

# ASTRONOMY

## The Astronomy Department:

Department website: <https://www.astro.columbia.edu/>

Office location: 1328 Pupin

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Director of Undergraduate Studies:

Professor Frederik (Frits) Paerels, 1022 Pupin, [frits@astro.columbia.edu](mailto:frits@astro.columbia.edu)

## The Study of Astronomy and Astrophysics

Astronomy is, at once, the oldest science and one of the most vibrant fields of modern research. Its goal is to construct testable, quantitative, coherent models of the universe (the UNItY of the dIVERSE) and its contents—galaxies, stars, and planets. The department offers two majors, both of which require a solid grounding in the mathematics and physics necessary for the pursuit of the discipline.

## Student Advising

Professor Frederik (Frits) Paerels (DUS), 1022 Pupin, [frits@astro.columbia.edu](mailto:frits@astro.columbia.edu)

## Consulting Advisers

We mostly do advising on an individual basis. You can stop by during office hours (changing, check the department Undergraduate Advising page: <https://www.astro.columbia.edu/content/undergraduate>), or you can make an appointment with the DUS (email). The DUS encourages you to come by in person and talk, and limit 'email advising'. We get to know you better that way (and you us), and the DUS can talk much faster than he can type.

You can sign up for our general department events email list: send email to [listserv@lists.columbia.edu](mailto:listserv@lists.columbia.edu) and include this line in the body of the message (not the subject line): subscribe astro-events (your first name)(your last name). All information important to undergraduate students (events, opportunities, meetings, curriculum, etc.) is sent to the undergraduate email list; to subscribe, send email to [listserv@lists.columbia.edu](mailto:listserv@lists.columbia.edu) and include this line in the body of the message (not the subject line): subscribe astro-ugs (your first name)(your last name). Consider joining the society of undergraduate students in astronomy: <https://blueshift.astro.columbia.edu>. To sign up to their mailing list, send email to [listserv@lists.columbia.edu](mailto:listserv@lists.columbia.edu), and include this line in the body of the message (not the subject line): subscribe blueshift (your first name)(your last name).

Throughout the year, we typically have a number of advising events, and those will be announced through the undergraduate and blueshift mailing lists: a general advising session on applying to graduate school (early Fall; mainly for juniors and seniors, but everyone is welcome), a general advising session on how to become involved in research in astronomy and astrophysics (early Fall), a general Department Open House (in the weeks before Major Declaration, early Spring).

You can find a one-page undergraduate astronomy flyer here:

<https://www.astro.columbia.edu/sites/default/files/content/docs/undergrad%20flyer.pdf>

You can find a suggested schedule of courses for the major (but note that this is not a mandatory or necessary time sequence; it's meant to help you start thinking):

<https://www.astro.columbia.edu/sites/default/files/content/docs/Suggested%20Sequence%20of%20Courses%20for%20Majors.pdf>

## Enrolling in Classes

There are no specific steps, prerequisites, or placement tests to enroll in any astronomy classes, other than the ones that are listed in the Bulletin (e.g. you should have taken basic calculus before enrolling in the Introductory Physics Sequence, and the Introduction to Astrophysics sequence).

## Preparing for Graduate Study

The astrophysics major is designed as preparation for graduate study and consists of a standard physics major sequence; a yearlong introduction to astrophysics (typically taken in the sophomore year, but open to first-years with adequate preparation in calculus and physics); and two required courses covering advanced topics in astronomy. Research, in the form of summer internships and/or term-time independent projects, which can lead to a senior thesis, is strongly encouraged. For a research thesis, students should enroll in the parallel, two-semester sequence ASTR UN3997-ASTR UN3998 INDEPENDENT RESEARCH, preferably in their senior year. Students begin the research project in the fall and complete the written thesis in the spring.

The astronomy major provides a basis for further study in the field, but is also designed to be compatible with liberal arts students who pursue other careers and those wishing to combine astronomy with related sciences other than physics, such as chemistry or geology. It requires only two physics courses beyond the introductory sequence and can be completed easily if begun in the sophomore year.

## Coursework Taken Outside of Columbia

### Advanced Placement

The standard CC rules for AP credit apply. If you are wondering whether AP Physics can be counted: our standard advice is to take the Intro Physics sequence anyway, unless special circumstances apply.

### Barnard College Courses

1000-level Astronomy courses taken at Barnard are equivalent to 1000-level courses at Columbia. When working on an Astrophysics Major, you may replace the Physics 4021/4022 Quantum Mechanics I, II sequence by: BC 3006 Quantum Physics plus Physics 4023 Statistical Physics.

### Transfer Courses

The standard Columbia College (and School of General Studies) rules with regard to transfer credit apply.

### Study Abroad Courses

If you are considering studying abroad for a semester, come talk to the DUS. We can find courses that will fulfill Columbia requirements at many institutions (and may even be able to tell you about individual instructors in astrophysics courses...). Students have taken courses as far afield as Tokyo and Istanbul.

## Summer Courses

The department usually teaches one 1000-level Summer course (Astronomy 1403 or 1404).

## Core Curriculum Connections

In a deep sense: connections everywhere. In a narrow sense: no connection.

## Undergraduate Research and Senior Thesis

### Undergraduate Research in Courses

You are encouraged to undertake an original research project, especially if you want to prepare for graduate school. You can enroll in Astronomy 3997 (Fall semesters) or 3998 (Spring semesters) for a semester-long research project, for 3 credits. The general expectation is that this will take about as much time as taking a regular 3-credit class (about a day per week).

### Senior Thesis Coursework and Requirements Undergraduate Research Outside of Courses

Many students use one Summer (sometimes multiple Summers) to conduct research. The Department usually organizes an informational meeting in the Fall semester on how you can go about finding opportunities (sign up for the department undergraduate mailing list to receive announcements).

## Department Honors and Prizes

The Department of Astronomy does not have Departmental Honors or Prizes. The Department has a Research Fellowship for Astronomy or Astrophysics Majors at CC, BC, and GS, the Bell-Burnell Fellowship, to carry out research in the Summer between the junior and senior years.

## Professors

Marcel Agüeros  
James Applegate  
Greg Bryan (Chair)  
Zoltan Haiman  
Jules P. Halpern (*emeritus*)  
David J. Helfand  
Kathryn Johnston  
Laura Kay (Barnard)  
Jeremiah P. Ostriker  
Frederik B. S. Paerels  
Joseph Patterson (*emeritus*)  
Mary E. Putman  
David Schiminovich  
Jacqueline van Gorkom (*emeritus*)

## Associate Professor

David Kipping  
Lorenzo Sironi

## Assistant Professors

Kishalay De  
Jane Huang

## Adjunct Professors

Michael Allison (GISS)  
Mordecai-Mark MacLow (Hayden Planetarium)  
Rebecca Oppenheimer (Hayden Planetarium)  
Michael Shara (Hayden Planetarium)  
Ruth Angus (Hayden Planetarium)

## Adjunct Senior Research Scientist

Melissa K. Ness

## On Leave

Prof. Bryan, Johnston (Spring 2025)

## Guidance for Undergraduate Students in the Department

### Program Planning for all Students

If you are interested in pursuing a Major in Astronomy or Astrophysics, make an appointment with the DUS to discuss a course of study, and do this early. The programs can in principle be completed in two years-but only if you have already completed almost all other requirements. Most students prefer to start on Major-required courses in their first and/or second year. You can find an example schedule here: <https://www.astro.columbia.edu/sites/default/files/content/docs/Suggested%20Sequence%20of%20Courses%20for%20Majors.pdf>

There is an implied progressive structure to some of the courses: for instance, taking the Introductory Physics Sequence means you should have taken basic Calculus. Likewise, starting on the Introduction to Astrophysics sequence means you know basic, calculus-based physics. If in doubt about the flexibility of the schedule, talk to the DUS.

Courses in which the grade of D has been received do not count toward the major, minor, or concentration requirements.

### Course Numbering Structure

The 1000-level courses do not use calculus (but they are quantitative!), and are meant to provide an overview of fields of astronomy and astrophysics for non-major students. They can all count towards fulfilling the science requirements for non-science majors. With one exception (see under the Astronomy Major), the 1000-level courses can not be counted towards the credits for an Astrophysics or Astronomy Major.

The 2000-level courses (Introduction to Astrophysics I and II) provide an overview of astrophysics at the introductory professional level: calculus based, physics-based.

3000-level courses in the Astronomy department are more advanced electives. They generally assume you are familiar with the content of the 2000-level courses. Most 3000-level courses, as well as ASTR GU4260 MODELING THE UNIVERSE, are offered every other year. Students should inquire with the director of undergraduate studies if they have specific questions on the course schedule. ASTR UN3996 Current Research in Astrophysics is a one-point course offered in the fall, designed to introduce majors to research methods and topics. It requires students to attend the department colloquia and a seminar designed to help students understand the colloquium topic. The 3000-level courses need not be taken in any particular order.

4000-level courses are aimed at advanced undergraduates and beginning graduate students.

## Guidance for First-Year Students

If you think you may want to pursue a Major in Astronomy or Astrophysics, come talk to the DUS. If you have to make quick decisions by yourself: the rule of thumb is: start with the Math requirements, the next priority is Introductory Physics, then Astrophysics and Astronomy.

## Guidance for Transfer Students

The standard Columbia College rules for transfer credit apply. You should contact the DUS as soon as you know you are transferring to plan for what will probably be a tight program (depending in what year you transfer, but especially when you start as a junior).

If you are considering applying to graduate school, we need to make sure, in particular, that you get to do an individual research project.

## Undergraduate Programs of Study

### Required Coursework for all Programs

Common to both the Astronomy and the Astrophysics Major are the Calculus sequence and an Introductory Physics sequence (the Physics 1400, 1600, or 2800 series).

### Major in Astronomy

#### Mathematics

Calculus sequence through MATH UN1202 Calculus IV or MATH UN1208 Honors Mathematics IV

#### Astronomy

Select one of the following options:

##### Option 1:

Two 3-point 1000-level astronomy courses

12 points in astronomy at the 2000-level or above

##### Option 2:

ASTR UN2001	INTRO TO ASTROPHYSICS I
& ASTR UN2002	and INTRO TO ASTROPHYSICS II

9 points in astronomy at the 3000-level or above

#### Physics

Select one of the following physics sequences:

##### Sequence 1:

PHYS UN1401 & PHYS UN1402 & PHYS UN1403	INTRO TO MECHANICS # THERMO and INTRO ELEC/MAGNETISM # OPTCS and INTRO-CLASSCL # QUANTUM WAVES
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##### Sequence 2:

PHYS UN1601 & PHYS UN1602 & PHYS UN2601	PHYSICS I:MECHANICS/RELATIVITY and PHYSICS II: THERMO, ELEC # MAG and PHYSICS III:CLASS/QUANTUM WAVE
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##### Sequence 3:

PHYS UN2801 & PHYS UN2802	ACCELERATED PHYSICS I and ACCELERATED PHYSICS II
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#### Additional Physics Courses

Two physics courses at the 3000-level or above

Students contemplating graduate study are advised to include at least two of these physics courses:

PHYS UN3003	MECHANICS
PHYS UN3007	ELECTRICITY-MAGNETISM
PHYS GU4021 & PHYS GU4022	QUANTUM MECHANICS I and QUANTUM MECHANICS II

One of these may be substituted for 3 points of astronomy.

### Major in Astrophysics

Students considering an Astrophysics major are encouraged to meet with the director of undergraduate studies. If possible, it is useful to start the physics sequence in the first year.

#### Mathematics

Calculus sequence through MATH UN1202 Calculus IV or MATH UN1208 Honors Mathematics IV

#### Astronomy

ASTR UN2001 & ASTR UN2002	INTRO TO ASTROPHYSICS I and INTRO TO ASTROPHYSICS II
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6 points in astronomy at the 3000-level or above

#### Physics

Select one of the following physics sequences:

##### Sequence 1:

PHYS UN1401 & PHYS UN1402 & PHYS UN1403	INTRO TO MECHANICS # THERMO and INTRO ELEC/MAGNETISM # OPTCS and INTRO-CLASSCL # QUANTUM WAVES
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##### Sequence 2:

PHYS UN1601 & PHYS UN1602 & PHYS UN2601	PHYSICS I:MECHANICS/RELATIVITY and PHYSICS II: THERMO, ELEC # MAG and PHYSICS III:CLASS/QUANTUM WAVE
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##### Sequence 3:

PHYS UN2801 & PHYS UN2802	ACCELERATED PHYSICS I and ACCELERATED PHYSICS II
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#### Additional Physics Courses

PHYS UN3003	MECHANICS
PHYS UN3007	ELECTRICITY-MAGNETISM
PHYS UN3008	ELECTROMAGNETIC WAVES # OPTICS
PHYS GU4021 & PHYS GU4022	QUANTUM MECHANICS I and QUANTUM MECHANICS II

OR

PHYS BC3006 & PHYS GU4023	QUANTUM PHYSICS and THERMAL # STATISTICAL PHYSICS
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### Joint Minor -- Earth and Space

Note that the information on this page is identical to the information on the corresponding page for the Department of Earth and Environmental Sciences.

The minor in Earth and Space requires a minimum of 15 points, distributed as follows:

#### Introductory Course

3 points minimum (one course):

One of the following:

ASTR UN1453	ANOTHER EARTH
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ASTR BC1753	LIFE IN THE UNIVERSE
EESC UN2300	EARTH'S ENVIRO SYST: LIFE SYST

### **Astronomy Courses**

6 points minimum (two courses):

Two of the following:

ASTR UN1403	EARTH, MOON, AND PLANETS
ASTR UN1404	STARS, GALAXIES # COSMOLOGY
ASTR UN1420	Galaxies and Cosmology
ASTR UN1836	STARS AND ATOMS

Or the following ASTR sequence:

ASTR UN2001	INTRO TO ASTROPHYSICS I
ASTR UN2002	INTRO TO ASTROPHYSICS II

### **DEES Courses**

6 points minimum (two courses):

One of the following:

EESC UN2200	EARTH'S ENVIRONMENTAL SYSTEMS: THE SOLID EARTH
EESC UN3201	SOLID EARTH DYNAMICS

Plus one of the following:

EESC UN2100	EARTH'S ENVIRO SYST: CLIM SYST
EESC UN3101	Geochemistry for a Habitable Planet

## **For students who entered Columbia in or before the 2023-24 academic year Concentration in Astronomy**

An extra 3 points of physics can substitute for 3 points of astronomy, as long as the course submitted is at the equivalent or higher level. The concentration requirements are as follows:

### **Mathematics**

9 points of mathematics

### **Astronomy**

15 points of astronomy, nine of which must be at or above the 2000-level

### **Physics**

9 points of physics

## **Fall 2024**

### **ASTR UN1403 EARTH, MOON, AND PLANETS. 3.00 points.**

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: recommended preparation: a working knowledge of high school algebra.

Prerequisites: recommended preparation: a working knowledge of high school algebra. The overall architecture of the solar system. Motions of the celestial sphere. Time and the calendar. Major planets, the earth-moon system, minor planets, comets. Life in the solar system and beyond. This course is similar to ASTR BC 1753. You cannot enroll in both courses and receive credit for both

### **ASTR UN1420 Galaxies and Cosmology. 3 points.**

CC/GS: Partial Fulfillment of Science Requirement

Galaxies contain stars, gas dust, and (usually) super-massive black holes. They are found throughout the Universe, traveling through space and occasionally crashing into each other. This course will look at how these magnificent systems form and evolve, and what they can tell us about the formation and evolution of the Universe itself. You cannot enroll in ASTR UN1420 in addition to ASTR BC1754 or ASTR UN1404 and receive credit for both.

### **ASTR UN1453 ANOTHER EARTH. 3.00 points.**

CC/GS: Partial Fulfillment of Science Requirement

This course cannot be taken for credit if BC1753 has been taken.

This course will explore the unique properties of Earth, compared to other planets in the Solar System, and the possibility of Earth-like planets around other stars. The basics of the Solar System, gravity, and light will be covered, as well as the geology and atmospheres of the terrestrial planets. The properties of Earth that allowed life to develop and whether life can develop on other planets will be discussed. Finally, the discovery of planets beyond our Solar System and the likelihood of another Earth will be a key component of the course

### **ASTR UN1836 STARS AND ATOMS. 3.00 points.**

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: recommended preparation: a working knowledge of high school algebra.

Prerequisites: recommended preparation: a working knowledge of high school algebra. What is the origin of the chemical elements? This course addresses this question, starting from understanding atoms, and then going on to look at how atoms make stars and how stars make atoms. The grand finale is a history of the evolution of the chemical elements throughout time, starting from the Big Bang and ending with YOU. You cannot enroll in ASTR UN1836 in addition to ASTR BC1754 or ASTR UN1404 and receive credit for both

Spring 2025: ASTR UN1836

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 1836	001/14275	T Th 1:10pm - 2:25pm 702 Hamilton Hall	James Applegate	3.00	50/80

### **ASTR UN1903 ASTRONOMY LAB I. 1.00 point.**

Laboratory for ASTR UN1403. Projects include observations with the departments telescopes, computer simulation, laboratory experiments in spectroscopy, and the analysis of astronomical data. Lab 1 ASTR UN1903 - goes with ASTR BC1753, ASTR UN1403 or ASTR UN1453

Spring 2025: ASTR UN1903

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 1903	001/11204	M 6:00pm - 9:00pm 1402 Pupin Laboratories	Greg Bryan, Stephen Coffey	1.00	20/20
ASTR 1903	002/11205	T 7:00pm - 10:00pm 1402 Pupin Laboratories	Greg Bryan, Justin Vega	1.00	19/20

**ASTR UN1904 ASTRONOMY LAB II. 1.00 point.**

Laboratory for ASTR UN1404. Projects include use of telescopes, laboratory experiments in the nature of light, spectroscopy, and the analysis of astronomical data. Lab 2 ASTR UN1904 - goes with ASTR BC1754 or ASTR UN1404 (or ASTR UN1836 or ASTR UN1420)

Spring 2025: ASTR UN1904

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 1904	001/11206	W 6:00pm - 9:00pm 1402 Pupin Laboratories	Greg Bryan, Fred Angelo Garcia	1.00	8/14

**ASTR UN2001 INTRO TO ASTROPHYSICS I. 3.00 points.**

Prerequisites: a working knowledge of calculus. Corequisites: a course in calculus-based general physics. First term of a two-term calculus-based introduction to astronomy and astrophysics. Topics include the physics of stellar interiors, stellar atmospheres and spectral classifications, stellar energy generation and nucleosynthesis, supernovae, neutron stars, white dwarfs, and interacting binary stars

**ASTR UN2900 FRONTIERS OF ASTROPHYSICS. 1.00 point.**

Several members of the faculty each offer a brief series of talks providing context for a current research topic in the field and then present results of their ongoing research. Opportunities for future student research collaboration are offered. Grading is Pass/Fail

**ASTR UN3101 MODERN STELLAR ASTROPHYSICS. 3.00 points.**

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: one year of calculus-based general physics. Introductory astronomy is not required, but some exposure to astronomy is preferable. In the first half of the course, we will examine the physics of stellar interiors in detail, leading us to develop models of stellar structure and consider how stars evolve. In the second half of the course, we will discuss special topics, such as pre-main sequence evolution, the late stages of stellar evolution, and supernovae and compact objects.

**ASTR UN3601 RELATVITY,BLACK HOLES,COSMOLGY. 3.00 points.****ASTR UN3986 ASTROSTATISTICS. 3.00 points.**

Astronomers live in era of "big data". Whilst astronomers of a century ago collected a handful of photographic plates each night, modern astronomers collect thousands of images encoded by millions of pixels in the same time. Both the volume of data and the ever present desire to dig deeper into data sets has led to a growing interest in the use of statistical methods to interpret observations. This class will provide an introduction to the methods commonly used in understanding astronomical data sets, both in terms of theory and application. It is one six classes the department offers every fourth semester

**ASTR UN3997 INDEPENDENT RESEARCH. 3.00 points.**

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: the instructor's permission. For an independent research project or independent study, a brief description of the proposed project or reading, with the supervising faculty member's endorsement, is required for registration.

Prerequisites: the instructor's permission. For an independent research project or independent study, a brief description of the proposed project or reading, with the supervising faculty member's endorsement, is required for registration. A variety of research projects conducted under the supervision of members of the faculty. Observational, theoretical, and experimental work in galactic and extragalactic astronomy and cosmology. The topic and scope of the work must be arranged with a faculty member in advance; a written paper describing the results of the project is required at its completion (note that a two-term project can be designed such that the grade YC is given after the first term). Senior majors in astronomy or astrophysics wishing to do a senior thesis should make arrangements in May of their junior year and sign up for a total of 6 points over their final two terms. Both a substantial written document and an oral presentation of thesis results are required

## Spring 2025

**ASTR UN1234 UNIVERSAL TIMEKEEPER. 3.00 points.**

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: high school algebra and latent curiosity are assumed. The goal of the course is to illustrate — and perhaps even inculcate — quantitative and scientific reasoning skills. The subject material employed in this task is the study of atoms and their nuclei which, through a wide variety of physical and chemical techniques, can be used to reconstruct quantitatively the past. Following an introduction to atoms, light, and energy, we will explore topics including the detection of art forgeries, the precise dating of archeological sites, a reconstruction of the development of agriculture and the history of the human diet, the history of past climate (and its implications for the future), the history and age of the Earth, and the history of the Universe. The course has no required text. Readings of relevant articles and use of on-line simulations will be required.

Spring 2025: ASTR UN1234

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 1234	001/14272	M W 2:40pm - 3:55pm 402 Chandler	David Helfand	3.00	44/80
ASTR 1234	AU1/18497	M W 2:40pm - 3:55pm Othr Other	David Helfand	3.00	6/6

**ASTR BC1753 LIFE IN THE UNIVERSE. 3.00 points.**

An introductory course intended primarily for nonscience majors. This interdisciplinary course focuses on the subject of Life in the Universe. We will study historical astronomy, gravitation and planetary orbits, the origin of the chemical elements, the discoveries of extrasolar planets, the origin of life on Earth, the evolution and exploration of the Solar System, global climate change on Venus, Mars and Earth, and the Search for Extraterrestrial Life (SETI). You cannot receive credit for this course and for ASTR UN1403 or ASTR UN1453. Can be paired with the optional Lab class ASTR UN1903

Spring 2025: ASTR BC1753

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 1753	001/00430	T Th 2:40pm - 3:55pm 408 Zankel	Nicholas Lubert	3.00	142/140

Fall 2025: ASTR BC1753

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 1753	001/00877	T Th 2:40pm - 3:55pm Room TBA	Nicholas Lubert	3.00	0/60

**ASTR UN1836 STARS AND ATOMS. 3.00 points.**

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: recommended preparation: a working knowledge of high school algebra.

Prerequisites: recommended preparation: a working knowledge of high school algebra. What is the origin of the chemical elements? This course addresses this question, starting from understanding atoms, and then going on to look at how atoms make stars and how stars make atoms. The grand finale is a history of the evolution of the chemical elements throughout time, starting from the Big Bang and ending with YOU. You cannot enroll in ASTR UN1836 in addition to ASTR BC1754 or ASTR UN1404 and receive credit for both

Spring 2025: ASTR UN1836

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 1836	001/14275	T Th 1:10pm - 2:25pm 702 Hamilton Hall	James Applegate	3.00	50/80

**ASTR UN1903 ASTRONOMY LAB I. 1.00 point.**

Laboratory for ASTR UN1403. Projects include observations with the departments telescopes, computer simulation, laboratory experiments in spectroscopy, and the analysis of astronomical data. Lab 1 ASTR UN1903 - goes with ASTR BC1753, ASTR UN1403 or ASTR UN1453

Spring 2025: ASTR UN1903

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 1903	001/11204	M 6:00pm - 9:00pm 1402 Pupin Laboratories	Greg Bryan, Stephen Coffey	1.00	20/20
ASTR 1903	002/11205	T 7:00pm - 10:00pm 1402 Pupin Laboratories	Greg Bryan, Justin Vega	1.00	19/20

**ASTR UN1904 ASTRONOMY LAB II. 1.00 point.**

Laboratory for ASTR UN1404. Projects include use of telescopes, laboratory experiments in the nature of light, spectroscopy, and the analysis of astronomical data. Lab 2 ASTR UN1904 - goes with ASTR BC1754 or ASTR UN1404 (or ASTR UN1836 or ASTR UN1420)

Spring 2025: ASTR UN1904

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 1904	001/11206	W 6:00pm - 9:00pm 1402 Pupin Laboratories	Greg Bryan, Fred Angelo Garcia	1.00	8/14

**ASTR UN2002 INTRO TO ASTROPHYSICS II. 3.00 points.**

Prerequisites: a working knowledge of calculus.

Prerequisites: a working knowledge of calculus. Corequisites: the second term of a course in calculus-based general physics. Continuation of ASTR UN2001; these two courses constitute a full year of calculus-based introduction to astrophysics. Topics include the structure of our galaxy, the interstellar medium, star clusters, properties of external galaxies, clusters of galaxies, active galactic nuclei, and cosmology

Spring 2025: ASTR UN2002

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 2002	001/14277	M W 1:10pm - 2:25pm 602 Northwest Corner	Frederik Paerels	3.00	28/30

**ASTR UN2910 Introduction to Research Skills in Astrophysics. 1.00 point.**

Participation in research is an essential component of a complete undergraduate science education, and is mandatory for those students wishing to go on to the PhD. This course is designed to introduce students to doing astronomy beyond the classroom. It will cover basic topics including but not limited to: coding in astronomy, utilizing international archives, manipulating data, running simulations, reading academic papers, making and giving presentations, academic culture, time management, working in collaborations, and career paths. Students will engage in first-hand research on a specific astronomical topic in order to put their skills to practice. By the end of the course, students should be fully prepared to enter a summer research internship and make the most of their time there. We encourage students considering majoring in Astronomy or Astrophysics who are interested in astrophysical research to take this course. Priority will be given to those interested in majoring in Astrophysics who have no prior research experience. Students should have taken at least one semester of college-level physics and have a knowledge of calculus. No prior experience in python coding is required

Spring 2025: ASTR UN2910

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 2910	001/14279	F 10:00am - 1:00pm 1332 Pupin Laboratories	Alexandra Masegian	1.00	13/12

**ASTR UN3103 GALAXIES. 3.00 points.**

Prerequisites: one year of calculus-based general physics.

Prerequisites: one year of calculus-based general physics. Galaxies fill the universe with structure. They are bound objects that harbor stars, gas, dust and dark matter. This course will discuss the content and structure of galaxies. It will start with the Milky Way, a rotating spiral galaxy, with a particular emphasis on the properties of the interstellar medium. Dwarf galaxies, the building blocks of larger galaxies, will subsequently be discussed, followed by spiral, elliptical and irregular galaxies. The formation and evolution of these different galaxy types will be an important focus of the course, as well as the environment in which the galaxies reside. We will intersperse reviews of current papers on galaxies throughout the semester

Spring 2025: ASTR UN3103

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 3103	001/14281	M W 10:10am - 11:25am 602 Northwest Corner	Mary Putman	3.00	9/25
ASTR 3103	AU1/18498	M W 10:10am - 11:25am Othr Other	Mary Putman	3.00	3/3

**ASTR UN3105 EXOPLANETS AND ASTROBIOLOGY. 3.00 points.**

Prerequisites: One year of calculus-based physics.

The emerging field of extrasolar planets and astrobiology will be covered at a quantitative level, with a major emphasis on astrophysical phenomena and techniques. The subject will be introduced through an investigation of current planetary formation theories and approaches to planet detection, including what we currently know about extrasolar planets and detailed reference to state-of-the-art studies. An astronomer's view of the origin of life and extreme biology will be developed and applied to questions of cosmo-chemistry, observable life-signatures, habitable zones and other astrophysical constraints on the development of organisms.

Spring 2025: ASTR UN3105

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 3105	001/14283	T Th 2:40pm - 3:55pm 307 Uris Hall	Jane Huang	3.00	10/30

**ASTR UN3646 OBSERVATIONAL ASTRONOMY. 3.00 points.**

Prerequisites: one year of general astronomy.

Prerequisites: one year of general astronomy Introduction to the basic techniques used in obtaining and analyzing astronomical data. Focus on ground-based methods at optical, infrared, and radio wavelengths. Regular use of the telescope facilities atop the roof of the Pupin Labs and at Harriman Observatory. The radio-astronomy portion consists mostly of computer labs, In research projects, students also work on the analysis of data obtained at National Observatories

Spring 2025: ASTR UN3646

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 3646	001/14285	Th 7:00pm - 9:30pm 1402 Pupin Laboratories	David Schiminovich	3.00	20/20

**ASTR UN3998 INDEPENDENT RESEARCH. 3.00 points.**

Prerequisites: the instructor's permission. For an independent research project or independent study, a brief description of the proposed project or reading, with the supervising faculty member's endorsement, is required for registration.

Prerequisites: the instructors permission. For an independent research project or independent study, a brief description of the proposed project or reading, with the supervising faculty members endorsement, is required for registration. A variety of research projects conducted under the supervision of members of the faculty. Observational, theoretical, and experimental work in galactic and extragalactic astronomy and cosmology. The topic and scope of the work must be arranged with a faculty member in advance; a written paper describing the results of the project is required at its completion (note that a two-term project can be designed such that the grade YC is given after the first term). Senior majors in astronomy or astrophysics wishing to do a senior thesis should make arrangements in May of their junior year and sign up for a total of 6 points over their final two terms. Both a substantial written document and an oral presentation of thesis results are required

Spring 2025: ASTR UN3998

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 3998	001/14289		Marcel Agueros	3.00	11/15

**ASTR GR6013 Stars and Planets. 3.00 points.**

An in-depth exploration of the physical processes governing the structure, formation, and evolution of stellar and planetary systems, with emphasis on the underlying astrophysical principles

Spring 2025: ASTR GR6013

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 6013	001/15336	M W 1:10pm - 2:25pm 1332 Pupin Laboratories	Michael Shara	3.00	11/20

**ASTR GR8003 ASTROPHYSICAL FLUID DYNAMICS. 3.00 points.**

Spring 2025: ASTR GR8003

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 8003	001/14291	M W 10:10am - 11:25am 1332 Pupin Laboratories	Lorenzo Sironi	3.00	9/20

**ASTR GR9002 GRADUATE SEMINAR. 3.00 points.**

Spring 2025: ASTR GR9002

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 9002	001/14293	F 2:00pm - 4:00pm 1332 Pupin Laboratories	Kishalay De	3.00	17/20

**ASTR GR9004 RESEARCH PROFESSIONAL DEVELOPMENT SEMINAR II. 3.00 points.**

This two-semester course aims to help our students acquire the foundational skills for a successful and satisfying professional life. The course will consist of three themes: 1) Discussing greatest hits and frontiers in the field 2) The research process, using the projects that participating students are currently working on. 3) Navigating science and careers: considering the people and institutions that make up the field, the frameworks in place that support them and the culture that pervades them; career pathways

Spring 2025: ASTR GR9004

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 9004	001/14296		David Kipping	3.00	11/15

## All Courses (including those not offered in academic year 2024-2025)

### ASTR UN1234 UNIVERSAL TIMEKEEPER. 3.00 points.

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: high school algebra and latent curiosity are assumed. The goal of the course is to illustrate — and perhaps even inculcate — quantitative and scientific reasoning skills. The subject material employed in this task is the study of atoms and their nuclei which, through a wide variety of physical and chemical techniques, can be used to reconstruct quantitatively the past. Following an introduction to atoms, light, and energy, we will explore topics including the detection of art forgeries, the precise dating of archeological sites, a reconstruction of the development of agriculture and the history of the human diet, the history of past climate (and its implications for the future), the history and age of the Earth, and the history of the Universe. The course has no required text. Readings of relevant articles and use of on-line simulations will be required.

#### Spring 2025: ASTR UN1234

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 1234	001/14272	M W 2:40pm - 3:55pm 402 Chandler	David Helfand	3.00	44/80
ASTR 1234	AU1/18497	M W 2:40pm - 3:55pm Othr Other	David Helfand	3.00	6/6

### ASTR S1403D Earth, Moon, and Planets. 3 points.

May be counted toward the science requirement for most Columbia University undergraduate students. The overall architecture of the solar system. Motions of the celestial sphere. Time and the calendar. Major planets, the earth-moon system, minor planets, comets. Life in the solar system and beyond.

### ASTR UN1403 EARTH, MOON, AND PLANETS. 3.00 points.

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: recommended preparation: a working knowledge of high school algebra.

Prerequisites: recommended preparation: a working knowledge of high school algebra. The overall architecture of the solar system. Motions of the celestial sphere. Time and the calendar. Major planets, the earth-moon system, minor planets, comets. Life in the solar system and beyond. This course is similar to ASTR BC 1753. You cannot enroll in both courses and receive credit for both

### ASTR UN1404 STARS, GALAXIES # COSMOLOGY. 3.00 points.

CC/GS: Partial Fulfillment of Science Requirement

Distances to, and fundamental properties of, nearby stars; nucleosynthesis and stellar evolution; novae and supernovae; galaxies; the structure of the universe and theories concerning its origin, evolution, and ultimate fate. You can only receive credit for ASTR UN1404 if you have not taken ASTR BC1754, ASTR UN1420 or ASTR UN1836

### ASTR UN1453 ANOTHER EARTH. 3.00 points.

CC/GS: Partial Fulfillment of Science Requirement

This course cannot be taken for credit if BC1753 has been taken.

This course will explore the unique properties of Earth, compared to other planets in the Solar System, and the possibility of Earth-like planets around other stars. The basics of the Solar System, gravity, and light will be covered, as well as the geology and atmospheres of the terrestrial planets. The properties of Earth that allowed life to develop and whether life can develop on other planets will be discussed. Finally, the discovery of planets beyond our Solar System and the likelihood of another Earth will be a key component of the course

### ASTR UN1420 Galaxies and Cosmology. 3 points.

CC/GS: Partial Fulfillment of Science Requirement

Galaxies contain stars, gas dust, and (usually) super-massive black holes. They are found throughout the Universe, traveling through space and occasionally crashing into each other. This course will look at how these magnificent systems form and evolve, and what they can tell us about the formation and evolution of the Universe itself. You cannot enroll in ASTR UN1420 in addition to ASTR BC1754 or ASTR UN1404 and receive credit for both.

### ASTR UN1610 THEOR-UNIVERS:BABYLON-BIG BANG. 3.00 points.

CC/GS: Partial Fulfillment of Science Requirement

Milestones in the science of cosmology over the past 6000 years. Skylore and observation in ancient cultures. The twin revolutions of the Greeks: Pythagoras and Ptolemy; and Aristotle, Aquinas, and the Great Chain of Being. The scientific revolution: the impersonal and deterministic world-order of Newton, Laplace, and Kelvin. The erosion of that world-order by mathematics and experiment in the 20th century (relativity, quantum physics, dark matter, and the expanding universe). Today's searches for a new grand order in the Universe, which can cope - or maybe not - with these blows to yesterday's comfortable wisdom

### ASTR BC1753 LIFE IN THE UNIVERSE. 3.00 points.

An introductory course intended primarily for nonscience majors. This interdisciplinary course focuses on the subject of Life in the Universe. We will study historical astronomy, gravitation and planetary orbits, the origin of the chemical elements, the discoveries of extrasolar planets, the origin of life on Earth, the evolution and exploration of the Solar System, global climate change on Venus, Mars and Earth, and the Search for Extraterrestrial Life (SETI). You cannot receive credit for this course and for ASTR UN1403 or ASTR UN1453. Can be paired with the optional Lab class ASTR UN1903

#### Spring 2025: ASTR BC1753

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 1753	001/00430	T Th 2:40pm - 3:55pm 408 Zankel	Nicholas Luber	3.00	142/140

#### Fall 2025: ASTR BC1753

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 1753	001/00877	T Th 2:40pm - 3:55pm Room TBA	Nicholas Luber	3.00	0/60

**ASTR BC1754 Stars, Galaxies, and Cosmology. 3 points.**

BC: Fulfillment of General Education Requirement: Quantitative and Deductive Reasoning (QUA).

Prerequisites: Recommended preparation: A working knowledge of high school algebra.

Corequisites: Suggested parallel laboratory course: ASTR C 1904y. Examines the properties of stars, star formation, stellar evolution and nucleosynthesis, the Milky Way and other galaxies, and the cosmological origin and evolution of the universe. Students may not receive credit for both ASTR BC 1754 and ASTR C1404.

**ASTR UN1836 STARS AND ATOMS. 3.00 points.**

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: recommended preparation: a working knowledge of high school algebra.

Prerequisites: recommended preparation: a working knowledge of high school algebra. What is the origin of the chemical elements? This course addresses this question, starting from understanding atoms, and then going on to look at how atoms make stars and how stars make atoms. The grand finale is a history of the evolution of the chemical elements throughout time, starting from the Big Bang and ending with YOU. You cannot enroll in ASTR UN1836 in addition to ASTR BC1754 or ASTR UN1404 and receive credit for both

Spring 2025: ASTR UN1836

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 1836	001/14275	T Th 1:10pm - 2:25pm 702 Hamilton Hall	James Applegate	3.00	50/80

**ASTR UN1903 ASTRONOMY LAB I. 1.00 point.**

Laboratory for ASTR UN1403. Projects include observations with the departments telescopes, computer simulation, laboratory experiments in spectroscopy, and the analysis of astronomical data. Lab 1 ASTR UN1903 - goes with ASTR BC1753, ASTR UN1403 or ASTR UN1453

Spring 2025: ASTR UN1903

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 1903	001/11204	M 6:00pm - 9:00pm 1402 Pupin Laboratories	Greg Bryan, Stephen Coffey	1.00	20/20
ASTR 1903	002/11205	T 7:00pm - 10:00pm 1402 Pupin Laboratories	Greg Bryan, Justin Vega	1.00	19/20

**ASTR UN1904 ASTRONOMY LAB II. 1.00 point.**

Laboratory for ASTR UN1404. Projects include use of telescopes, laboratory experiments in the nature of light, spectroscopy, and the analysis of astronomical data. Lab 2 ASTR UN1904 - goes with ASTR BC1754 or ASTR UN1404 (or ASTR UN1836 or ASTR UN1420)

Spring 2025: ASTR UN1904

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 1904	001/11206	W 6:00pm - 9:00pm 1402 Pupin Laboratories	Greg Bryan, Fred Angelo Garcia	1.00	8/14

**ASTR UN2001 INTRO TO ASTROPHYSICS I. 3.00 points.**

Prerequisites: a working knowledge of calculus. Corequisites: a course in calculus-based general physics. First term of a two-term calculus-based introduction to astronomy and astrophysics. Topics include the physics of stellar interiors, stellar atmospheres and spectral classifications, stellar energy generation and nucleosynthesis, supernovae, neutron stars, white dwarfs, and interacting binary stars

**ASTR UN2002 INTRO TO ASTROPHYSICS II. 3.00 points.**

Prerequisites: a working knowledge of calculus.

Prerequisites: a working knowledge of calculus. Corequisites: the second term of a course in calculus-based general physics. Continuation of ASTR UN2001; these two courses constitute a full year of calculus-based introduction to astrophysics. Topics include the structure of our galaxy, the interstellar medium, star clusters, properties of external galaxies, clusters of galaxies, active galactic nuclei, and cosmology

Spring 2025: ASTR UN2002

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 2002	001/14277	M W 1:10pm - 2:25pm 602 Northwest Corner	Frederik Paerels	3.00	28/30

**ASTR UN2900 FRONTIERS OF ASTROPHYSICS. 1.00 point.**

Several members of the faculty each offer a brief series of talks providing context for a current research topic in the field and then present results of their ongoing research. Opportunities for future student research collaboration are offered. Grading is Pass/Fail

**ASTR UN3101 MODERN STELLAR ASTROPHYSICS. 3.00 points.**

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: one year of calculus-based general physics.

Introductory astronomy is not required, but some exposure to astronomy is preferable. In the first half of the course, we will examine the physics of stellar interiors in detail, leading us to develop models of stellar structure and consider how stars evolve. In the second half of the course, we will discuss special topics, such as pre-main sequence evolution, the late stages of stellar evolution, and supernovae and compact objects.

**ASTR UN3102 Planetary Dynamics and Physics of the Solar System. 3 points.**

CC/GS: Partial Fulfillment of Science Requirement

The physics and astrophysics of planets, comets, asteroids, natural and artificial satellites, and pretty much anything in the Solar System - including the Sun. Detailed study of the Earth's atmosphere and oceans: circulations, climate, and weather. Orbital dynamics. The emerging science of extrasolar planets. The origin, evolution, and eventual fate of planets.

**ASTR UN3103 GALAXIES. 3.00 points.**

Prerequisites: one year of calculus-based general physics.

Prerequisites: one year of calculus-based general physics. Galaxies fill the universe with structure. They are bound objects that harbor stars, gas, dust and dark matter. This course will discuss the content and structure of galaxies. It will start with the Milky Way, a rotating spiral galaxy, with a particular emphasis on the properties of the interstellar medium. Dwarf galaxies, the building blocks of larger galaxies, will subsequently be discussed, followed by spiral, elliptical and irregular galaxies. The formation and evolution of these different galaxy types will be an important focus of the course, as well as the environment in which the galaxies reside. We will intersperse reviews of current papers on galaxies throughout the semester

Spring 2025: ASTR UN3103

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 3103	001/14281	M W 10:10am - 11:25am 602 Northwest Corner	Mary Putman	3.00	9/25
ASTR 3103	AU1/18498	M W 10:10am - 11:25am Othr Other	Mary Putman	3.00	3/3

**ASTR UN3105 EXOPLANETS AND ASTROBIOLOGY. 3.00 points.**

Prerequisites: One year of calculus-based physics.

The emerging field of extrasolar planets and astrobiology will be covered at a quantitative level, with a major emphasis on astrophysical phenomena and techniques. The subject will be introduced through an investigation of current planetary formation theories and approaches to planet detection, including what we currently know about extrasolar planets and detailed reference to state-of-the-art studies. An astronomer's view of the origin of life and extreme biology will be developed and applied to questions of cosmo-chemistry, observable life-signatures, habitable zones and other astrophysical constraints on the development of organisms.

Spring 2025: ASTR UN3105

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 3105	001/14283	T Th 2:40pm - 3:55pm 307 Uris Hall	Jane Huang	3.00	10/30

**ASTR UN3106 The Science of Space Exploration. 3 points.**

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: one semester course in introductory astronomy or astrophysics (e.g., ASTR W1403, ASTR W1404, ASTR W1420, ASTR W1836, ASTR W2001, ASTR W2002, ASTR BC1753, and ASTR BC1754). Ability in mathematics up to and including calculus is strongly urged. How and why do humans explore space? Why does it require such extraordinary effort? What have we found by exploring our Solar System? We investigate the physics and biological basis of space exploration, and the technologies and science issues that determine what we can accomplish. What has been accomplished in the past, what is being explored now, and what can we expect in the future? How do space scientists explore the Solar System and answer science questions in practice? What do we know about solar systems beyond our own?

**ASTR UN3273 HIGH ENERGY ASTROPHYSICS. 3.00 points.**

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: one year of calculus-based general physics. No previous, \nastronomy background required.

A survey of the most energetic and explosive objects in the Universe and their radiation. Topics include: techniques of X-ray and gamma-ray astronomy; observations of neutron stars (pulsars) and black holes; accretion disks and relativistic jets; supernovae, supernova remnants, gamma-ray bursts, quasars and active galactic nuclei; clusters of galaxies; cosmic rays and neutrinos.

**ASTR UN3602 PHYSICAL COSMOLOGY. 3.00 points.**

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: one year of calculus-based general physics.

Prerequisites: one year of calculus-based general physics. The standard hot big bang cosmological model and modern observational results that test it. Topics include the Friedmann equations and the expansion of the universe, dark matter, dark energy, inflation, primordial nucleosynthesis, the cosmic microwave background, the formation of large-scale cosmic structures, and modern cosmological observations

**ASTR UN3646 OBSERVATIONAL ASTRONOMY. 3.00 points.**

Prerequisites: one year of general astronomy.

Prerequisites: one year of general astronomy Introduction to the basic techniques used in obtaining and analyzing astronomical data. Focus on ground-based methods at optical, infrared, and radio wavelengths. Regular use of the telescope facilities atop the roof of the Pupin Labs and at Harriman Observatory. The radio-astronomy portion consists mostly of computer labs, In research projects, students also work on the analysis of data obtained at National Observatories

Spring 2025: ASTR UN3646

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 3646	001/14285	Th 7:00pm - 9:30pm 1402 Pupin Laboratories	David Schiminovich	3.00	20/20

**ASTR UN3985 Statistics and the Universe (Seminar). 3 points.**

Essential statistical methods will be applied in a series of case studies and research projects taken from the latest advances in cosmology, astronomy and physics. Statistics of measurement and detection, fundamentals of hypothesis testing, classifications, data modeling, time-series analysis, correlation and clustering will be explored through hands-on investigation using data from recent experiments and surveys.

**ASTR UN3996 Current Research in Astrophysics. 1 point.**

Prerequisites: two semesters of astronomy classes and two semesters of physics classes.

The goal of this course is to introduce astronomy and astrophysics majors to the methods and topics of current astronomical research. The course will also help with the development of critical thinking skills. Each week, the topic of the course will be centered on the subject of the Astronomy department colloquium; this may include research on planets, stars, galaxies or cosmology. There will be two required meetings per week: the first will be to discuss papers related to the colloquium (time TBD), and the second will be the colloquium itself (at 4:15 pm each Wednesday). Grading is Pass/Fail.

**ASTR UN3997 INDEPENDENT RESEARCH. 3.00 points.**

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: the instructor's permission. For an independent research project or independent study, a brief description of the proposed project or reading, with the supervising faculty member's endorsement, is required for registration.

Prerequisites: the instructor's permission. For an independent research project or independent study, a brief description of the proposed project or reading, with the supervising faculty member's endorsement, is required for registration. A variety of research projects conducted under the supervision of members of the faculty. Observational, theoretical, and experimental work in galactic and extragalactic astronomy and cosmology. The topic and scope of the work must be arranged with a faculty member in advance; a written paper describing the results of the project is required at its completion (note that a two-term project can be designed such that the grade YC is given after the first term). Senior majors in astronomy or astrophysics wishing to do a senior thesis should make arrangements in May of their junior year and sign up for a total of 6 points over their final two terms. Both a substantial written document and an oral presentation of thesis results are required

**ASTR UN3998 INDEPENDENT RESEARCH. 3.00 points.**

Prerequisites: the instructor's permission. For an independent research project or independent study, a brief description of the proposed project or reading, with the supervising faculty member's endorsement, is required for registration.

Prerequisites: the instructor's permission. For an independent research project or independent study, a brief description of the proposed project or reading, with the supervising faculty member's endorsement, is required for registration. A variety of research projects conducted under the supervision of members of the faculty. Observational, theoretical, and experimental work in galactic and extragalactic astronomy and cosmology. The topic and scope of the work must be arranged with a faculty member in advance; a written paper describing the results of the project is required at its completion (note that a two-term project can be designed such that the grade YC is given after the first term). Senior majors in astronomy or astrophysics wishing to do a senior thesis should make arrangements in May of their junior year and sign up for a total of 6 points over their final two terms. Both a substantial written document and an oral presentation of thesis results are required

Spring 2025: ASTR UN3998

Course Number	Section/Call Number	Times/Location	Instructor	Points	Enrollment
ASTR 3998	001/14289		Marcel Agueros	3.00	11/15

**ASTR GU4260 MODELING THE UNIVERSE. 3.00 points.**

CC/GS: Partial Fulfillment of Science Requirement

Prerequisites: one year of calculus-based general physics.

Prerequisites: one year of calculus-based general physics. The goal of this course is to provide a basic hands-on introduction to the practice and theory of scientific computing with applications in astronomy and astrophysics. The course will include an introduction to programming, as well as a sampling of methods and tools from the field of scientific computing. The course will include a hands-on project in which students use numerical methods to solve a research problem. Students who are interested in participating in research projects are strongly encouraged to take the course in their sophomore or junior year

**ASTR GU4302 General Relativity, Black Holes, and Cosmology. 3 points.**

CC/GS: Partial Fulfillment of Science Requirement

Einstein's General Theory of Relativity replaced Newtonian gravity with an elegant theory of curved spacetime. Einstein's theory led to unforeseen and unnerving predictions of singularities and cosmological instabilities. Nearly a century later, these mathematical oddities have been confirmed astrophysically in the existence of black holes, an expanding universe, and a big bang. The course will cover Einstein's General Theory, beginning with special relativity, with an emphasis on black holes and the big bang.

**ASTR GU4303 ASTROSTATISTICS. 3.00 points.**

Astronomers live in era of "big data". Whilst astronomers of a century ago collected a handful of photographic plates each night, modern astronomers collect thousands of images encoded by millions of pixels in the same time. Both the volume of data and the ever present desire to dig deeper into data sets has led to a growing interest in the use of statistical methods to interpret observations. This class will provide an introduction to the methods commonly used in understanding astronomical data sets, both in terms of theory and application. It is one six classes the department offers every fourth semester

**ASTR GR6001 RADIATIVE PROCESSES. 3.00 points.**

Prerequisites: 3000-level electromagnetic theory and quantum mechanics.

Prerequisites: 3000-level electromagnetic theory and quantum mechanics. Radiation mechanisms and interaction of radiation with matter. Applications of classical and semiclassical radiation theory and atomic physics to astrophysical settings. Radiative transfer, polarization, scattering, line radiation, special relativity, bremsstrahlung, synchrotron radiation, inverse Compton scattering, ionization losses, shocks and particle acceleration, plasma processes, atomic structure and spectroscopic terms, radiative transitions and oscillator strengths, curve of growth, molecular spectra

**ASTR GR6003 GALAXIES. 3.00 points.**

An introduction to the study of galaxies, from both observational and theoretical perspectives. The course will review our current understanding of the formation and evolution of galaxies through descriptions of: their structure and dynamics; the gas and stellar populations they contain; and what we know about the distribution of dark matter within them.

**ASTR GR6005 PHYSICAL COSMOLOGY LEC. 3.00 points.**

## Of Related Interest

**Physics and Astronomy (Barnard)**

ASTR BC1753	LIFE IN THE UNIVERSE
ASTR BC1754	Stars, Galaxies, and Cosmology
<b>Physics</b>	
PHYS UN3002	From Quarks To the Cosmos: Applications of Modern Physics