ASTRONOMY–PHYSICS, B.A.

Astronomy, the oldest of the sciences, for the last several decades has been one of the most exciting fields of modern scientific research. New discoveries concerning the solar system, stars, galaxies, and the origin of the universe continue to be made by both ground and space telescopes. To understand and pursue modern astronomy, one must have a solid background in physics and mathematics as well as in astronomy.

The astronomy–physics major, administered by the Department of Astronomy, provides undergraduates the opportunity to appreciate our current understanding of the astronomical universe, while developing the necessary physics and math background. Students who intend to continue astronomy in a graduate program are strongly encouraged to do a Senior Thesis (ASTRON 681 Senior Honors Thesis/ASTRON 682 Senior Honors Thesis (honors) or ASTRON 691 Senior Thesis/ASTRON 692 Senior Thesis). The experiences 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.

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/#requirementsforundergraduatetestudytext) section of the Guide.

Requirements Detail

<table>
<thead>
<tr>
<th>Category</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Education</td>
<td>• Breadth—Humanities/Literature/Arts: 6 credits</td>
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<tr>
<td></td>
<td>• 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</td>
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<tr>
<td></td>
<td>• Breadth—Social Studies: 3 credits</td>
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<td></td>
<td>• Communication Part A &amp; Part B *</td>
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<td></td>
<td>• Ethnic Studies *</td>
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<tr>
<td></td>
<td>• Quantitative Reasoning Part A &amp; Part B *</td>
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* 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 BREADTH AND 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. View a comparison of the degree requirements here. (https://pubs.wisc.edu/home/archives/ug15/images/babs2009.pdf)

BACHELOR OF ARTS DEGREE REQUIREMENTS

Requirements Detail

<table>
<thead>
<tr>
<th>Type</th>
<th>Detail</th>
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<tbody>
<tr>
<td>Mathematics</td>
<td>Fulfilled with completion of University General Education requirements Quantitative Reasoning a (QR A) and Quantitative Reasoning b (QR B) coursework. Please note that some majors may require students to complete additional math coursework beyond the B.A. mathematics requirement.</td>
</tr>
<tr>
<td>Foreign Language</td>
<td>• Complete the fourth unit of a foreign language; OR</td>
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<td></td>
<td>• Complete the third unit of a foreign language and the second unit of an additional foreign language</td>
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Note: A unit is one year of high school work or one semester/term of college work.

L&S Breadth

<table>
<thead>
<tr>
<th>Category</th>
<th>Detail</th>
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<tbody>
<tr>
<td>Liberal Arts and Science Coursework</td>
<td>108 credits</td>
</tr>
<tr>
<td>Depth of Intermediate/Advanced work</td>
<td>60 intermediate or advanced credits</td>
</tr>
<tr>
<td>Major</td>
<td>Declare and complete at least one (1) major</td>
</tr>
<tr>
<td>Total Credits</td>
<td>120 credits</td>
</tr>
<tr>
<td>UW-Madison Experience</td>
<td>30 credits in residence, overall</td>
</tr>
<tr>
<td>Minimum</td>
<td>2,000 in all coursework at UW–Madison</td>
</tr>
<tr>
<td>GPAs</td>
<td>2,000 in intermediate/advanced coursework at UW–Madison</td>
</tr>
</tbody>
</table>

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 and do not need to complete the L&S breadth and 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:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astronomy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASTRON 310</td>
<td>Stellar Astrophysics ²</td>
<td>2</td>
</tr>
<tr>
<td>ASTRON 320</td>
<td>The Interstellar Medium</td>
<td>2</td>
</tr>
<tr>
<td>ASTRON 330</td>
<td>Galaxies ²</td>
<td>2</td>
</tr>
<tr>
<td>ASTRON 335</td>
<td>Cosmology ²</td>
<td>2</td>
</tr>
<tr>
<td>ASTRON 340</td>
<td>Solar System Astrophysics</td>
<td>2</td>
</tr>
<tr>
<td>ASTRON 500</td>
<td>Techniques of Modern Observational Astrophysics ²</td>
<td>2</td>
</tr>
</tbody>
</table>

Physics

Select one of the following sequences for Introductory Physics:

Option 1 (Recommended Sequence):
- PHYSICS 247 A Modern Introduction to Physics
- PHYSICS 248 A Modern Introduction to Physics
- PHYSICS 249 A Modern Introduction to Physics

Option 2:
- PHYSICS 201 General Physics
- PHYSICS 202 General Physics
- PHYSICS 205 Modern Physics for Engineers

Option 3:
- PHYSICS 207 General Physics
- PHYSICS 208 General Physics
- PHYSICS 241 Introduction to Modern Physics

Additional PHYSICS to reach minimum of 34 credits, to include the following:
- PHYSICS 311 Mechanics
- PHYSICS 322 Electromagnetic Fields
- PHYSICS 415 Thermal Physics
- PHYSICS 448 Atomic and Quantum Physics
- PHYSICS 449 and Atomic and Quantum Physics or PHYSICS 531 Introduction to Quantum Mechanics

Select a 300-level or higher laboratory course:
- ASTRON 510 Radio Astronomy Laboratory
- PHYSICS 308 Intermediate Laboratory - Electromagnetic Fields and Optics
- PHYSICS 321 Electric Circuits and Electronics

Total Credits: 34

1. ASTRON 103 The Evolving Universe: Stars, Galaxies, and Cosmology and ASTRON 104 Our Exploration of the Solar System are not required for majors.
2. ASTRON 310 Stellar Astrophysics is a prerequisite for ASTRON 330 Galaxies, ASTRON 335 Cosmology, and ASTRON 500 Techniques of Modern Observational Astrophysics.
3. E M A 201 Statics, E M A 202 Dynamics and M E 240 Dynamics count toward the 28 credits of PHYSICS requirement.

RESIDENCE AND QUALITY OF WORK

2.000 GPA on 15 upper-level major credits in residence: ASTRON 300 through 699 and PHYSICS 300 through 699

15 credits in the ASTRON and PHYSICS, taken on campus

HONORS IN THE MAJOR

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

HONORS IN THE ASTRONOMY-PHYSICS MAJOR REQUIREMENTS

To earn a B.A. or B.S. with Honors in the Major in Astronomy–Physics, students must satisfy both the requirements for the major (above) and the following additional requirements:

- Earn a 3.300 overall university GPA
- Earn a 3.500 GPA for all ASTRON 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
  - A two-semester Senior Honors Thesis in ASTRON 681 Senior Honors Thesis and ASTRON 682 Senior Honors Thesis, with a grade of AB or better, for a total of 6 credits.

UNIVERSITY DEGREE REQUIREMENTS

Requirements Detail

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. Students should be able to grasp the main points, scientific goals, and research methods used in an article and should be able to 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.

**Computing:** Computers are fundamental to astronomical research. An introduction through COMP SCI 302 Introduction to Programming or short courses run by the computing center should be considered.

**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 301 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:** French, German, Russian, and especially Spanish are the most useful foreign languages for astronomy students, but are not required.

**PEOPLE**

Professors Barger, Bershady, Gallagher, Heinz, Lazarian, Mathieu, Stanimirovic, Wilcots, Zweibel

Associate Professors Townsend, Tremonti

Assistant Professor D’Onghia

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

**ADVISING AND CAREERS**

**ADVISING**

For pre-major advising, or to declare the astronomy–physics major, students should contact Professor Townsend at townsend@astro.wisc.edu. Additional information and handouts on the major are available in the office of the undergraduate coordinator at 2554 Sterling Hall.

Please contact Professor Richard Townsend, townsend@astro.wisc.edu, 4550 Sterling Hall or Prof. Snezana Stanimirovic, sstanim@astro.wisc.edu, 4514 Sterling Hall to schedule an appointment to declare the major, or contact department office for an advisor.