Astronomy-Physics

UNIVERSITY OF WISCONSIN-MADISON

astro.wisc.edu

Letters and Science BA or BS

Astronomy-Physics Major Checklist

General Education

		Completed
Natural Sciences	4-6 credits in two courses or one 4-5 cr. course w/lab	
Humanities/Literature/Art	6 credits	
Social Studies	3 credits	
Communication-A **Communication-B**	3-6 credits	
Quantitative Reasoning A **Quantitative Reasoning B**	3-6 credits	
Ethnic Studies	3 credits	

BA/BS Degree Requirements

Math	**BA**	Met with Quan A & B	
Math	**BS**	Two 3+ credit courses at I/A level (math comp sci, stat) Limited to one each area	
Language	**BA**	Option 1: 4th level of a Foreign Language Option 2: 3rd level of one language and 2nd level of another	
Language	**BS**	Complete 3rd level of a Foreign Language	
Humanities		12 credits total (L, H, X, Z) (6 of those in literature- L)	
Social Science		12 credits total (S, W, Y, Z)	
Natural Science	**BA**	12 credits (B, P, N, W, X, Y) One 3+ credit in Biology, One 3+ credit physical science, remaining credits in any science	
Natural Science	**BS**	12 credits (B, P, N, W, X, Y) 6 credits in Biology and 6 credits in Physical Science	

Attribute Guide

a	COMM A	H	HUMANITIES
b	COMM B	I	INTERMEDIATE
q	QUANTITATIVE A	L	LITERATURE
r	QUANTITATIVE B	N	NATURAL SCIENCE
e	ETHNIC STUDIES	P	PHYSICAL SCIENCE
A	ADVANCED	S	SOCIAL SCIENCE
B	BIOLOGICAL STUDIES	W	SOCIAL OR NATURAL SCIENCE
C	LAS CREDIT	X	HUMANITIES OR NATURAL SCIENCE
D	INTERMEDIATE OR ADVANCED	Y	BIOLOGICAL OR SOCIAL SCIENCE
E	ELEMENTARY	Z	HUMANITIES OR SOCIAL SCIENCE

Astronomy-Physics Majors

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

Major Requirements

		Completed
Math	Complete the BS/BA math requirements, but keep in mind Math 221 is a pre-requisite for Physics 201 and 207 and Math 222 is a pre-req for Physics 247	
Physics	Prior to declaring the major, students must complete 2 of the 3 classes in an Introductory Physics sequence	
14 Credit series	**Physics 247, 248 and 249 Recommended**, Physics 201(r,P), 202(P), 205 or Physics 207(r,P), 208(P), 241 sequences are also available	

Core (34+ credits) Major requires at least 6 credits in Astronomy and 28 credits in Physics

In addition, the specific course requirements for the major are below:

Astronomy: 6+ Credits	At least two of the following (but note that 310 is a prerequsite for 330, 335, and 500) ASTRON 310(P): Stellar Astrophysics | ASTRON 320(P): The Interstellar Medium | ASTRON 330(A): Galaxies and Cosmology | ASTRON 335(P): Cosmology; ASTRON 340(P): Solar System Astronomy | ASTRON 500(A): Techniques of Modern Observational Astrophysics **Note: Astronomy 103 and 104 are not required for the major**	
Physics: 28+ Credits total	**Complete intro sequence from above** PHYSICS 311(P): Mechanics | PHYSICS 322(P): Electromagnetic Fields | PHYSICS 415(P): Thermal Physics | PHYSICS 448(P): Atomic & Quantum Physics PHYSICS 449(P): Quantum Physics | PHYSICS 531(P): Introduction to Quantum Mechanics (may be substituted for the 448-449 sequence)	

****A 300 level or higher lab course must be taken: ASTRON 510 or PHYSICS 308 (Electromagnetic Fields and Optics) or 321 (Electric Circuits and Electronics) are recommended**

Recommended Additional Courses

Math: Mathematics courses other than those required as pre-requisites for physics courses are not required for the major, but the following are recommended
MATH 319(N): Ordinary Differential Equations | Math 321(N) and 322(N): Applied Analysis
Ph D track: MATH 320(N): Linear Mathematics or MATH 340(N): Matrix and Linear Algebra
Additional math or statistics should be chosen after consulting with faculty or your advisor

Computing: Computers are fundamental to astronomical research. An introduction through COMPSCI 302(r,N) 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(r,N) (or 309(N)/310(N) for a more solid foundation), are suggested

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

Astronomy and Physics Courses

Courses in Astronomy			Attribute	Prerequisite
ASTRON	100	Survey of Astronomy	__PEC	Completion of QR-A. Open to all Undergrads. Stdts may not receive cr for both Astron 100 & either Astron 103 or 104. Not open to stdts who meet prereq for Astron 200
ASTRON	103	The Evolving Universe	__PEC	Completion of QR-A. Open to all Undergrads. Stdts may not receive cr for both Astron 100 & 103. Not open to stdts who meet prereq for Astron 200
ASTRON	104	Exploration of Solar System	__PEC	Completion of QR-A. Open to all Undergrads. Stdts may not receive cr for both Astron 100 & 104
ASTRON	113	Hands on the Universe	r_PEC	Open to all Undergrads. Intended to be taken concurrently with Astron 103. Prev Astron 100 or Astron 103 or cons inst acceptable. Satisfies QR-B only if Astron 100 or Astron 103 is also completed. Not open to stdts who have taken Astron 110
ASTRON	150	Topics in Astronomy> The Dark Side of the Universe	__PEC	Astron 100, 103, or 104, as appropriate for topic, or consent of instructor
ASTRON	160	Life in the Universe	__PEC	Open to all undergrads
ASTRON	199	Directed Study	___EC	Astron 100 or equiv or cons inst. Open to Fr
ASTRON	200	The Physical Universe	__PIC	Physics 202 or 208 or cons inst. Not open to stdts who have taken Astron 100 or 103. Simple calculus required
ASTRON	206	History-Astronomy&Cosmology	__HIC	So st
ASTRON	310	Stellar Astrophysics	__PIC	Math 222 & Physics 205 or 241
ASTRON	320	The Interstellar Medium	___AC	Math 222 and Physics 205 or 241
ASTRON	330	Galaxies	___AC	Astron 310
ASTRON	340	Solar System Astrophysics	__PIC	Math 222 & Physics 205 or 241
ASTRON	500	Tech-Mod Observatl Astrophy	___AC	Grad st or Astron 310 & cons inst
ASTRON	550	Astrodynamics	__PAC	EMA 202 or 221; or Physics 311 or con reg; or cons inst
ASTRON	620	Smr-Astrophysical Topics	___AC	Astron 310 or cons inst
ASTRON	681	Senior Honors Thesis	___AC	Cons inst
ASTRON	682	Senior Honors Thesis	___AC	Cons inst
ASTRON	691	Senior Thesis	___AC	Sr st astronomy-physics major & cons inst
ASTRON	692	Senior Thesis	___AC	Astron 691 & cons inst
ASTRON	699	Directed Study	___AC	L & S Undergrads need 2.5, Jr or Sr st & cons inst
ASTRON	700	Basic Astrophysics I		Grad st in astronomy or physics, or cons inst
ASTRON	702	Basic Astrophysics II		Grad st in astronomy or physics, or cons inst
ASTRON	715	Stellar Interiors&Evolution		Astron 700 or cons inst
ASTRON	730	Galaxies		Grad st in Astron or cons inst
ASTRON	910	Seminar in Astrophysics		Cons inst
ASTRON	990	Research and Thesis		Grad st in astron
Courses in Physics			**Attribute**	**Prerequisite**
PHYSICS	103	General Physics	r_PEC	Completion of QR-A. High school algebra, geometry and some trig; Not open if you've taken Physics 201, 207, or 247; Open to Frosh. For students who don't need a calc.level course; Not recommended for students in the physical sci.and engr
PHYSICS	104	General Physics	__PEC	Physics 103. Not open to those who have taken Physics 202, 208, or 248; Open to Freshman
PHYSICS	107	Ideas of Modern Physics	r_PEC	Completion of QR-A. High school algebra & geometry. Not open to students who have taken an intermediate or advanced level physics course. Open to Freshmen
PHYSICS	109	Physics in the Arts	r_PEC	Completion of QR-A. High school algebra & geometry. Not open to students who have had an intermediate or advanced level physics course, including Physics 371. Open to Freshmen
PHYSICS	115	Energy	r_PEC	Completion of QR-A. High school algebra and geometry. Not open to students who have taken Physics 103, 201, 207, or 247
PHYSICS	199	Directed Study	___EC	Cons inst. Open to Fr
PHYSICS	201	General Physics	r_PIC	Math 211 or 221 or 1 year high school calculus or instructor consent. Not open to students who have taken Physics 207 or 247; Open to Freshmen
PHYSICS	202	General Physics	__PIC	Physics 201, 207, or EMA 201 and EMA 202, or EMA 201 and ME 240, or equivalent. Not open to students who have taken Physics 208 or 248
PHYSICS	205	Mod Physics for Engineers	__PIC	Physcis 202, 208 or 248. Not open to students who have taken Physics 241, 244, or 249
PHYSICS	206	Special Topics in Physics	___IC	Prereqs vary according to topic
PHYSICS	207	General Physics	r_PIC	Math 221 or 211 or 1 year high school calculus or instructor consent. Not open to students who have taken Physics 201 or 247; Open to Freshmen
PHYSICS	208	General Physics	__PIC	Physics 201, 207, or 247. Not open to students who have taken Physics 202 or 248; Open to Freshmen
PHYSICS	235	Intro-Solid State Electronics	___IC	Open to Fr. Math 222 & Physics 202
PHYSICS	241	Intro to Modern Physics	__PIC	Physics 202 or 208 or 248 & Math 222. Not open to students who have taken Physics 205, 244, or 249
PHYSICS	247	A Modern Intro to Physics	__PIC	Math 222 or concurrent registration or instructor consent; Open to Freshmen. Intended primarily for physics, AMEP, astronomy-physics majors; Also suitable for those majoring in science or mathematics
PHYSICS	248	A Modern Intro to Physics	__PIC	Physics 247, Math 234 or concurrent enrollment; Open to Freshmen. Intended primarily for physics, AMEP, and astronomy-physics majors
PHYSICS	249	A Modern Intro to Physics	__PIC	Physics 248 & Math 234, or consent of instructor; concurrent registration in Physics 307 required. Not open to students who have taken Physics 241; Open to Freshmen. Intended primarily for physics, AMEP, astronomy-physics majors
PHYSICS	265	Intro-Medical Physics	__PIC	A yr crse of college level intro physics
PHYSICS	298	Directed Study	___IC	Intro physics and cons inst
PHYSICS	299	Directed Study	___IC	Intro physics and cons inst

PHYSICS	301	Physics Today	___IC	Physics 208 or equiv
PHYSICS	307	Intmed Lab-Mech&Mod Physics	__PAC	Physics 202 or 208. Physics 205, 241, or 244 or con reg recommended
PHYSICS	308	Intermediate Lab-Electromag	__PAC	Physics 202 or 208. Physics 205, 241, or 244 recommended. Physics 322 and 325 or con reg recommended
PHYSICS	311	Mechanics	__PAC	Physics 202 or 208, & Math 320 or 319 or cons inst
PHYSICS	321	Elect Circuits & Electronic	__PAC	Physics 202 or 208, & Math 320 or 319 or cons inst
PHYSICS	322	Electromagnetic Fields	__PAC	Physics 311
PHYSICS	325	Wave Motion and Optics	__PAC	Physics 205, 241, or 244, and Physics 311. Physics 322 or concurrent enrollment recommended
PHYSICS	371	Acoustics for Musicians	r_PIC	Completion of QR-A, High school algebra. Intended primarily for musicians and others with some music background
PHYSICS	406	Special Topics in Physics: General Relativity	___AC	Physics 241 or cons inst
PHYSICS	407	Advanced Laboratory	__PAC	Physics 307 or 308 or cons inst
PHYSICS	415	Thermal Physics	__PAC	Physics 241, 244, or 205 & 311
PHYSICS	448	Atomic and Quantum Physics	__PAC	Physics 205, 241, or 244, and Physics 311 and 322. Not open to those who have had Physics 531
PHYSICS	449	Atomic and Quantum Physics	__PAC	Physics 448
PHYSICS	498	Directed Study	___AC	Cons inst
PHYSICS	499	Directed Study	___AC	Cons inst
PHYSICS	501	Radiolgcal Physcs&Dosimetry	___AC	Calculus and modern physics
PHYSICS	525	Introduction to Plasmas	__PAC	One crse in electromagnetic fields beyond elem physics
PHYSICS	527	Plasma Confinement&Heating	__PAC	NEEP/Phys/ECE 525 or equiv
PHYSICS	531	Intro to Quantum Mechanics	__PAC	Physics 311 & 322 & a course in modern physics, or equiv, or cons inst. Not open to those who have had Physics 448
PHYSICS	535	Intro-Particle Physics	__PAC	Physics 531 or equiv
PHYSICS	545	Intro to Atomic Structure	__PAC	A course in quantum mechanics or cons inst
PHYSICS	546	Lasers	__PAC	Physics 322 or ECE 420 or equiv; Physics 545, or 449 or 531
PHYSICS	551	Solid State Physics	__PAC	A course in quantum mechanics or cons inst
PHYSICS	563	Radionuclides-Med & Biology	__PIC	Physics 205, Physics 241, or Physics 249, or Graduate Standing
PHYSICS	601	Scientific Presentation	__PAC	Grad st or Sr st in the Honors program or cons inst
PHYSICS	603	Wkshp-College Physics Tchg	__PAC	At least 9 cr in intmed physics
PHYSICS	619	Microscopy of Life	___IC	2nd semester intro physics including light & optics (e.g. 104, 202, 208) or cons inst
PHYSICS	623	Electronic Aids to Measmnt	__PAC	Undergraduates who have 3 semesters of calculus level physics may enroll with consent of instructor
PHYSICS	625	Applied Optics	__PAC	Three semesters of calculus level physics or equiv. Sr or Grad st or cons inst
PHYSICS	681	Senior Honors Thesis	___AC	Consent of instructor. Note that no credit for physics 681 will be received until successful completion of 682. Must be taken as a sequence with 682.
PHYSICS	682	Senior Honors Thesis	___AC	Consent of instructor. Must be taken as a sequence following 681
PHYSICS	691	Senior Thesis	___AC	Consent of instructor. Note that no credit for Physics 691 will be received until successful completion of 692. Must be taken as a sequence with 692
PHYSICS	711	Theoreticl Physics-Dynamics		Physics 311 or equiv
PHYSICS	715	Statistical Mechanics		Physics 711, 531 & 415, or equiv
PHYSICS	717	Relativity		Physics 721
PHYSICS	721	Theor Physics-Electrodynmcs		Physics 322 or equiv
PHYSICS	724	Waves&Instabilities-Plasmas		NEEP/ECE/Physics 525 & Physics 721 or ECE 740 or cons inst
PHYSICS	726	Plasma Magnetohydrodynamics	___IC	NEEP/ECE/Physics 525 & Physics 721 or ECE 740 or cons inst
PHYSICS	731	Quantum Mechanics		Physics 449 or 531, or equiv
PHYSICS	732	Quantum Mechanics		Physics 721 & 731
PHYSICS	735	Particle Physics		Physics 535, 731 or equiv or cons inst
PHYSICS	736	Nuclear, Particle&Astrophysics		Physics 535 or cons inst
PHYSICS	748	Linear Waves		ECE 440 or Physics 322 or cons inst
PHYSICS	751	Adv Solid State Physics		Physics 731 and 551 or equiv
PHYSICS	799	Independent Study		Cons inst
PHYSICS	801	Topics-Theoretical Physics / Superconductivity		Cons inst
PHYSICS	805	Special Topics in Physics: Laboratory Plasma Astrophysics		Cons inst
PHYSICS	831	Advanced Quantum Mechanics		Physics 732
PHYSICS	832	Advanced Quantum Mechanics		Physics 831
PHYSICS	835	Collider Phys Phenomenology		Phys 735 or equiv or cons inst
PHYSICS	910	Seminar in Astrophysics		Cons inst
PHYSICS	922	Seminar in Plasma Physics		Graduate or professional standing
PHYSICS	990	Research		Consent of instructor

Additional Information for Astronomy-Physics Majors

Pathways into the Program

Interest from High School

Current UW Students from Intro Courses

Interested Transfer Students

High School Tips

http://guide.wisc.edu/explore-majors/

https://www.admissions.wisc.edu/apply/

UW Application Requirement

1. Application
2. $60.00 Fee
3. All Transcripts
4. Test Scores ACT/SAT
5. Two essays
6. One letter of recommendation

Advising for Astro-Physics

http://astro.wisc.edu/

Academic Advisor - Eric Schueffner

elschueffner@wisc.edu

608.890.3231

Astronomy Faculty Advisors:

Richard Townsend

townsend@astro.wisc.edu

608.262.1752

Snezana Stanimirovic

sstanimi@astro.wisc.edu

608.890.1458

Advising in Letters & Science

http://ls.wisc.edu/

Letters and Science Advising

L&S Academic Advising Services

608-262-5858

101 Ingraham Hall - 8:00-4:30 M-F

General: acac@saa.ls.wisc.edu

Freshman: advisingaas@ls.wisc.edu

Transfers: transferstudents@ls.wisc.edu

First and Second Year Tips:

Consider taking Astro 200 (The Physical Universe)

1. Attend Astronomy Open House
2. Meet Major Advisors
3. Attend Majors Fairs / Career Fairs
4. Connect and join student organizations - UPS
5. Explore internships and career options

During your First and Second Year:

1. Attend Astronomy Open House
2. Meet Major Advisors
3. Attend Majors Fairs / Career Fairs
4. Connect and join student organizations - UPS
5. Explore internships and career options

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 to Declare:

Complete 2 of 3 classes in an intro Physics Sequence

247, 248, 249 (recommended) or 207, 208, 241

or 201, 202, 295; prior to declaring major

Steps to Declare:

1. Contact Astro Faculty Advisors to organize a meeting

Richard Townsend or Snezana Stanimirovic

2. Meet with Eric Schueffner (Academic Advisor)

Professional Societies

University Physical Society (UPS)/Physics Club

2328 Chamberlin Hall

ups-officers@googlegroups.com

608-263.2805

Junior Year:

Complete Core Courses (34+ credits):

See Checklist lab

Research and Internships

Work with faculty, L&S career services and your advisor

During Jr/Sr years:

1. Plan ahead for research projects
2. Get involved with department/faculty
3. Present Research at UW Undergraduate Symposiums or AAS
4. Work as an Astronomy Tutor
5. Take part in Summer REU (Research Experience for Undergrads)
6. Connect with Alumni & potential graduate programs, employment
7. Attend Career Fairs, Stellar Careers Workshop, & REU/Grad-school workshop
8. Get internship experience
9. Attend Astronomy Colloquium
10. Work on cover letter and resume
11. Apply for Jobs or Graduate Schools
12. Utilize L&S Career Development

Honors Program

https://honors.ls.wisc.edu/

Senior Year:

By senior year, you should have a good idea as to the career you want. You should be completing your major while planning for your career or further schooling (GRE, networking, applications etc.)

Utilize advising but also Career Services

L&S Career Services

711 State St.(Bookstore)

608-262-3921

careers@ls.wisc.edu

EDUCATIONAL AND RESEARCH OPPORTUNITIES IN ASTRONOMY AND ASTROPHYSICS

AT THE UNIVERSITY OF WISCONSIN-MADISON

http://www.astro.wisc.edu

THE DEPARTMENT OF ASTRONOMY AT THE UNIVERSITY OF WISCONSIN-MADISON OFFERS A PROGRAM OF STUDY AND RESEARCH LEADING TO THE B.S. DEGREE IN ASTRONOMY-PHYSICS

FACULTY AND CURRENT RESEARCH INTERESTS

Amy Barger:	Observational cosmology, distant galaxies and supermassive black holes, star formation and accretion histories of the universe.
Matthew A. Bershady:	Extragalactic astronomy and cosmology, galaxy kinematics and image structure; quasars, optical and infrared spectra and instrumentation.
Elena D'Onghia:	Cosmology, nature of dark matter, large scale structure formation, dynamics and galaxy formation.
John S. Gallagher:	Multi-wavelength observational investigations of evolutionary processes in galaxies, stellar populations, classical novae.
Sebastian Heinz:	Relativistic jets, black holes, AGN, X-ray binaries, galaxy clusters, gamma ray bursts, interstellar and intergalactic medium.
Alex Lazarian:	Theoretical astrophysics, e.g. magnetic turbulence, magnetic reconnection, cosmic rays, star formation, physics of dust.
Robert D. Mathieu:	Observational studies of star formation, binary stars, and open star clusters; high-resolution optical and infrared spectroscopy.
Snezana Stanimirovic:	Galactic disk/halos, dust properties in low-metallicity environments, physics of the ISM, radio techniques and applications.
Richard H. Townsend:	Stellar astrophysics, magnetic fields, stellar winds, massive stars.
Christy Tremonti:	Galaxy and AGN co-evolution, galactic chemical evolution.
Eric M. Wilcots:	Studies of the structure and evolution of galaxies through radio and optical observations; distribution and kinematics of gas in and around galaxies.
Ellen G. Zweibel:	Theoretical astrophysics, especially plasma astrophysics; evolution of astrophysical magnetic fields, interstellar astrophysics, star formation, stellar physics.

SENIOR SCIENTISTS AND EMERITI

Joseph P. Cassinelli:	Structure of stellar winds, high resolution X-ray observations, effects of rotation and magnetic fields on the circumstellar envelopes of hot stars.
Edward B. Churchwell:	Star formation, hot molecular cores, UC HII regions, atomic abundances; radio and infrared astronomy.
Matt Haffner:	Milky Way structure and dynamics; physics of the interstellar medium; extended galactic halos; diffuse emission-line spectroscopy; remote observing.
Kenneth H. Nordsieck:	Stellar and extragalactic optical/ultraviolet spectropolarimetry, ground-based instrument control, space astronomy.
Marina Orio:	Transients' populations, interacting binaries, accreting and hydrogen burning white dwarfs.
Jeffrey W Percival:	Instrument control software, telescope control systems, guidance and navigation for suborbital rockets.
Ronald J. Reynolds:	High-resolution spectroscopy of diffuse sources, development of high throughput spectrometers, physics of the interstellar medium.
Blair D. Savage:	Physical properties of the interstellar medium, gas in galactic halos and the intergalactic medium; high-resolution ultraviolet spectroscopy.
Linda Sparke:	Structure and dynamics of galaxies, modeling of warped disks and polar rings; dynamical models for bars; circumstellar and circumbinary disks.
Bart Wakker:	High-velocity clouds and low-redshift intergalactic medium.
Barbara Whitney:	Radiative transfer models of planets, forming stars, and galaxies; infrared surveys of our Galaxy and the Magellanic Clouds.

ASSOCIATED FACULTY

The Department works closely with the members of the Department of Physics in the Space Physics, Optical Spectroscopy, and Atomic Physics groups. Active researchers and programs include: Dan McCammon, X-ray astronomy, soft X-ray background, the hot interstellar medium; James Lawler, laboratory measures of atomic transition probabilities; Peter Timbie, measurements of cosmic background radiation; Francis Halzen and Robert Morse, neutrino astronomy; Cary Forest, plasma astrophysics.

Undergraduate Academic Program

Astronomy, the oldest of the sciences, has been one of the most exciting fields of modern scientific research for the last several decades. 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 (soon to be Astronomy-Astrophysics), administered by the Astronomy Department, provides undergraduates the opportunity to develop an appreciation of our current understanding of the astronomical universe, while developing the necessary physics and math background. Astronomy majors frequently participate in various research projects in the Department, experiencing a real research environment while developing technical and writing skills.

Research Facilities

The Department has a 26% share in the **WIYN** 3.5m Telescope, an advanced technology optical telescope located on Kitt Peak in Arizona. WIYN is instrumented with a multi-object and two integral-field fiber spectrographs, a mosaic CCD camera, a tilt-tip imager, and a high-resolution near-infrared imaging camera. Remote observing is done routinely from the Department. Graduate and undergraduate students frequently travel to WIYN to make their own observations. The Department also has a major share in the nearby 0.9m telescope.

The University of Wisconsin-Madison is also a major partner in the **Southern African Large Telescope (SALT)**, an 11m spectroscopic telescope located outside Sutherland, South Africa. The Robert Stobie Spectrograph (RSS) that is the primary first light instrument for SALT (first light was summer 2006) was designed and built in our Department. Today, RSS-NIR, its sibling spectrograph for near-infrared spectroscopy, is also being designed and built on campus.

On Cerro Tololo in Chile is the remotely operable **Wisconsin H-Alpha Mapper (WHAM)** observatory dedicated to studies of the diffuse interstellar medium.

Washburn Observatory, which opened in 1878, pioneered in the development of photoelectric astronomy, and our Space Astronomy Laboratory led in the birth of ultraviolet astronomy. Wisconsin astronomers served on instrument teams responsible for the Hubble Space Telescope (HST) high-resolution spectrograph, the wide field planetary camera and the cosmic origins spectrograph. Today instrumentation remains a strong component of our programs for observational research from the ground and in space. The Department also operates the **Pine Bluff Observatory**, which is located 15 miles west of Madison, a site historically used as a test-bed for innovative instrumentation.

Astronomers at Wisconsin use a wide variety of observatories to obtain data for their observational programs. In addition to our own facilities, astronomers are also frequent visitors to U.S. national astronomical research facilities at the National Optical Astronomy Observatories, the National Radio Astronomy Observatory, the Infrared Telescope Facility, and NASA (e.g., HST, Chandra and Spitzer). As astronomy has become increasingly international in scope, more of our staff and students are working with unique facilities run by other countries, such as the Australia Telescope Compact Array and the James Clerk Maxwell Telescope.

Astronomy at Wisconsin combines strong traditions in observational, instrumental, and theoretical research. The analysis and interpretation of astronomical data require specialized tools, and the Department operates a powerful network of image processing workstations. Theory programs currently focus on stellar atmospheres and mass loss, interstellar matter, radiative transport, compact objects and jets, plasma astrophysics, and computational astrophysics. Theorists use both national high performance computing facilities and several large departmental computer clusters.

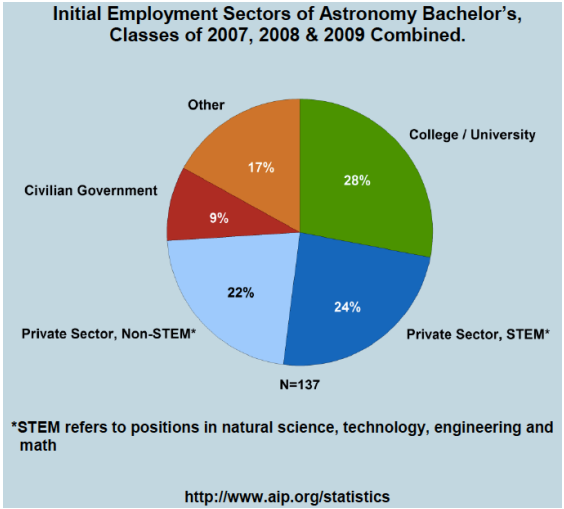
Skills that you will learn as an Astronomy-Physics Major

Astronomy majors gain proficiency in physics and math. They develop good computer and programming skills, data collection and analysis skills, and good communication and teamwork skills. Some students become involved with building instruments, learning electronics, materials fabrication, machining, and other skills in the process. Most importantly, astronomy majors develop analytical skills and an ability to solve complex problems that insures success in any field.

Who Hires Astronomy-Physics Bachelors?

About half of new astronomy bachelor's recipients enter the workforce after earning their degree. The other half continues in PhD programs in astronomy, physics or related disciplines. Astronomers with advanced (PhD) degrees, work at national observatories, national laboratories, federal research agencies, and astronomy and physics departments at universities and colleges.
Astronomers with bachelor degrees find jobs mainly in three sectors:

- College/University (e.g. research assistant, technician, planetarium, science museums);
- Private Sector in STEM fields (e.g. engineering fields, information technology, software developers);
- Private Sector in Non-STEM fields (e.g. associates in retail, finance or business); Other positions, including high school and elementary teachers, science journalism, and non-profit organizations.



Undergraduate Faculty Advisor: To get involved in research projects, discuss your course choices, resolve an academic Issue or declare a major, call or email Prof. Richard Townsend (Fall) or Prof. Stanimirovic (Spring) to set an appointment:
Prof. Richard Townsend, 4550 Sterling Hall, 608-890-1458, **townsend@astro.wisc.edu**
Prof. Snezana Stanimirovic, 4514 Sterling Hall, 608-890-1458, **sstanimi@astro.wisc.edu**

Undergraduate Coordinator: Sheri Pittman**,** 2554 Sterling Hall**,** 608-890-3775**: pittman@astro.wisc.edu**.
See Sheri to fill out forms to declare the astronomy major or register for independent study.

Department of Astronomy Contact Information:

Main Office Suite: 2532 Sterling Hall, 475 N Charter Street, 608-262-3071, **http://astro.wisc.edu**
Astronomy Undergraduate Lounge: 3527 Sterling Hall
Astronomy Undergraduate research Room: 3321 Sterling Hall
Woodman Astronomy Library: 6515 Sterling Hall

Astronomy 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 astronomy and at least 28 credits in physics. Before declaring the major, students must complete Physics 247, 248, and 249 (recommended sequence), or 207, 208, and 241, or Physics 201, 202, 205. 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:

At least two of the following (but note that 310 is a prerequisite for 330, 335, and 500):

310 Stellar Astrophysics, 3 cr
320 The Interstellar Medium, 3 cr
330 Galaxies and Cosmology, 3 cr
335 Cosmology, 3 cr
340 Solar System Astronomy, 3 cr
500 Techniques of Modern Observational Astrophysics, 3 cr

Note: Astronomy 103 and 104 are not required for majors.

Physics:

247-248-249 A Modern Introduction to Physics (or 201-202-205; or 207-208-241) 14 cr
311 Mechanics, 3 cr
322 Electromagnetic Fields, 3 cr
415 Thermal Physics, 3 cr
448 Atomic and Quantum Physics, 3 cr
449 Atomic and Quantum Physics, 3 cr
531 Introduction to Quantum Mechanics (3) may be substituted for the 448-449 sequence.

A 300-level or higher laboratory course must be taken; Astronomy 510 or Physics 308 (Intermediate Laboratory-Electromagnetic Fields and Optics) or 321 (Electric Circuits and Electronics) are recommended to satisfy this requirement.

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 (Ordinary Differential Equations)
Math 321 and 322 (Applied Analysis)
If a student plans to work toward the PhD degree the student should also take:
Math 320 (Linear Mathematics) or
Math 340 (Matrix and Linear Algebra)

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

Computing: Computers are fundamental to astronomical research. An introduction through Comp Sci 302 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. Statistics 301, or Statistics 309/310 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.

Honors in the Major

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

1. A minimum grade point average of 3.5 in all 300 or higher level courses is required for the major.
2. Completion of four 300 or higher level astronomy courses with a minimum grade point average of 3.5 and an overall GPA of at least 3.3 in all courses taken at UW–Madison at the time of graduation.
3. Completion of a Senior Honors Thesis (Astron 681/682) with a grade of AB or better. Students wishing to pursue Honors in the Major should contact the undergraduate advisor to seek guidance about planning the best possible Honors in the Major curriculum that reflects their special interests.

ASTRONOMY–PHYSICS, B.S.

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/#requirementsforundergraduatestudytext) section of the *Guide*.

Requirements	Detail
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 BREADTH AND DEGREE REQUIREMENTS: BACHELOR OF SCIENCE (B.S.)

Students pursuing a bachelor of science 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 SCIENCE DEGREE REQUIREMENTS

Requirements	Detail
Mathematics	Two (2) 3+ credits of intermediate/advanced level MATH, COMP SCI, STAT Limit one each: COMP SCI, STAT
Foreign Language	Complete the third unit of a foreign language Note: A unit is one year of high school work or one semester/term of college work.
L&S Breadth	• Humanities, 12 credits: 6 of the 12 credits must be in literature • Social Sciences, 12 credits • Natural Sciences, 12 credits: must include 6 credits in biological science; and must include 6 credits in physical science
Liberal Arts and Science Coursework	108 credits
Depth of Intermediate/Advanced work	60 intermediate or advanced credits
Major	Declare and complete at least one (1) major
Total Credits	120 credits
UW-Madison Experience	30 credits in residence, overall 30 credits in residence after the 90th credit
Minimum GPAs	2.000 in all coursework at UW–Madison 2.000 in intermediate/advanced 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* 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:

Code	Title	Credits
Astronomy [1]		
Select 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		
Select one of the following sequences for Introductory Physics: [3]		*28*
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 & PHYSICS 449	Atomic and Quantum Physics 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 in all ASTRON, PHYSICS and major courses

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.*

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, sstanimi@astro.wisc.edu, 4514 Sterling Hall to schedule an appointment to declare the major; or contact department office for an advisor.

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.

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