Space Science, MS

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 will be 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: The University of Alabama in Huntsville's Center for Space Plasma and Aeronomic Research and Marshall Space Flight Center.

The Master's degree program in Space Science empowers our graduate students to think analytically on 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 in 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 M.S. 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. We also provide teachers and educators with opportunities to develop and strengthen their knowledge and skills in space-related fields, as well as promote space science nationally and internationally through faculty and student research.

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. In addition, 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:

• To be technically competent in space-related fields; able to work on diverse technical problems that typically arise in a technologically-based work and industry environment; able to communicate effectively the results of their work to the professional community through reports and presentations; or to present technical space-related material to students at the high school and junior college level, and to promote their science to the public with outreach 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 highly technological society throughout the world. The M.S. program will focus on the development and provision of technical skills to graduate students. M.S. graduates will fit more directly into technical/industry and educational workforce.

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<thead>
<tr>
<th>Fall</th>
<th>Semester Hours</th>
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<tbody>
<tr>
<td>SPA 522</td>
<td>INTRODUCTION TO PLASMA PHYSICS</td>
</tr>
<tr>
<td>SPA 622</td>
<td>CLASSICAL QUANTUM STATISTICS</td>
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<tr>
<td>MA 607</td>
<td>MATHEMATICAL METHODS I</td>
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<td>Term Semester Hours:</td>
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Year 1

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<th>Spring</th>
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<tr>
<td>PH 631</td>
<td>ELECTROMAGNETIC THEORY I</td>
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<tr>
<td>MA 609</td>
<td>MATHEMATICAL METHODS II</td>
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<tr>
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<td>SPACE PHYSICS I</td>
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Year 2

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<tr>
<td>SPA 628</td>
<td>SOLAR PHYSICS</td>
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Information below is intended for prospective students who are considering a Master's degree in Space Science from UAH.

All questions about enrolling in our M.S. program should be directed to Dr. Robert Preece (rob.preece@nasa.gov), Chair of the SPA Graduate Committee.

Requirements for M.S. Degree - Thesis Option

1. Complete the core coursework (21 credit hours), see Core Courses below.
2. Complete an additional 9 credit hours of elective courses. These are chosen from the Elective Courses list.
4. Write and defend a Master's thesis.

Requirements for M.S. Degree - Non Thesis Option

1. Complete the core coursework (21 credit hours), see Core Courses below.
2. Complete an additional 15 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 40% or above in all three sections is required for a M.S. pass.

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<tr>
<td>SPA 622</td>
<td>CLASSICAL &amp; QUANTUM STATISTICS</td>
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<td>SPA 623</td>
<td>TRANSPORT PROCESSES IN SPACE</td>
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<tr>
<td>SPA 624</td>
<td>SPACE PHYSICS I</td>
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Elective Courses

Choose 5 courses from the following: 15

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<tr>
<td>SPA 625</td>
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<td>SPA 627</td>
<td>HIGH ENERGY RADIATION DET&amp;MSRM</td>
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<td>SPA 629</td>
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<td>SPA 630</td>
<td>WAVES IN FLUIDS</td>
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<td>COMPETITIVE GRANT WRITING WKSP</td>
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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. Topics 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 METHODS 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  


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. Prerequisite: 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 particle 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-particle 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 sources 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 instrument 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 occurring outside the boundaries of the solar system. Subjects include stellar structure and rotation, waves and instabilities in astrophysical plasmas, the physics of spherical 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 Schrödinger equations, solitons. Prerequisite: SPA 610.

SPA 631 - WAVES AND FIELDS  
Semester Hours: 3 


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 

SPA 663 - COMPUTATIONAL FLUID DYNAMICS & 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


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.