Space Science, PhD

Mission

The Department of Space Science's primary objective is to prepare the next generation of space professionals and workforce by educating and providing opportunities for our graduate students to engage in cutting-edge research in solar physics, heliospheric science, cosmic ray physics and high-energy astrophysics. Our graduate students are afforded a unique unified Space Science graduate program under the umbrella of a single university department, while introducing students to an academic discipline, solar and space physics, with global consequences that are both intellectually stimulating and relevant to society with faculty from the Department of Space Science and our research partners: UAH’s Center for Space Plasma and Aeronomic Research and Marshall Space Flight Center.

The Doctoral degree program in Space Science empowers our graduate students to think analytically about real science and technology problems to become part of a multi-talented, creative workforce for the future of the United States. The Department of Space Science strives to increase the diversification of the space professional and workforce population by encouraging the participation of women and underrepresented groups on the Space Science program.

Our secondary objective is to enhance and promote space subjects and disciplines locally at UAH, in the community of Huntsville, and within the state of Alabama through scientific research, outreach, and community partnerships with schools and other educational institutions. Our Ph.D. program teaches problem solving and communication skills for future science, engineering, and technology professionals through research in the field of Space Science in order to meet current and future technology needs and demands by training students to formulate and solve technical problems in general research, commercial, and industrial settings.

Admission Requirements

The Department of Space Science will follow the guidelines set by the Graduate School at The University of Alabama in Huntsville as the primary criteria for selecting students for admission into the program. The Department Faculty will carefully evaluate the past performance of each student, as documented in transcripts for all undergraduate and graduate courses. The GRE will be required for all students and TOEFL or IELTS is required for all international students. Letters of recommendation will be used to assess the student’s potential for graduate school. Finally, the student must demonstrate a strong interest in performing research in Space Science, as indicated in the personal statement on his or her application.

Expectations of the students:

- Ph.D. degree recipients are expected to conduct original, independent research adhering to the principles of scientific rigor and research ethics. A person with a Ph.D. in Space Science will be able to communicate effectively the results of his or her work to the professional community through publications and conference presentations, and to promote science to the public with outreach activities. Graduates who choose to enter a research-oriented field will be ready to seek external funding and write research proposals, successfully competing with the nation's top scientists in space related fields. They are also expected to serve the world's scientific community through peer review, panel service, meeting organizing, and mentoring activities.
- For those students desiring to enter a non-space science related field, we expect our students to have learned the technical and communications skills to meet the needs of a technologically-based society, and who can contribute to the broader research, industry, and commercial sectors – i.e., we do not just train our students to be future scientists but instead have the skills and training to contribute to a technologically-based society across the world. The Ph.D. program will focus on original research and the development and provision of technical skills, especially programming and analytic, to graduate students.

http://www.uah.edu/science/departments/space-science

Requirements for a Ph.D. degree

1. Complete the core coursework (24 credit hours), see Core Courses below.
2. Complete an additional 18 credit hours of elective courses. These are chosen from the Elective Courses list.
3. Pass a Comprehensive Examination ("Comps"). The Comps are offered annually during the summer semester and consist of three sections: (a) Electromagnetic Theory, (b) Classical and Quantum Statistics, and (c) Plasma Physics. A passing grade of 60% or above in all three sections is required for a Ph.D. pass.
4. Give at least two seminar (Journal Club) presentations. Students are encouraged to share the results of their research work with their peers and faculty members. Journal Club presentations are part of the regular Space Science seminar series.
5. Pass a Ph.D. qualifier exam. This step involves writing a dissertation proposal and forming a Ph.D. committee, that would normally consist of the student's faculty advisor and at least three other members from the UAH graduate faculty. We encourage students to invite at least one committee member from another department or research center.
6. Complete 18 credit hours of dissertation units (SPA 799).

7. Write and defend a Ph.D. dissertation.
8. Students must have a first authored peer reviewed paper published or accepted in a major international journal before their graduation date. Examples of acceptable journals include The Astrophysical Journal, Journal of Geophysical Research, Physics of Plasmas, Geophysical Research Letters, and Physical Review.

Code	Title	Semester Hours
Core Courses		
SPA 522	INTRODUCTION TO PLASMA PHYSICS	3
MA 607	MATHEMATICAL METHODS I	3
MA 609	MATHEMATICAL METHODS II	3
SPA 622	CLASSICAL & QUANTUM STATISTICS	3
PH 631	ELECTROMAGNETIC THEORY I	3
PH 732	ELECTROMAGNETIC TH II	3
SPA 623	TRANSPORT PROCESSES IN SPACE	3
SPA 624	SPACE PHYSICS I	3
Elective Courses		
SPA 526	SPACE WEATHER	3
SPA 625	SPACE PHYSICS II	3
SPA 627	HIGH ENERGY RADIATION DET&MSRM	3
SPA 628	SOLAR PHYSICS	3
SPA 629	ASTROPHYSICAL FLUID DYNAMICS	3
SPA 630	WAVES IN FLUIDS	3
SPA 662	COMPUTATIONAL PHYSICS	3
SPA 663	COMPUTATIONAL FLUID DYNMC &MHD	3
SPA 689	SELECTED TOPICS	3
SPA 741	PHYSICS OF COSMIC RAYS	3
SPA 742	GAMMA-RAY BURSTS AND JETS	3
SPA 771	COMPETITIVE GRANT WRITING WKSP	1
SPA 789	SELECTED TOPICS	3

Year 1		
Fall		**Semester Hours**
SPA 522	INTRODUCTION TO PLASMA PHYSICS	3
SPA 622	CLASSICAL QUANTUM STATISTICS	3
MA 607	MATHEMATICAL METHODS I	3
	Term Semester Hours:	9
Spring		
PH 631	ELECTROMAGNETIC THEORY I	3
MA 609	MATHEMATICAL METHODS II	3
SPA 624	SPACE PHYSICS I	3
	Term Semester Hours:	9
Year 2		
Fall		
SPA 625	SPACE PHYSICS II	3
SPA 662	COMPUTATIONAL PHYSICS	3
PH 732	ELECTROMAGNETIC TH II	3
	Term Semester Hours:	9
Spring		
SPA 623	TRANSPORT PROCESSES IN SPACE	3
SPA 629	ASTROPHYSICAL FLUID DYNAMICS	3
SPA 627	HIGH ENERGY RADIATION DETMSRM	3
	Term Semester Hours:	9

Year 3		
Fall		
SPA 628	SOLAR PHYSICS	3
SPA 630	WAVES IN FLUIDS	3
SPA 741	PHYSICS OF COSMIC RAYS	3
	Term Semester Hours:	9
Spring		
SPA 626		3
SPA 663	COMPUTATIONAL FLUID DYNMC MHD	3
SPA 799	DOCTORAL DISSERTATION	3
SPA 771	COMPETITIVE GRANT WRITING WKSP	1
	Term Semester Hours:	10
Year 4		
Fall		
SPA 742	GAMMA-RAY BURSTS AND JETS	3
SPA 799	DOCTORAL DISSERTATION	3-9
	Term Semester Hours:	6-12
Spring		
SPA 799	DOCTORAL DISSERTATION	3-9
	Term Semester Hours:	3-9
	Total Semester Hours:	64-76

SPA 489 - SELECTED TOPICS
Semester Hours: 3

Selected topics in Space Science not covered in other courses.

SPA 522 - INTRODUCTION TO PLASMA PHYSICS
Semester Hours: 3

Provides students with an introduction to the basic physical processes associated with plasmas, which permeate all space environments. Both particle and fluid approaches are introduced, and a variety of elementary drift and wave phenomena are derived. Applications of the theory to various plasma instabilities are explored, along with specific examples of where these may occur in space science. While the goal of this course is to prepare students for more advanced topics in space physics, many of the fundamentals covered are equally relevant for students interested in plasma confinement and its associated engineering challenges.

SPA 526 - SPACE WEATHER
Semester Hours: 3

Physics of solar active regions, physics of solar flares and coronal mass ejections (CMEs), the propagation of CMEs, the acceleration and propagation of solar energetic particles, CME interaction with earth's magnetosphere.

SPA 532 - SPACE ORIENTATION EDUCATORS
Semester Hours: 3

A weeklong course at the U.S. Space and Rocket Center in Huntsville, Alabama for pre-service and in-service teachers. The inquiry based workshops are taught around the theme of space exploration include activities to be done across the curriculum. All activities are correlated to National Math, Science, Technology, Social Studies, and Reading Standards. Activities based on curriculum developed by NASA, CAP, NSATA, and the USSRC. Topicis include moon, mars, rocketry, propulsion, hydroponics, math, biology, history and literature.

SPA 582 - SCIENCE CAREER PREP
Semester Hour: 1

This course will review many of the soft skills necessary to function as a successful scientist, whether in an academic career, in a federal laboratory, a for-profit research career in a company, or even a commercial career. Your career begins with graduate school, and learning the skills for a successful graduate career will carry over to your professional career. The goal of the course is impart wisdom from successfull graduate students and career scientists, providing both a basis for a successful graduate career and your subsequent career. The course will help students reduce the learning things "the hard way" approach by providing guidance for your career path. Each week will focus on a different skill that a career scientist requires.

SPA 610 - ADV MATH METHDS FOR SPA SCI
Semester Hours: 3

This course will focus on analytical methods for a series of advanced topics with an emphasis on practical applications to space science, such as Vector and Fourier Analysis, ODEs/PDEs in space science, and Green's functions, Spherical Harmonics, Spectral Analysis, Wavelet Transforms, Fractals and Complexity, and Inverse Problems.

SPA 622 - CLASSICAL & QUANTUM STATISTICS
Semester Hours: 3

Statistical methods, systems of particles, statistical thermodynamics, kinetic theory, methods of statistical mechanics, equilibrium between phases of chemical species. Quantum statistics of identical particles. Spin and statistics. Bose-Einstein and Fermi-Dirac distributions.

SPA 623 - TRANSPORT PROCESSES IN SPACE
Semester Hours: 3

Course presents a systematic treatment of classical and anomalous transport theory for gases, plasmas, energetic particles, and low frequency turbulence. The Chapman-Enskog approach is used to derive transport coefficients for neutral gases and collisional plasmas. The relationship between multi-fluid and MHD models is presented. Weak solutions and shock waves are discussed. The transport of energetic particles that experience scattering by magnetic field fluctuations is presented, together with basic models of the turbulence responsible for scattering turbulence transport in expanding flows such as the solar wind. Prerequsite: SPA 622 and SPA 522.

SPA 624 - SPACE PHYSICS I
Semester Hours: 3

A broad introduction to particle, MHD, and kinetic phenomena in space. This course is intended for all students interested in space, astro-, and plasma physics. Course covers fusion processes inside the Sun, solar neutrinos, solar atmosphere, coronal magnetic fields, physical mechanisms of magnetic field line reconnection and magnetic dynamo, the interaction between the solar wind with planets and the interstellar medium, corotating and merged interaction regions, collisional and collisionless shock waves in space. Includes an introduction to charged partical acceleration in the heliosphere. Examines differences between planetary magnetospheres, solar-terrestrial relationships, solar activity, climate, and culture. Prerequisite: SPA 522, SPA 631 (w/concurrency).

SPA 625 - SPACE PHYSICS II
Semester Hours: 3

The course develops a deeper understanding and knowledge of plasma instabilities, kinetic dispersion relations, microinstabilities, electrostatic and electromagnetic instabilities; advanced magnetohydrodynamics including MHD turbulence, reconnection; wave-partical interactions, including basic quasi-linear theory; weak and strong wave turbulence; nonlinear waves; collisionless shock waves. Prerequisite: SPA 624.

SPA 627 - HIGH ENERGY RADIATION DET&MSRM
Semester Hours: 3

This course will provide students with basic understanding of radiation detection for space-based missions. This course will cover the basic nuclear processes in radioactive souces and the interaction of radiation with matter. The statistical treatment of experimental data will be reviewed. General characteristics common to all types of detectors will be given. We will then cover specific classes of detectors focusing on ionization, scintillation and semiconductor detectors. Light collection and detection techniques will follow. The student will then be introduced to basic signal processing and timing techniques important to a successful intstrument design. This course will be taught from a physicist point of view emphasizing the physical processes and interactions that make detection of radiation possible. This course is suitable for those students interested in detector development or astrophysical data analysis using state-of-the-art technology.

SPA 628 - SOLAR PHYSICS
Semester Hours: 3

The workings of the sun, from its interior to the outer reaches of the corona with emphasis on the observations. Energy release in core of the Sun and its transport to the solar atmosphere. Dynamo process and the 11 year solar activity cycle. Formation of active regions and structure of sunspots. The structure of corona, with particular details on the active region corona and its heating to several million kelvin. Energy release processes including solar flares and coronal mass ejections.

SPA 629 - ASTROPHYSICAL FLUID DYNAMICS
Semester Hours: 3

Covers astrophysical phenomena occuring outside the boundaries of the solar system. Subjects include stellar structure and rotation, waves and instabilities in astrophysical plasmas, the physics of sperical and disk accretion, supernova blast waves, and charged particle transport and acceleration in cosmic plasmas. Introduction to the principles of stellar formation, helioseismology, stellar dynamo, coronal heating, and astrophysical turbulence. Prerequisite: SPA 522.

SPA 630 - WAVES IN FLUIDS
Semester Hours: 3

Comprehensive introduction to the science of wave motions in fluids. Waves and first-order (hyperbolic) equations, wave hierarchies; gas dynamics and fluid equations; acoustics, nonlinear plane waves, simple waves, shock waves and structure, shock reflection, similarity solutions, supersonic flows in gas dynamics; the wave equation, including plane, spherical and cylindrical waves, geometrical optics, including far-field approximation, caustics, nonhomogeneous media, anisotropy; water waves, including shallow water theory; group velocity, dispersion; nonlinear waves, including Korteweg-de Vries, sine-Gordon, and nonlinear Schroedinger euqations, solitons. Prerequisite: SPA 610.

SPA 631 - WAVES AND FIELDS
Semester Hours: 3

This course will cover the following topics: 1) Review of static solutions of the Maxwell equations. Boundary-value applications. Green function solutions. 2) Covariant electrodynamics: Basic application of special relativity to charged particles and fields. Lienard-Wiechert potentials. Solutions to the wave equation. 3) Space Science applications: Thermal Spectra and Particle Distributions. Cyclotron and synchrotron radiation. Bremsstrahlung and collisions. Compton Scattering. Prerequisite: SPA 610.

SPA 636 - ADV SPACE WEATHER
Semester Hours: 3

Advanced topics in Space Weather with emphasis on practical effects and impacts on human technology and society: interaction of solar disturbances with Earth's magnetosphere, Solar Energetic Particles, and their effects; Forecasting and Nowcasting of Space Weather; Space Weather at Mars and other planets. Prerequisite: SPA 522.

SPA 662 - COMPUTATIONAL PHYSICS
Semester Hours: 3

Numerical methods to solve common physics problems using C or Fortran. Numerical integration and differentiation, root finding, data fitting, introductory stochastic methods, linear and non-linear differential equations. Fourier analysis. Elliptic parabolic hyperbolic partial differential equations via finite differences, integro-differential equations. Applications to classical dynamics, electromagnetism, statistical and quantum physics.

SPA 663 - COMPUTATIONAL FLUID DYNMC &MHD
Semester Hours: 3

Numerical simulations of various problems in space physics, astrophysics, engineering, and plasma dynamics. Finite- volume and finite-difference, shock-capturing and shock-fitting methods for hyperbolic equations, including gas dynamics, MHD, and shallow water equations. The hierarchy of numerical methods is introduced in a systematic way, starting from standard linear schemes and arriving at modern discontinuity-capturing non-linear methods. Exact and approximate Riemann solvers, characteristic analysis of underlying equations. Different implementations of boundary conditions are introduced in relation with the mathematical properties of quasilinear hyperbolic systems. Prerequisite: SPA 624, SPA 662.

SPA 689 - SELECTED TOPICS
Semester Hours: 3

Selected Topics in Space Science not covered in other courses.

SPA 699 - MASTER'S THESIS
Semester Hours: 1-6

SPA 741 - PHYSICS OF COSMIC RAYS
Semester Hours: 3

Covers two principal areas of cosmic ray physics: (i) cosmic ray origin and acceleration, and (ii) cosmic ray transport and detection. Includes galactic cosmic rays, anomalous cosmic rays, and solar energetic particles. Transport theory, acceleration mechanisms and observational signatures. Prerequisite: SPA 623.

SPA 742 - GAMMA-RAY BURSTS AND JETS
Semester Hours: 3

Astrophysical jet sources: kinetic and magnetically-dominated relativistic outflows. Blandford-McKee solution. Photospheres. Relativistic shock physics. Emission in relativistic plasmas. Gamma-ray bursts; observations, theory. Prerequisite: SPA 622, SPA 624.

SPA 771 - COMPETITIVE GRANT WRITING WKSP
Semester Hour: 1

This course is designed for senior level graduate students who are about to graduate and start their professional career. It will introduce students to the real and complete process of competing for grant support. It is comprised of a series of lectures (workshops), case studies, and ends with a formal proposal from each participant and a mock review process.

SPA 789 - SELECTED TOPICS
Semester Hours: 3

Selected Topics in Space Science not covered in other courses.

SPA 796 - JOURNAL CLUB
Semester Hour: 1

This course requires graduate students to read, interpret and present literature critically to fellow students, researchers, and faculty. Students stay abreast of current knowledge in the field, develop presentation skills and promote department unity. Faculty instructor will lead, assign, and provide students feedback on their presentations.

SPA 799 - DOCTORAL DISSERTATION
Semester Hours: 1-9

Students must have passed the Comprehensive Examination at PhD level and have PhD advisor's approval. No more than 9 hours may be taken prior to passing the Qualifying Examination.