophysical theories and observations of basic systems such as planets, stars, interstellar gas, galaxies, and structure of the Universe (cosmology). Learn to apply physical principles and mathematical techniques learned previously in required courses to understand the natural laws governing these systems. Use simple scientific computing methods to analyze and physically interpret numerical models of astronomical systems.
3. Learn how to read and critically evaluate scientific literature. Grasp the main points, scientific goals, and research methods used in an article and discern whether the article supports or conflicts with material presented elsewhere.
4. Learn the basics of oral and written scientific communication. Written coursework will be assessed on the basis of clear writing, appropriate level of detail in reporting calculations, and computations and appropriate bibliographic references and citations as well as on scientific accuracy. Learn to give clear and accurate short oral presentations with appropriate supporting materials.
5. Be trained in principles and standards of professional and ethical conduct. Learn when and how to cite references and when it is appropriate to credit the contributions of others or claim credit for one's own work. Learn what constitutes a professional or unprofessional demeanor and how to apply principles of equality in an educational or workplace setting. Learn how to address a breakdown of professional ethics and standards if experienced or observed.
6. Develop the skills to carry out a small independent research project. Learn to define the scope of the project, how to conduct an effective literature search, and perform computations, analyze data, and report on the literature as appropriate. Learn the basics of presenting the results of the project, whether as a paper, poster, talk, or some combination. The project may involve group work, or teamwork, depending on logistics and the nature of the project. Note: Not all Astronomy majors engage in independent research; this learning goal applies only to majors who have a formal research advisor to perform the assessment.

FOUR-YEAR PLAN

SAMPLE FOUR-YEAR PLAN

This Sample Four-Year Plan is a tool to assist students and their advisor(s). Students should use it—along with their DARS report, the Degree Planner, and Course Search & Enroll tools—to make their own four-year plan based on their placement scores, credit for transferred courses and approved examinations, and individual interests. As students become involved in athletics, honors, research, student organizations, study abroad, volunteer experiences, and/or work, they might adjust the order of their courses to accommodate these experiences. Students will likely revise their own four-year plan several times during college.

First Year

Fall	Credits	Spring	Credits
MATH 221 (QR-B)	5	MATH 222	4
Biological Science Breadth	3	ASTRON 200 (non-majors take 103)	3
Humanities Breadth	3	Biological Science Breadth	3
Foreign Language (if needed)	4	Foreign Language (if needed)	4
		Communication A	2
	15		**16**

Second Year

Fall	Credits	Spring	Credits
PHYSICS 247, 201, or 207	5	PHYSICS 248, 202, or 208	5
MATH 234	4	Literature Breadth	3
Social Science Breadth	3	Social Science Breadth	4

Foreign Language (if needed)	4	MATH 320[1]	3
	16		**15**

Third Year

Fall	Credits	Spring	Credits
PHYSICS 249, 205, or 241	4	PHYSICS 311	3
ASTRON 310	3	ASTRON 320 (or another ASTRON 300 level course)	3
MATH 321[2]	3	Social Science Breadth	3
Communication B	3	Literature Breadth	3
		MATH 322[2]	3
	13		**15**

Fourth Year

Fall	Credits	Spring	Credits
PHYSICS 322	3	Social Science Breadth	3
PHYSICS 448	3	PHYSICS 449	3
Ethnic Studies	3	PHYSICS 415	3
Elective	4	Humanities Breadth	3
ASTRON 510 (or any 300-level (or higher) Physics lab)	2	Astronomy 300 Level OR Elective	3
	15		**15**

Total Credits 120

1. Alternatively, students may wish to consider MATH 319 and MATH 340.
2. Students are encouraged to consider MATH 321 and MATH 322 for additional preparation prior to coursework completed in the fourth year of this plan.

ADVISING AND CAREERS

ADVISING

For premajor advising and major advising, students should contact the Undergraduate Advisor Eric Schueffner (elschueffner@wisc.edu) or Faculty Advisors: Professor Elena D'Onghia (edonghia@astro.wisc.edu (townsend@astro.wisc.edu)) and Professor Snezana Stanimirovic, (sstanimi@astro.wisc.edu).

We encourage students to meet major advisors as early as possible. Undergraduate Advisor Eric Schueffner (via Starfish) can assist students with curriculum and course scheduling, career planning, academic concerns, and overall performance and strategies.

Those needing additional information and guidance on the major can see our undergraduate coordinator Heather Sauer (2554 Sterling Hall, hsauer@wisc.edu).

To declare the astronomy—physics major, please contact Professor D'Onghia or Professor Stanimirovic to schedule an appointment.

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: MATH 320 Linear Algebra and Differential Equations OR MATH 319 Techniques in Ordinary Differential Equations and MATH 340 Elementary Matrix and Linear Algebra. If a student plans to work toward the Ph.D degree, the student should also take MATH 321 Applied Mathematical Analysis and MATH 322 Applied Mathematical Analysis. Additional mathematics (or statistics) courses should be chosen after consultation with the undergraduate advisor.

Computing: Computers are fundamental to astronomical research. An introduction through Introduction to Programming, or short courses run by the computing center should be considered. COMP SCI 220 Data Science Programming I is a good option.

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. STAT 302 Accelerated Introduction to Statistical Methods, or STAT/MATH 309 Introduction to Probability and Mathematical Statistics I/STAT/MATH 310 Introduction to Probability and Mathematical Statistics II for a more solid foundation, are suggested.

Languages: Spanish but also, French, German and Russian are also useful foreign languages for astronomy students, but are not required.

L&S CAREER RESOURCES

SuccessWorks at the College of Letters & Science helps students leverage the academic skills learned in their major, certificates, and liberal arts degree; explore and try out different career paths; participate in internships; prepare for the job search and/or graduate school applications; and network with professionals in the field (alumni and employers). In short, SuccessWorks helps students in the College of Letters & Science discover themselves, find opportunities, and develop the skills they need for success after graduation.

SuccessWorks can also assist students in career advising, résumé and cover letter writing, networking opportunities, and interview skills, as well as course offerings for undergraduates to begin their career exploration early in their undergraduate career.

Students should set up their profiles in Handshake (https://careers.ls.wisc.edu/handshake/) to take care of everything they need to explore career events, manage their campus interviews, and **apply to jobs and internships from 200,000+ employers around the country**.

- SuccessWorks (https://careers.ls.wisc.edu/)
- Set up a career advising appointment (https://careers.ls.wisc.edu/make-an-appointment/)
- INTER-LS 210 L&S Career Development: Taking Initiative (1 credit, targeted to first- and second-year students)—for more information, see Inter-LS 210: Career Development, Taking Initiative (https://careers.ls.wisc.edu/inter-ls-210-career-development-taking-initiative/)
- INTER-LS 215 Communicating About Careers (3 credits, fulfills Com B General Education Requirement)
- Handshake (https://careers.ls.wisc.edu/handshake/)
- Learn how we're transforming career preparation: L&S Career Initiative (http://ls.wisc.edu/lsci/)

PEOPLE

Faculty:

Professors Richard Townsend (chair), Amy Barger, Matt Bershady, Sebastian Heinz, Alex Lazarian, Bob Mathieu, Snezana Stanimirovic, Christy Tremonti, Susanna Widicus Weaver, Eric Wilcots, and Ellen Zweibel

Associate Professor Elena D'Onghia

Assistant Professor Ke Zhang

Staff:
Department Administrator: Steve Anderson
Student Coordinator: Heather Sauer
Undergraduate Advisor: Eric Schueffner