Physics

Degrees Offered

- Master of Science (M.S.)
- Doctor of Philosophy (Ph.D.)

Nature of the Program

The graduate programs in Physics provide a solid foundation in the fundamentals as well as a diverse range of specializations for research (https://physics.wvu.edu/research/). The programs’ strengths include Astronomy and Astrophysics, Biophysics, Experimental Condensed Matter and Materials Physics, Theoretical and Computational Condensed Matter and Materials Physics, Optical and Laser Physics, Physics Education Research, and Plasma and Space Physics. In addition to working with physics faculty in these research areas, graduate students have worked with faculty in a range of other departments at WVU. The Department is supported by several in-house facilities including a machine shop and electronics shop, high-performance computational facilities for condensed matter and astrophysics and a physics cleanroom. The Department has strong collaboration with other facilities at WVU, such as the engineering fabrication and characterization facility (http://sharedresearchfacilities.wvu.edu/) and the bio- and health sciences facilities (http://www.hsc.wvu.edu/). Many of the research groups are affiliated with the WVNano Initiative (https://undergraduateapplication.wvu.edu/, the Green Bank Observatory (https://science.nrao.edu/facilities/gbt/) in Green Bank WV, and the DIII-D Research Program (https://fusion.gat.com/global/DIII-D/).

Financial Aid

With rare exceptions, all doctoral students receive financial support; the department makes every effort to secure funding for eligible master’s students as well. Beginning students usually receive teaching assistantships; more advanced students receive research assistantships. Several fellowships are available for outstanding students, allowing full-time concentration on coursework and research and a more rapid progress toward the degree. Students on visas must comply with the conditions of their visa for financial support.

FACULTY

CHAIR

- D.J. Pisano - Ph.D. (University of Wisconsin - Madison)
  Astronomy/Astrophysics

ASSOCIATE CHAIR

- Alan Bristow - Ph.D. (University of Sheffield)
  Condensed Matter Physics

PROFESSORS

- Wathiq Abdul-Razzaq - Ph.D. (University of Illinois - Chicago)
  Physics Education
- Paul Cassak - Ph.D. (University of Maryland)
  Plasma Physics
- Leonardo Golubovic - Ph.D. (University of Belgrade)
  Condensed Matter Physics and Statistical Physics
- Matthew B. Johnson - Ph.D. (California Institute of Technology)
  Condensed Matter Physics
- Mark E. Koepke - Ph.D. (University of Maryland)
  Plasma Physics
- Lian Li - PhD (University of Arizona)
  Carroll Professor, Condensed Matter Physics
- Duncan Lorimer - Ph.D. (University of Manchester)
  Astrophysics/Astronomy
- Maura McLaughlin - Ph.D. (Cornell University)
  Eberly Family Professor, Astrophysics/Astronomy
- D.J. Pisano - Ph.D. (University of Wisconsin - Madison)
  Astrophysics/Astronomy
- Aldo Humberto Romero - Ph.D. (University of California - San Diego)
  Condensed Matter Physics
• Earl E. Scime - Ph.D. (University of Wisconsin - Madison)
  Oleg D. Jefimenko Professor, Plasma Physics
• Tudor Stanescu - Ph.D. (University of Illinois)
  Theoretical Condensed
• Gay Stewart - Ph.D. (University of Illinois-Urbana Champaign)
  Eberly Professor of STEM Education
• John Stewart - Ph.D. (University of Illinois-Urbana Champaign)
  Physics Education Research

ASSOCIATE PROFESSORS
• Loren Anderson - Ph.D. (Boston University)
  Astrophysics/Astronomy
• Alan Bristow - Ph.D. (University of Sheffield)
  Condensed Matter Physics; Associate Chair
• Cheng Cen - Ph.D. (University of Pittsburgh)
  Condensed Matter Physics
• Zachariah Etienne - Ph.D. (University of Illinois)
  Astronomy
• Edward Flagg - Ph.D. (University of Texas - Austin)
  Condensed Matter Physics
• Mikel Holcomb - Ph.D. (University of California - Berkeley)
  Condensed Matter Physics
• Sean McWilliams - Ph.D. (University of Maryland)
  Astrophysics/Astronomy
• Paul Miller - Ph.D. (West Virginia University)
  Physics Education Research
• Weichao Tu - Ph.D. (University of Colorado-Boulder)
  Space Plasma Physics
• Kathryn Williamson - Ph.D. (Montana State University)
  Astronomy Education Research

ASSISTANT PROFESSORS
• Adam Kobelski - Ph.D. (University of Montana)
  Solar Physics, Physics Education Research
• Joonhee Lee - Ph.D. (Seoul National University)
  Biophysics
• Sarah Burke Spolaor - Ph.D. (Swinburne Institute of Technology)
  Astrophysics/Astronomy

RESEARCH ASSISTANT PROFESSOR
• Yanjun Ma - Ph.D. (University of Pittsburgh)
  Condensed Matter Physics
• Qiang Wang - Ph.D. (University of Colorado - Boulder)
  Condensed Matter Physics

PROFESSORS EMERITI
• Larry Halliburton - Ph.D. (University of Missouri - Columbia)
  Condensed Matter Physics
• Arthur S. Pavlovic - Ph.D. (Columbia University)
  Condensed Matter Physics
• Mohindar S. Seehra - Ph.D. (University of Rochester)
  Condensed Matter Physics
• Richard Treat - Ph.D. (University of California - Riverside)
  General Relativity
• H. Arthur Weldon - Ph.D. (Massachusetts Institute of Technology)
  Particle Physics
Admissions

The M.S. (http://catalog.wvu.edu/graduate/eberlycollegeofartsandsciences/physics/#masterstext) and the Ph.D. (http://catalog.wvu.edu/graduate/eberlycollegeofartsandsciences/physics/#doctoraltext) in physics are separate degree programs, and students should consider which is the most appropriate for their career goals. Students who are admitted to the Ph.D. may earn the M.S. as part of their plan of study.

M.S. IN PHYSICS

In addition to WVU’s general admission requirements (http://catalog.wvu.edu/graduate/graduateeducationatwestvirginiauniversity/#classificationstext), applicants are expected to have a bachelor’s degree in physics, astronomy, or a related field, with upper-division courses in electricity and magnetism, mechanics, quantum mechanics, thermodynamics, and mathematical methods. Applicants lacking some of these courses, if they qualify for provisional admission (http://catalog.wvu.edu/graduate/graduateeducationatwestvirginiauniversity/#Provisional_Graduate_Students), may be admitted provisionally and will be allowed to remedy the deficiencies by taking appropriate coursework. Typically, competitive applicants have a cumulative GPA of at least 3.0.

Students must complete a graduate application, which will require submission of the applicant’s ranked areas of research interest and the faculty (https://physics.wvu.edu/faculty-and-staff/faculty/) the applicant would wish to work with. Applicants must also submit transcripts from all institutions attended, a resume or curriculum vitae, a personal statement, and three letters of recommendation. Students with undergraduate degrees not in physics or astronomy, or who believe that their undergraduate GPA does not reflect their physics knowledge, are strongly encouraged to submit the subject GRE. The statement of purpose should explain the applicant’s previous academic experience and highlight their interest in pursuing graduate school in physics and astronomy at WVU. While there is no specific length requirement, the essay should demonstrate clear and concise scientific writing.

A short list of prospective students should expect a brief phone interview prior to being offered admission to the program.

PH.D. IN PHYSICS

In addition to WVU’s general admission requirements (http://catalog.wvu.edu/graduate/graduateeducationatwestvirginiauniversity/#classificationstext), applicants are expected to have a bachelor’s degree in physics, astronomy, or a related field, with upper-division courses in electricity and magnetism, mechanics, quantum mechanics, thermodynamics, and mathematical methods. Applicants lacking some of these courses, if they qualify for provisional admission (http://catalog.wvu.edu/graduate/graduateeducationatwestvirginiauniversity/#Provisional_Graduate_Students), may be admitted provisionally and will be allowed to remedy the deficiencies by taking appropriate coursework. Typically, competitive applicants have a cumulative GPA of at least 3.0.

Students must complete a graduate application, which will require submission of the applicant’s ranked areas of research interest and the faculty (https://physics.wvu.edu/faculty-and-staff/faculty/) the applicant would wish to work with. Applicants must also submit transcripts from all institutions attended, a resume or curriculum vitae, a personal statement, and three letters of recommendation. Students with undergraduate degrees not in physics or astronomy, or who believe that their undergraduate GPA does not reflect their physics knowledge, are strongly encouraged to submit the subject GRE. The statement of purpose should explain the applicant’s previous academic experience and highlight their interest in pursuing graduate school in physics and astronomy at WVU. While there is no specific length requirement, the essay should demonstrate clear and concise scientific writing.

A short list of prospective students should expect a brief phone interview prior to being offered admission to the program.

List of Admission Requirements for MS and PhD Applications:

- See the steps to apply for admissions and access the application here (https://graduateadmissions.wvu.edu/how-to-apply/)
- Transcripts from all institutions attended
- Three letters of recommendation from professional or academic references
- Curriculum Vitae or Resume
- Statement of purpose

International Applications:

- See the steps to apply for admissions and access the application here (https://graduateadmissions.wvu.edu/how-to-apply/)
- International applications should view additional requirements here (http://catalog.wvu.edu/graduate/graduateeducationatwestvirginiauniversity/#internationaltext) and here (https://graduateadmissions.wvu.edu/how-to-apply/apply-for-2020-2021/international-graduate-applicant/)
- Language proficiency is required in order to hold a graduate teaching assistantship. See here (https://elli.wvu.edu/testing-resources/english-proficiency-gtas/).

Application Deadlines:

- The Physics program admits students for the Fall semester only
- The application deadline is January 15th
- Completed applications for admission may be considered after the January 15th deadline on a space-available basis
- Exceptional applicants may be nominated by the Physics program for competitive University Fellowships. Qualified applicants will be notified if they are nominated. More information on WVU fellowships can be found here (https://graduateeducation.wvu.edu/fellowships/).
Certain application requirements may be waived based on a preliminary review of an application by the program.

More information can be found on the department's website (https://physics.wvu.edu/students/graduate-students/). Applicants needing additional information may contact the department: physics@mail.wvu.edu.

Major Code: 1463

For specific information on the following program, please see the link to the right:

- Physics, M.S.

For specific information on the following program, please see the link to the right:

- Physics, Ph.D.

**Degree Progress**

Typical plans of study for M.S. and Ph.D. students are available in the Graduate Student Handbook. Students are evaluated each year by either the Graduate Advisor or their Ph.D. committee (after passing their oral exam).

To remain in good standing in the program, M.S. students must maintain a cumulative GPA of 2.75 or better and a 2.75 or better in courses applied to the degree. For doctoral students to be considered in good standing, each student must maintain a cumulative GPA of 3.0 or better and a 3.0 or better in courses applied to the degree. Ph.D. students have a total of four attempts to pass all three written qualifier exams and seven semesters after admission to pass the oral qualifier exam. The committee that gives the oral exam must consist of at least four members, with one of these members being external to the department. This committee also forms the Ph.D. advisory committee and the defense exam committee, with the chair of this committee being the student’s research advisor.

After the oral exam, Ph.D. student has 5 years to defend (http://catalog.wvu.edu/graduate/advisingcoursesdegrees/degree_regulations/#timelimittext) their Ph.D. dissertation. Each year, Ph.D. students must give a presentation and submit a report to the Ph.D. advisory committee for the evaluation of progress towards completion of the Ph.D. degree is reviewed and discussed. The report has to be signed by all members of the committee, along with any comments and recommendations, before being submitted to the Departmental graduate advisor. More information is available in the Physics and Astronomy Graduate Student Handbook.

**Academic Standards**

To be a graduate student in good standing requires the following:

- Maintain a GPA of 2.75 or better in graduate physics courses taken at WVU, excluding PHYS 797.
- A GPA of 3.0 or better is required for graduation.
- All entering Ph.D. students are required to take all three written graduate exams at the beginning of, or immediately prior to, their first semester.
- Following the initial exam, as needed, Ph.D. students can retake exams up to three times, but no later than the beginning of their fourth semester of graduate studies.
- Ph.D. students must select a Ph.D. committee of four faculty after passing the written exams.
- Ph.D. students must complete the oral candidacy examination within three semesters (after completing the third section of the written candidacy examination).
- Students admitted as M.S. degree candidates are not expected to take the graduate qualifying exams but must maintain a GPA of 2.75 and complete their M.S. degree within three years.

**ASTRONOMY COURSES**

**ASTR 591. Advanced Topics. 1-6 Hours.**
PR: Consent. Investigation in advanced topics that are not covered in regularly scheduled courses.

**ASTR 592. Directed Study. 1-6 Hours.**
Directed study, reading, and/or research.

**ASTR 593. Special Topics. 1-6 Hours.**
A study of contemporary topics selected from recent developments in the field.

**ASTR 594. Seminar. 1-6 Hours.**
Special seminars arranged for advanced graduate students.

**ASTR 595. Independent Study. 1-9 Hours.**
Faculty-supervised study of topics not available through regular course offerings.
ASTR 601. Graduate Astrophysics Seminar. 1 Hour.
This two-semester class is designed for first-year physics graduate students interested in studying astrophysics. The course provides students access to introductory material they will need for the rest of their graduate astrophysics courses and research, including order-of-magnitude estimates, coordinate systems, blackbody radiation, radiative transfer, stellar structure and evolution, statistics, compact objects, relativity, and cosmology.

ASTR 691. Advanced Topics. 1-6 Hours.
PR: Consent. Investigation in advanced topics that are not covered in regularly scheduled courses.

ASTR 692. Directed Study. 1-6 Hours.
Directed study, reading, and/or research.

ASTR 693. Special Topics. 1-6 Hours.
A study of contemporary topics selected from recent developments in the field.

ASTR 694. Seminar. 1-6 Hours.
Special seminars arranged for advanced graduate students.

ASTR 695. Independent Study. 1-9 Hours.
Faculty-supervised study of topics not available through regular course offerings.

ASTR 696. Graduate Seminar. 1-3 Hours.
PR: Consent. Each graduate student will present at least one seminar to the assembled faculty and graduate student body of his or her program.

ASTR 697. Research. 1-9 Hours.
ASTR 697. Research. I, II, S. 1-15 hr. PR: Consent. Research activities leading to thesis (697), problem report (697), research paper or equivalent scholarly project (697), or a dissertation (797). (Grading is S/U).

ASTR 698. Thesis or Dissertation. 1-6 Hours.
PR: Consent. This is an optional course for programs that wish to provide formal supervision is needed during the writing of student reports (698), theses (698), or dissertations (798). (Grading is Normal).

ASTR 699. Graduate Colloquium. 1-6 Hours.
PR: Consent. For graduate students not seeking coursework credit but who wish to meet residency requirements, use the University’s facilities, and participate in its academic and cultural programs. Note: Graduate students who are not actively involved in coursework or research are entitled, through enrollment in their department's 699/799 Graduate Colloquium, to consult with graduate faculty, participate in both formal and informal academic activities sponsored by their program, and retain all of the rights and privileges of duly enrolled students. Grading is normal; colloquium credit may not be counted against credit requirements for masters programs. Registration for one credit of 699/799 graduate colloquium satisfies the University requirement of registration in the semester in which graduation occurs.

ASTR 700. Radio Astronomy. 3 Hours.
Introduction to radio astronomy theory and techniques suitable for graduate students. Topics covered include radio-wave fundamentals, antenna theory, radiation mechanisms, extragalactic sources, pulsars and cosmology.

ASTR 701. Computational Astrophysics. 3 Hours.
Introduction to C programming to solve astrophysical problems. Topics covered include hypothesis testing, Monte Carlo simulations and Fourier techniques for analysis of astronomical data.

ASTR 702. Stellar Structure and Evolution. 3 Hours.
Comprehensive discussion of birth, life cycle and end products of stars. Topics covered include main-sequence evolution, giant stars, white dwarfs, supernovae neutron stars and black holes.

ASTR 703. Galactic Astronomy. 3 Hours.
Detailed study of galactic structures. Topics covered include galactic dynamics, rotation and spiral density waves, the interstellar medium and supernova remnants.

ASTR 704. General Relativity. 3 Hours.
Innovative 'physics- first' introduction to Einstein's relativistic theory of gravity. Topics covered include special relativity, curved space time, gravitational collapse and black holes.

ASTR 705. The Interstellar Medium. 3 Hours.
PR: ASTR 694. In-depth look at the interstellar medium (ISM), the material in between stars, with a focus on our own Milky Way Galaxy. Topics covered include the composition of our Galaxy, the phases of the ISM, the properties of the gas and dust in the ISM, dust and gas chemistry, magnetic fields, and dynamic processes.

ASTR 791. Advanced Topics. 1-6 Hours.
PR: Consent. Investigation in advanced topics that are not covered in regularly scheduled courses.

ASTR 792. Directed Study. 1-6 Hours.
Directed study, reading, and/or research.

ASTR 793. Special Topics. 1-6 Hours.
A study of contemporary topics selected from recent developments in the field.
ASTR 795. Independent Study. 1-9 Hours.
Faculty supervised study of topics not available through regular course offerings.

ASTR 796. Graduate Seminar. 1-3 Hours.
PR: Consent. Each graduate student will present at least one seminar to the assembled faculty and graduate student body of his or her program.

ASTR 797. Research. 1-9 Hours.
PR: Consent. Research activities leading to thesis (697), problem report (697), research paper or equivalent scholarly project (697), or a dissertation (797). (Grading may be S/U).

PHYSICS COURSES

PHYS 593. Special Topics. 1-6 Hours.
A study of contemporary topics selected from recent developments in the field.

PHYS 611. Introduction to Mathematical Physics. 3 Hours.
PR: Calculus, differential equations, PHYS 111 and PHYS 112 or equivalent. Complex variables: series, contour integration and conformal mapping; ordinary differential equations; Fourier series, Laplace transforms; Fourier transforms; special functions; Bessel functions and Legendre, Hermite differential equations; Poisson's equation, wave equation, and Laguerre polynomials; introduction to partial differential equations.

PHYS 631. Advanced Classical Mechanics 1. 3 Hours.
PR: PHYS 331 and PHYS 332 and differential equations. Lagrange and Hamilton form of equations of motion, rigid bodies, small and nonlinear oscillations. Transformation theory, relativistic dynamics, and systems with an infinite number of degrees of freedom.

PHYS 633. Electromagnetism 1. 3 Hours.

PHYS 634. Electromagnetism 2. 3 Hours.

PHYS 651. Quantum Mechanics 1. 3 Hours.

PHYS 652. Quantum Mechanics 2. 3 Hours.

PHYS 691. Advanced Topics. 1-6 Hours.
PR: Consent. Investigation of advanced topics not covered in regularly scheduled courses.

PHYS 693. Special Topics. 1-6 Hours.
A study of contemporary topics selected from recent developments in the field.

PHYS 697. Research. 1-9 Hours.
PR: Consent. Research activities leading to thesis, problem report, research paper or equivalent scholarly project, or a dissertation. (Grading may be S/U).

PHYS 710. Nonlinear Dynamics. 3 Hours.
PR: PHYS 631. Flows, fixed-point analysis, and bifurcations in 1D, 2D, and 3D using analytical, numerical, and geometrical approaches. Limit cycles, chaos, fractals, strange attractors, iterated maps, and Hamiltonian systems.

PHYS 725. Advanced Atomic and Molecular Physics 1. 3 Hours.

PHYS 761. Statistical Mechanics. 3 Hours.
PR: PHYS 461 and PHYS 651. Ensemble theory, applications to noninteracting systems, as well as perturbative and approximate treatment of interactions. Typical applications include equilibrium constants, polymers, white dwarfs, metals, superfluids, magnetic transitions.

PHYS 771. Introduction to Solid State Physics. 3 Hours.
PR: PHYS 471 and PHYS 651 or equivalent. Crystal structure and reciprocal lattices. Waves in crystals. Band structure and metals.

PHYS 772. Semiconductor Physics. 3 Hours.

PHYS 773. Collective Phenomena in Solids. 3 Hours.
PHYS 774. Optical Properties of Solids. 3 Hours.

PHYS 781. Principles of Plasma Physics. 3 Hours.
Plasmas occur naturally in electrical discharges and in space and are produced artificially in laboratory devices. This course is a survey of plasma phenomena using fluid and kinetic models.

PHYS 782. Computer Simulation of Plasma. 3 Hours.
PR: (PHYS 481 or PHYS 781) and PHYS 633; programming proficiency in C, FORTRAN, or BASIC. Projects teach mathematical and physical foundations of computer simulation algorithms and develop and refine physical understanding and intuition of phenomena encountered in plasma research.

PHYS 783. Advanced Kinetic Theory of Plasmas. 3 Hours.
PR: PHYS 481 and PHYS 631 and PHYS 634. The Vlasov equation, quasilinear theory, nonlinear phenomena. Plasma waves and instabilities. Landau damping and finite-Larmor-radius effects.

PHYS 784. Advanced Magnetohydrodynamic Theory of Plasmas. 3 Hours.

PHYS 790. Teaching Practicum. 1-3 Hours.
PR: Consent. Supervised practice in college teaching of physics. Note: This course is intended to insure that graduate assistants are adequately prepared and supervised when they are given college teaching responsibility. It will also present a mechanism for students not on assistantships to gain teaching experience. (Grading will be P/F.).

PHYS 791. Advanced Topics. 1-6 Hours.
PR: Consent. Investigation of advanced topics not covered in regularly scheduled courses.

PHYS 792. Directed Study. 1-6 Hours.
Directed study, reading, and/or research.

PHYS 793. Special Topics. 1-6 Hours.
A study of contemporary topics selected from recent developments in the field.

PHYS 795. Independent Study. 1-9 Hours.
Faculty supervised study of topics not available through regular course offerings.

PHYS 796. Graduate Seminar. 1-3 Hours.
PR: Consent. Each graduate student will present at least one seminar to the assembled faculty and graduate student body of his or her program.

PHYS 797. Research. 1-9 Hours.
PR: Consent. Research activities leading to thesis, problem report, research paper or equivalent scholarly project, or a dissertation. (Grading may be S/U).

PHYS 799. Graduate Colloquium. 1-6 Hours.
PR: Consent. For graduate students not seeking coursework credit but who wish to meet residency requirements, use of the University's facilities, and participate in its academic and cultural programs. Note: Graduate students who are not actively involved in coursework or research are entitled, through enrollment in their department's 699/799 Graduate Colloquium to consult with graduate faculty, participate in both formal and informal academic activities sponsored by their program, and retain all of the rights and privileges of duly enrolled students. Grading is P/F; colloquium credit may not be counted against credit requirements for masters programs. Registration for one credit of 699/799 graduate colloquium satisfies the University requirement of registration in the semester in which graduation occurs.

PHYS 930. Professional Development. 1-6 Hours.
Professional development courses provide skill renewal or enhancement in a professional field or content area (e.g., education, community health, geology.) These tuition-waived continuing education courses are graded on a pass/fail grading scale and do not apply as graduate credit toward a degree program.