Space Science

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

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Chair: Gary P. Zank, Eminent Scholar and Distinguished Professor

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The Space Science department offers the following graduate degree programs**:**

- Master of Space Science
- Doctorate of Space Science
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Program Objective

The Space Science department will provide opportunities through our graduate program for students to be introduced to and engage in cutting edge research in solar physics, heliospheric science, cosmic ray physics, and high-energy astrophysics with faculty from the Department of Space Science and with our research partners: The University of Alabama in Huntsville's (UAH's) Center for Space Plasma and Aeronomic Research (CSPAR) and Marshall Space Flight Center (MSFC). Additionally, the department will provide a unique unified Space Science graduate program under the umbrella of a single university department.

Learning Outcomes

Students will demonstrate:

- Inculcated problem solving skills through introductory research in the field of space science for future use in science, engineering, teaching, and technology professions
- Ability to write a scholarly document
- Ability to prepare and deliver an effective oral scientific presentation

Master's Program in Space Science

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

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. Jacob Heerikhuisen (jacob.heerikhuisen@uah.edu), Chair of the SPA Graduate Committee.

Requirements for M.S. Degree - Thesis Option

1. Complete the core coursework (15 credit hours), see Core Courses below.
2. Complete an additional 9 credit hours of elective courses. These are chosen from the Elective Courses list.
3. Complete SPA 582 and SPA 796 once.
4. Complete 6 hours of Master's thesis SPA 699.
5. Write and defend a Master's thesis.

Core courses		
SPA 522	INTRODUCTION TO PLASMA PHYSICS	3
SPA 610	ADV MATH METHDS FOR SPA SCI (ADVANCED MATH METHODS FOR SPA)	3
SPA 622	CLASSICAL & QUANTUM STATISTICS	3
SPA 624	SPACE PHYSICS I	3
SPA 631	WAVES AND FIELDS	3
Required Courses		
SPA 582	SCIENCE CAREER PREP (SCIENCE CAREER PRPARATION)	1
SPA 796	JOURNAL CLUB	1
Elective Courses		

Choose 3 courses from the following:		9
SPA 526	SPACE WEATHER	
SPA 623	TRANSPORT PROCESSES IN SPACE	
SPA 625	SPACE PHYSICS II	
SPA 627	HIGH ENERGY RADIATION DET&MSRM	
SPA 628	SOLAR PHYSICS	
SPA 629	ASTROPHYSICAL FLUID DYNAMICS	
SPA 630	WAVES IN FLUIDS	
SPA 662	COMPUTATIONAL PHYSICS	
SPA 663	COMPUTATIONAL FLUID DYNMC &MHD	
SPA 689	SELECTED TOPICS	
SPA 741	PHYSICS OF COSMIC RAYS	
SPA 742	GAMMA-RAY BURSTS AND JETS	
SPA 771	COMPETITIVE GRANT WRITING WKSP	
SPA 789	SELECTED TOPICS	
Total Semester Hours		**26**

Year 1

Fall		**Semester Hours**
SPA 522	INTRODUCTION TO PLASMA PHYSICS	3
SPA 582	SCIENCE CAREER PREP (SCIENCE CAREER PRPARATION)	1
SPA 610	ADV MATH METHDS FOR SPA SCI (ADVANCED MATH METHODS FOR SPA)	3
SPA 622	CLASSICAL QUANTUM STATISTICS	3
	Term Semester Hours:	**10**
Spring		
SPA 526	SPACE WEATHER (SPACE WEATHER)	3
SPA 624	SPACE PHYSICS I	3
SPA 631	WAVES AND FIELDS	3
SPA 796	JOURNAL CLUB	1
	Term Semester Hours:	**10**
Summer		
SPA 699	MASTER'S THESIS	3
	Term Semester Hours:	**3**
Year 2		
Fall		
SPA 627	HIGH ENERGY RADIATION DETMSRM	3
SPA 662	COMPUTATIONAL PHYSICS	3
SPA 699	MASTER'S THESIS	3
	Term Semester Hours:	**9**
	Total Semester Hours:	**32**

Requirements for M.S. Degree - Non Thesis Option

1. Complete the core coursework (15 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. Complete SPA 582 and SPA 796 once.
4. 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.

Core Courses

SPA 522	INTRODUCTION TO PLASMA PHYSICS	3
SPA 610	ADV MATH METHDS FOR SPA SCI (ADVANCED MATH METHODS FOR SPA)	3

SPA 622	CLASSICAL & QUANTUM STATISTICS	3
SPA 624	SPACE PHYSICS I	3
SPA 631	WAVES AND FIELDS	3
Required Courses		
SPA 582	SCIENCE CAREER PREP (SCIENCE CAREER PREPARATION)	1
SPA 796	JOURNAL CLUB	1
Elective Courses		
Choose 5 courses from the following:		15
SPA 526	SPACE WEATHER	
SPA 623	TRANSPORT PROCESSES IN SPACE	
SPA 625	SPACE PHYSICS II	
SPA 627	HIGH ENERGY RADIATION DET&MSRM	
SPA 628	SOLAR PHYSICS	
SPA 629	ASTROPHYSICAL FLUID DYNAMICS	
SPA 630	WAVES IN FLUIDS	
SPA 662	COMPUTATIONAL PHYSICS	
SPA 663	COMPUTATIONAL FLUID DYNMC &MHD	
SPA 689	SELECTED TOPICS	
SPA 741	PHYSICS OF COSMIC RAYS	
SPA 742	GAMMA-RAY BURSTS AND JETS	
SPA 771	COMPETITIVE GRANT WRITING WKSP	
SPA 789	SELECTED TOPICS	
Total Semester Hours		**32**

Pathway

Year 1		
Fall		**Semester Hours**
SPA 522	INTRODUCTION TO PLASMA PHYSICS	3
SPA 582	SCIENCE CAREER PREP (SCIENCE CAREER PREPARATION)	1
SPA 610	ADV MATH METHDS FOR SPA SCI (ADVANCED MATH METHODS FOR SPA)	3
SPA 622	CLASSICAL QUANTUM STATISTICS	3
	Term Semester Hours:	**10**
Spring		
SPA 526	SPACE WEATHER (SPACE WEATHER)	3
SPA 624	SPACE PHYSICS I	3
SPA 631	WAVES AND FIELDS	3
	Term Semester Hours:	**9**
Year 2		
Fall		
SPA 625	SPACE PHYSICS II	3
SPA 627	HIGH ENERGY RADIATION DETMSRM	3
SPA 662	COMPUTATIONAL PHYSICS	3
SPA 796	JOURNAL CLUB	1
	Term Semester Hours:	**10**
Spring		
SPA 628	SOLAR PHYSICS	3
	Term Semester Hours:	**3**
	Total Semester Hours:	**32**

Doctoral Program in Space Science

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

Requirements for a Ph.D. degree

1. Complete the core coursework (18 credit hours), see Core Courses below.
2. Complete an additional 30 credit hours of elective courses. These are chosen from the Elective Courses list.
3. Complete SPA 796 four times (only 1 credit hour counts toward degree hours).
4. Complete SPA 582 once.
5. 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.
6. 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 adviser and at least four other members from the UAH graduate faculty. We encourage students to invite at least one committee member external to the department.
7. Complete 18 credit hours of dissertation units SPA 799.
8. Write and defend a Ph.D. dissertation.
9. 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.

Core Courses		
SPA 522	INTRODUCTION TO PLASMA PHYSICS	3
SPA 610	ADV MATH METHDS FOR SPA SCI (ADVANCED MATH METHODS FOR SPA)	3
SPA 622	CLASSICAL & QUANTUM STATISTICS	3
SPA 623	TRANSPORT PROCESSES IN SPACE	3
SPA 624	SPACE PHYSICS I	3
SPA 631	WAVES AND FIELDS	3
Required Courses		
SPA 582	SCIENCE CAREER PREP (SCIENCE CAREER PREPARATION)	1
SPA 796	JOURNAL CLUB [1]	1
Elective Courses		
SPA 526	SPACE WEATHER	
SPA 625	SPACE PHYSICS II	
SPA 627	HIGH ENERGY RADIATION DET&MSRM	
SPA 628	SOLAR PHYSICS	
SPA 629	ASTROPHYSICAL FLUID DYNAMICS	
SPA 630	WAVES IN FLUIDS	
SPA 662	COMPUTATIONAL PHYSICS	
SPA 663	COMPUTATIONAL FLUID DYNMC &MHD	
SPA 689	SELECTED TOPICS	
SPA 741	PHYSICS OF COSMIC RAYS	
SPA 742	GAMMA-RAY BURSTS AND JETS	
SPA 771	COMPETITIVE GRANT WRITING WKSP	
SPA 789	SELECTED TOPICS	

1 Required to take class four times but only 1 credit hour counts toward degree hours

Pathway

Year 1

Fall		**Semester Hours**
SPA 522	INTRODUCTION TO PLASMA PHYSICS	3
SPA 582	SCIENCE CAREER PREP (SCIENCE CAREER PREPARATION)	1
SPA 610	ADV MATH METHDS FOR SPA SCI (ADVANCED MATH METHODS FOR SPA)	3
SPA 622	CLASSICAL QUANTUM STATISTICS	3
	Term Semester Hours:	**10**

Spring

SPA 526	SPACE WEATHER (SPACE WEATHER)	3
SPA 624	SPACE PHYSICS I	3
SPA 631	WAVES AND FIELDS	3
SPA 796	JOURNAL CLUB [1]	1
	Term Semester Hours:	**10**
Year 2		
Fall		
SPA 625	SPACE PHYSICS II	3
SPA 627	HIGH ENERGY RADIATION DETMSRM	3
SPA 662	COMPUTATIONAL PHYSICS	3
SPA 796	JOURNAL CLUB [1]	1
	Term Semester Hours:	**10**
Spring		
SPA 623	TRANSPORT PROCESSES IN SPACE	3
SPA 628	SOLAR PHYSICS	3
SPA 629	ASTROPHYSICAL FLUID DYNAMICS	3
SPA 796	JOURNAL CLUB [1]	1
	Term Semester Hours:	**10**
Year 3		
Fall		
SPA 630	WAVES IN FLUIDS	3
SPA 741	PHYSICS OF COSMIC RAYS	3
or SPA 742	or GAMMA-RAY BURSTS AND JETS	
SPA 796	JOURNAL CLUB [1]	1
SPA 799	DOCTORAL DISSERTATION	3
	Term Semester Hours:	**10**
Spring		
SPA 663	COMPUTATIONAL FLUID DYNMC MHD	3
SPA 771	COMPETITIVE GRANT WRITING WKSP	1
SPA 799	DOCTORAL DISSERTATION	6
	Term Semester Hours:	**10**
Year 4		
Fall		
SPA 799	DOCTORAL DISSERTATION	9
	Term Semester Hours:	**9**
Spring		
SPA 799	DOCTORAL DISSERTATION	3-9
	Term Semester Hours:	**3-9**
	Total Semester Hours:	**72-78**

[1] Required to take class four times but only 1 credit hour counts toward degree hours

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.

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.