Physics & Astronomy

THE UNIVERSITY OF MISSISSIPPI DEPARTMENT OF PHYSICS AND ASTRONOMY

Physics & Astronomy

The Department of Physics and Astronomy at The University of Mississippi is dedicated to providing a nurturing and challenging environment for our students. We take pride in our instruction of young future scientists. As a student in the department, you will work and interact with an enthusiastic and dedicated group of scholars. Our internationally recognized faculty carry out research at cutting-edge facilities on campus and around the world. A degree in physics will prepare you for employment in an industrial or government laboratory or for graduate study in experimental and theoretical physics. Many students use physics as a springboard to medicine and other professional career tracks.

Undergraduate

After becoming well-trained in critical thinking and problem solving, many physics majors move on to computational programs, engineering programs, medical schools, or even business or law degrees. The department also offers a special major for life science (premed) students leading to the Bachelor of Arts degree. Our B.A. graduates have exceptionally high acceptance rates (over 95%) at medical schools. An average of 30 undergraduate and 40 graduate physics majors are enrolled in any given semester.

Our *Bachelor of Science* degree offers a comprehensive curriculum designed to fully prepare students for graduate studies. The department is relatively small and intimate, allowing students and faculty to get to know each other and work closely together. More than 90 percent of B.S. graduates go on to graduate programs. Recent graduates have gone on to physics and astronomy programs at institutions such as Caltech, Cornell, and the University of Illinois.

The B.S. in physics requires 42 hours of credit from selected physics courses. The B.S. degree consists of the basic Physics for Scientists and Engineers (211, 212, 221, 222) in the freshman year and 34 hours of upper-division courses, which must include Mathematical Physics (308), Thermodynamics (309), Mechanics (310), Introduction to Modern Physics (317, 318), Optics (319), Electromagnetic Theory (401,402), and Introduction to Quantum Mechanics (451). One upper-division laboratory-based course is required in addition to Physics 319. This lab course is typically either Electronics (321) or Modern Physics Laboratory (417). For all majors Physics 498 is required. Additionally B.S. physics majors must take Math 261, 262, 263, 264, and 353, plus at least one of the following courses: Math 319, 454, or 459. All six required math courses should be completed by the end of the junior year.

The *Bachelor of Arts* in Physics requires 24 hours in physics and is offered in two tracks.

Track 1 includes the following: Physics 211, 221, 221, 222; at least 16 hours of approved physics courses at the 300 level or higher (excluding Phys 303), of which at least 6 hours are of approved physics courses at the 400 level or above.

Track 2 includes the following: Physics 213, 214, 223, 224, 303; at least 13 hours of approved physics courses at the 300 level or higher, of which at least 6 hours are of approved physics courses at the 400 level or above.

For both tracks Physics 498, Math 261, and 262 are also required.

The B.A. program is tailored to students whose career goals do not require graduate-level study in physics. UM students who graduate with a B.A. in physics and whose sights are set on a medical career have a remarkable track record of success. Nearly 100 percent of these students have been accepted into medical school.

Track 1 includes the following: Physics 211, 221, 221, 222; at least 16 hours from the following: 315, 319, 321, 413, 415, 417, and 422.

Track 2 includes the following: Physics 213, 214, 223, 224, 303; at least 13 hours from the following: 315, 319, 321, 413, 415, 417, and 422.

A minor in Physics consists of 18 hours in physics, which must include either the Physics for Science & Engineering I and II and their associated labs (Phys 221, 222) sequence or the General Physics I and II (Phys 213, 214) and their associated Labs (Phys 223, 224) sequence; and at least 10 hours chosen from electives in physics.

Physics Learning Center

The Physics Learning Center is located in Lewis Hall and provides assistance to students in introductory physics courses. The Center is open weekdays from 8:00 a.m. to 5:00 p.m. Students can take advantage of tutoring services and access to computers.

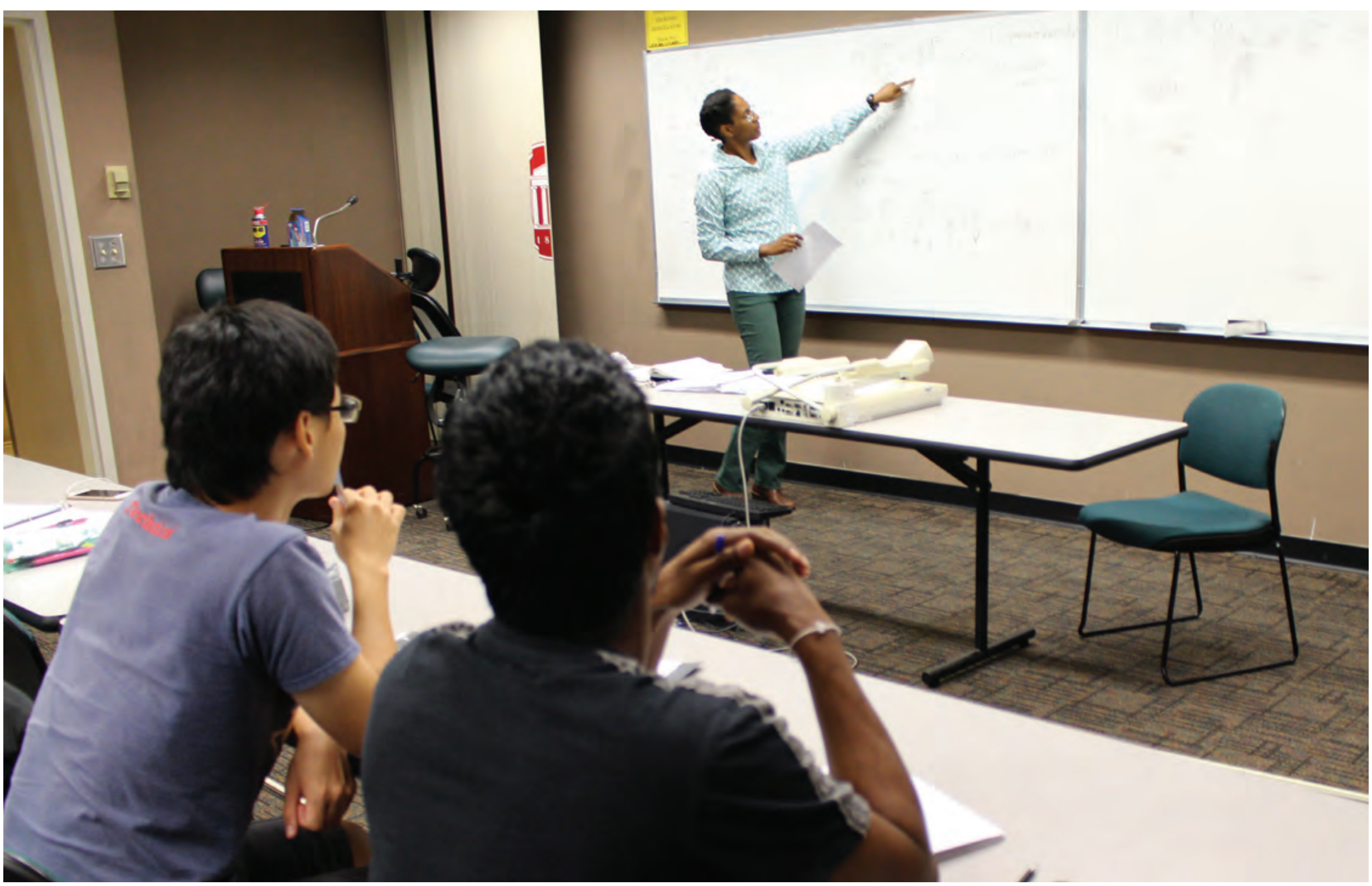
Graduate

The Department of Physics and Astronomy offers Master's and PhD degrees in Physics. All students admitted to our graduate program who maintain good academic standing receive full financial support—including a tuition waiver and generous living stipend through a combination of teaching assistantships, research assistantships, and non-service Honors Fellowships. This support is provided for the nine-month academic year, and additional sources of funding are usually available for the summer months. We offer exciting research opportunities in atmospheric physics, condensed matter physics, gravity, high energy physics, and physical acoustics. The University of Mississippi carries the R1 Carnegie designation reserved for doctoral universities with the highest level of research activity.

Admission to the graduate program is based on standardized tests (GRE and, for students from non-English-speaking countries, English proficiency tests), undergraduate academic performance (GPA), and recommendation letters, but we also try to make sure that there is a good fit between the students' interests and our research groups based on the applicants' personal statements. The goal of the admissions committee is to identify students who we believe have the skills and temperament to succeed in a research-oriented environment.

Degrees

Master of Arts — M. A. (course work only)
Master of Science — M. S. (course work and thesis)
Doctor of Philosophy — Ph.D.



NATIONAL CENTER FOR PHYSICAL ACOUSTICS

Facilities

The NCPA was founded out of the Department of Physics and now serves as a research lab for scientist in Physics, Engineering and Geology. It is a cutting edge research facility which maintains basic and applied research programs in many areas of physical acoustics; provides coordination of major, multi-university research programs in the United States; serves as an advocate for physical acoustics to federal agencies and other organizations; provides significant educational opportunities for students and postdocs; and provides direct research assistance to investigators throughout the world. The biennial Physical Acoustics Summer School, supported by the Acousitcal Society of America, is coordinated through the NCPA.

The Lewis Hall Research Wing has eight large laboratory rooms used for research in atmospheric physics, condensed matter, experimental high energy physics and gravitational and high energy theory. The Research Wing also houses the machine shop. The Physics Department's Machine Shop team is involved in the University of Mississippi's daily operations and serves as a resource to physics colleagues around the country. Our shop is responsible for the design and fabrication of physics test equipment, machines, fixtures, and other devices. It has been involved in many research projects, both in the U.S. and internationally.

Design is carried out using AutoCad and a variety of CAM software to support our CNC (Computer Numerically Controlled) machines. Implementation is accomplished by modern collaboration techniques that follow the process from design, through manufacturing, quality control, and finally shipment to our customers.

The Kennon Observatory was constructed in 1939 and consists of two copper-roofed domes. In the larger dome is a refractor telescope that was purchased from the Sr. Howard Grubb Co. in 1893. It actually consists of 3 co-aligned visual and photographic telescopes; a fifteen-inch f/12 visual telescope, a nine-inch photographic telescope and a four-inch visual telescope. The smaller dome currently houses a seventeen-inch f/6.8 Plane Wave, Corrected Dall-Kirkham (CDK) reflector telescope with an electronic CCD camera, the SBIG ST10 with an AO-7 adaptive optics accessory, attached Paramount ME.

We have a wide range of computing capabilities andd access to the facilities at the Mississippi Center for Supercomputing Research.

Atmospheric Physics

Thunderstorm electricity is the main focus of the atmospheric physics group at the University of Mississippi. Although this subject has been investigated for over 250 years, surprisingly little is known about the internal electrical structure of thunderstorms, about the mechanisms that produce that electrical structure, or about the time evolution of that structure.

Lightning flashes are also mysterious in several ways and are the subject of most research by the atmospheric physics group. In some mysterious way, a lightning flash initiates in a thunderstorm; the initiation processes turn the normally non-conducting air into a short, thin conductor called the lightning channel. Once the channel is established, the flash can move many kilometers on its own by extending the channel through a well-understood process called the stepped leader. However, we still do not understand exactly what physical mechanisms cause the first sparks of a lightning flash and how those sparks change the non-conducting air into the thin, conducting path.

Our recent NSF-sponsored research has advanced knowledge of lightning initiation in several ways, including providing the first and highest time-resolved video pictures (at 50,000 frames/second) of the “initial leader” of lightning initiation and identifying a VHF event and an electrostatic field change that seem to start the initial leader.

Current research seeks to learn more about lightning initiation and lightning propagation by using an array of electromagnetic sensors (Electric field change, VHF, and dE/dt) distributed at nine sites across northern Mississippi. The project also uses high speed video cameras to obtain pictures of lightning initiation. These lightning data are being used to gain a better understanding of the mechanisms that start a lightning flash via modeling studies.

Condensed Matter Physics

Efforts to understand and manipulate the properties of materials have been central to the conceptual development of physics and have led to important technological advances that have transformed our world—from semiconductor devices to superconductors. Condensed matter is a particularly broad subfield of physics, and it encompasses a wide range of topics and styles of research. Current work at The University of Mississippi includes theoretical, experimental, and computational projects that address both fundamental questions and practical applications.

Ferroelectrics

At the forefront are ongoing investigations into ferroelectric materials. These materials have a local electric polarization that is ordered across macroscopic domains within the sample. Mechanical deformations of the material, such as sound waves, are strongly coupled to this polarization. An unusual subclass of these materials includes thermoelectric and relaxor ferroelectrics, which exhibit exceptional electromechanical properties and are strong candidates for vibration energy harvesting and acoustic sensing applications. In laboratories on our campus, resonant ultrasound spectroscopy is used to investigate the effects of temperature and pressure on the elastic properties of such materials as they undergo structural phase transitions with changes in temperature and chemical composition.

Another line of research relates to acoustically stimulated nonlinear phenomena in ferroelectric crystals. Even carefully grown crystalline solids are riddled with various point defects, such as interstitial atoms and vacancies, and extended structural defects, such as dislocations and domain walls. When an acoustic wave propagates in this defect-rich medium, there are complicated interactions between the ultrasound, the crystal lattice structure, and the electrical charges. These interactions open up various exciting possibilities: crystal defect manipulation or “defect engineering”; sonoluminescence, in which ultrasound is converted to light; and acoustic memory, in which the ferroelectric sample apparently stores ultrasound energy and then re-emits it with a delay of about 100 μs. Acoustic waves in ferroelectric solids can also be manipulated with engineered nanostructures. Possible applications based on LiNbO3 and LiTaO3 comprise mobile communications (acousto-electric high-frequency filters), military applications for electronic coding-decoding devices (convolution by surface acoustic waves), medical therapeutic devices (ultrasonic heads), digital technologies (new ferroelectric memory cells and nano-sized capacitors), and quantum electronics.

Strong electronic correlations

The electrons in material systems play a special role, since their organization determines almost all the interesting chemical, thermal, electrical, and magnetic properties. Describing how large numbers of electrons behave—interacting with each other and with the background of atomic nuclei—is one of the most urgent and actively pursued goals of condensed matter physics. Future progress in this area will almost certainly provide new tools for the study of fundamental physics and offer guidance for the discovery and design of technologically useful materials.

The stumbling block is that the full-blown quantum many-body problem is hard. The historical approach for conventional solids, under the rubric of ` `band theory,'' is to ignore the difficulty and to assume that each electron can safely be treated as a semi-independent entity moving in an effective potential within the regular crystalline environment. But many condensed matter phenomena require an explanation that goes well beyond band theory. Prominent among these are superconductivity, superfluidity, magnetism, and Kondo physics.

Increasingly, we rely on computation studies to rigorously establish the behavior of suitable models. The progress on the numerical side can hardly be overstated: the availability of high performance computers and the development of powerful algorithms has made it possible to simulate quantum systems that were intractable not so long ago.

Gravitational Physics

Gravitational physics has grown over the past few decades from a relatively small area of research concerned mainly with the mathematical properties of Einstein's theory of general relativity into a broad field whose theoretical aspects range from astrophysics and cosmology to quantum gravity, one of the most challenging boundaries of our current understanding of the nature of matter and space time.

Gravitational physics has also developed a solid experimental side with the building of gravitational wave detectors and high-precision tests of gravitational effects on Earth and in orbit; it has found practical applications in the GPS system as well as in the guidance of spacecraft.

The University of Mississippi is at the forefront or modern research in experimental and theoretical gravity, astrophysics and cosmology. Here, researchers actively participate to the LIGO experiment. They study the emission of gravitational waves from astrophysical sources, try to understand the geometrical structure of space-time at the smallest scales, and contribute to the worldwide search for the ultimate theory of quantum gravity.

Gravitational Wave Astronomy

The first direct detection of gravitational waves by the LIGO experiment on September 14, 2015 marked a watershed moment in astronomy. Future detections will allow us to better understand the astrophysics of black holes and neutron stars, to test the behavior of Einstein's general relativity in conditions where the gravitational field is strong and dynamical, and perhaps even to observe deviations from Einstein's theory. The University of Mississippi is an institutional member of the LIGO Scientific Collaboration, contributing to the experiment in the areas of data analysis and detector characterization. One of the LIGO detectors is located in southern Louisiana, about four hours drive from The University of Mississippi. As part of their research, senior members of the LIGO Team and graduate students actively participate in commissioning and monitoring the instrument on site.

The University of Mississippi hosts one of the most active groups working on binary systems composed of black holes and/or neutron stars. Our main goal is to use gravitational-wave observations of these binaries to test Einstein's general relativity, to rule out alternative theories of gravity, and to tell black holes from more exotic alternatives. We are also exploring the astrophysical information carried by the full set of events that will be observed. LIGO will reveal important clues on the evolution of compact binaries and on their relation with gamma-ray bursts. Future space-based detectors like LISA will tell us how the massive black holes lurking at the center of most galaxies were born, and how they grew during cosmic history. From a more theoretical standpoint, we are studying Einstein's theory of gravity in the most extreme conditions with "numerical experiments" in which we smash black holes at speeds close to the speed of light.

This research crosses several fields, including astrophysics, post-Newtonian theory, perturbation theory of stars and black holes, numerical relativity, high-energy physics and gravitational wave data analysis.

Quantum Gravity and Extra Dimensions

Over the past two decades, attempts to formulate a theory of quantum gravity focused largely on loop quantum gravity and superstrings.

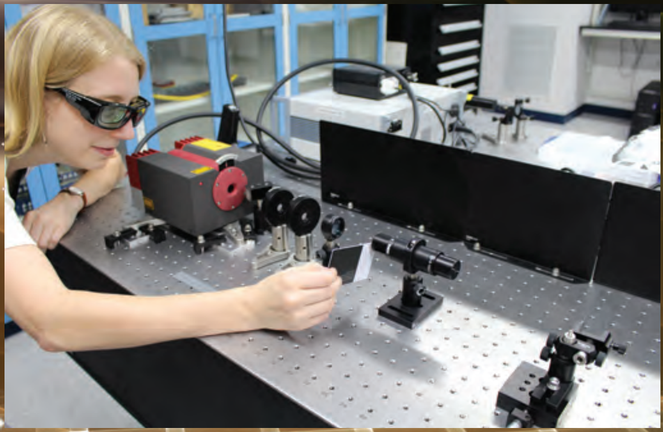
Loop quantum gravity aims towards a rigorous quantization of gravity as a theory of space-time geometry. Investigations at The University of Mississippi focus mainly on how the quantum geometry of space-time at the smallest scales leads to classical general relativity at macroscopic scales. Specific problems studied here include calculating the macroscopic observational effects of the microscopic quantum geometry, and finding quantum states for gravity, which appear like a classical continuum at large scales.

The existence of extra dimensions may lead to the exciting prospect that gravitational objects such as black holes and black strings could be created in man-made particle accelerators. Researchers at The University of Mississippi collaborate with high energy particle physicists in investigations of experimental signatures of these phenomena at the Large Hadron Collider and other particle accelerators.

Squeezed light is an experiment in quantum optics that manipulates Heisenberg's uncertainty principle and improves the measurement of gravitational waves at high frequencies. We've successfully demonstrated the long-term use of squeezed light at the German gravitational-wave detector GEO600 and it is now scheduled to be implemented as an upgrade to Advanced LIGO. Our work locally at UM is focused at the moment on testing some new optics that have the possibility of improving the implementation of squeezing at LIGO.

We're studying how important the alignment of the laser beam is to an ultra-low-loss polarizing beam splitter. Doing so involves ancillary projects, such as building a pre-mode cleaner, a three-mirror optical cavity that conditions the laser beam.

-Kate Dooley, Assistant Professor of Physics



High Energy Physics

The high energy physics group consists of 5 faculty in experimental and theoretical particle physics. We are working on several experiments and on several topics in flavor physics and extensions of the standard model.

Particle Physics Theory and Phenomenology

There is a large amount of data from flavor experiments. The B factories at BaBar and Belle have made many measurements in Flavor Changing Neutral Current Processes (FCNC) which are known to be very sensitive to new physics effects and new sources of CP violation which is required to explain the matter-antimatter asymmetry observed in nature. Most extensions of the Standard Model (SM) contain new CP violating phases which do not have to be small as CP is not an exact or approximates symmetry of nature. Hence, discovery of non-SM CP violation phases is not unexpected. One of the main research interests is to analyze data from current and future B physics experiments to find evidence for new physics and to find the nature of this new physics.

We also have interests in top quark properties and in the search for beyond the SM effects in top production, top decay, single top production and rare top decays.

In the neutrino sector our interest is in the study of deviations from the tri-bimaximal mixing (TBM) for neutrinos. The purpose behind the study is to understand the symmetry behind the tri-bimaximal mixing and how it is broken to generate deviation from the TBM.

CP Violation and New Physics on Belle II

Matter and anti-matter are thought to be created in equal abundance. Yet in the universe, matter is dominant over anti-matter. CP (charge-parity) violating effects within the fundamental forces are thought to have caused this particle over anti- particle asymmetry. The Belle II experiment is dedicated to the study of CP violation in the B-meson system. The goal is to see if beauty quarks decay differently from anti-beauty quarks. Our measurements are expected to be important in explaining why we now have a matter universe.

The Belle II experiment at the SuperKEKB collider is a major upgrade of the Belle experiment at the KEKB asymmetric $e+e-$ collider at KEK in Tsukuba, Japan. SuperKEKB is an asymmetric B factory (that is, it produces B mesons copiously at a high relativistic boost by colliding beams of electrons and positrons of unequal energy). The University of Mississippi group is playing a role in the construction, commissioning, and calibration of the on the imaging Time-of-Propagation (iTOP) detector. This subdetector of Belle II will perform an integral role in Particle identification (PID). We will engage in the studies of New Physics in B-meson decays and CP violation which include investigations of anomalies in semi-leptonic B to tau meson decays and B decays with loops which may contain new particles.

Anomalous Muon Magnetic Moment on Muon g-2

The Muon g-2 experiment at Fermilab is a major upgrade of a previous experiment, completed at Brookhaven National Laboratory in 2001. The measurement of the anomalous magnetic moment of the muon provoked world-wide interest because of the tantalizing evidence of deviation from the standard model. This experiment brings the storage ring from the original BNL experiment together with Fermilab's accelerator complex. It is expected that this g-2 measurement will have a four-fold improvement in the final uncertainties compared to the previous result. This includes both an improvement in collected statistics and in the systematic uncertainties of the measurement. A measured value of g-2 that is significantly different than the Standard Model prediction, would indicate the existence of new, as yet unobserved particles in nature.

The UM group's work on Muon g-2 focuses on the storage ring vacuum system, characterization of beam dynamic systematic uncertainties, and future tests of CPT and Lorentz invariance. We are responsible for aligning the vacuum chambers and the electrostatic quadrupole plates that focus the $\mu+$ beam The group is calculating uncertainties on the g-2 measurement arising from beam effects such as the time evolution of the muon bunch structure and momentum distribution. We are also very interested in a future μ- run to search for CPT and Lorentz violation signatures through g-2 differences in the two charge modes.

Neutrino Physics on MINERvA, SBND, and DUNE

The MINERvA neutrino interaction experiment at Fermilab is measuring several aspects of neutrino interactions in the few GeV energy region. The experiment will make cross section and form factor measurements using a fine-grained fully active scintillator (CH) target, and also investigate nuclear effects on neutrino interactionsusing integral nuclear targets made of helium, carbon, iron, and lead. MINERvA is extending its program of successful cross-section measurements using a new higher-energy, high statistics dataset. We work on MINERvA data analysis, using techniques borrowed from electron scattering to reveal the effect that atomic nuclei have on neutrino interactions.

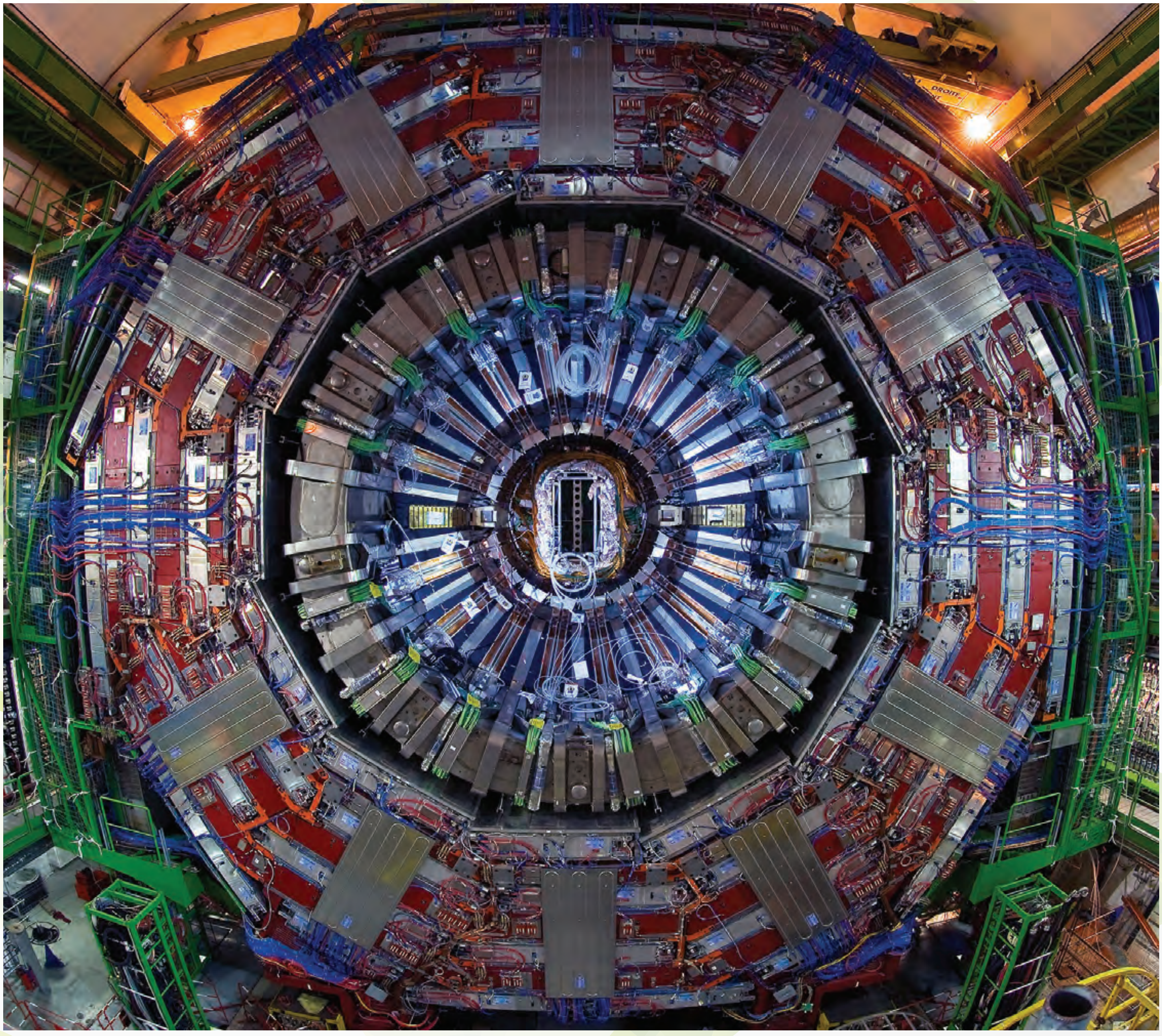
The group will also be involved in the short baseline neutrino program at Fermilab on the SBND experiment. On SBND, we will take on roles in the software and simulation groups, which are in need of increased effort. This is the first step of the Mississippi group towards full participation in the LBNF/DUNE program, and its search for CP violation in neutrino oscillations. Soon we will begin involvement in DUNE detector prototyping. Our group is also investigating improvements to the LBNF beamline.

New Accelerators

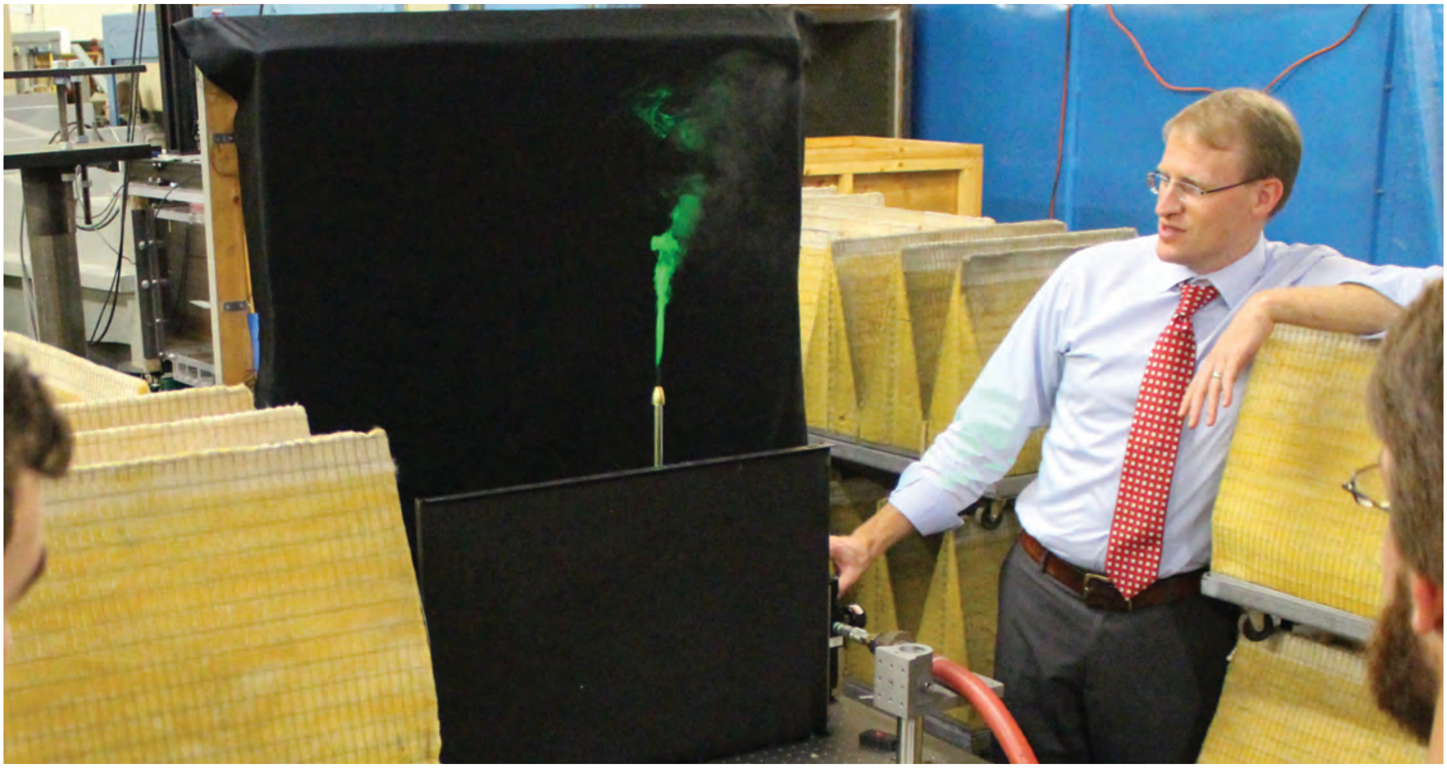
The Muon Ionization Cooling Experiment (MICE) is an important milestone towards a Neutrino Factory. The neutrino factory is a completely new type of accelerator and offers many new challenges. Probably the largest novelty from the point of view of accelerator physics is ionization cooling. MICE is being carried out at the Rutherford Appleton Laboratory (RAL) near Oxford in the United Kingdom.

The University of Mississippi has worked with physicists from two dozen universities and national labs to first design a neutrino factory with a muon storage ring and then a ring to collide muons head on. The neutrino factory can produce the quantity of neutrinos needed to study the puzzling neutrino mass. With muons being about 200 times more massive than electrons, a low energy muon collider will allow direct production of the Higgs boson, the particle responsible for giving mass to all other particles.

Our group has fabricated new types of radio-frequency cavities or muon acceleration and is building ultra-thin containers for liquid hydrogen to provide ionization cooling of muon beams. We are working on muon cooling calculations to produce intense muon beams for future accelerators.



Physical Acoustics



The Physical Acoustics Research Program at the University is one of the largest in the United States. Research includes the physical phenomena associated with acoustic waves from less than one hertz to many megahertz, and the use of acoustics as a tool to investigate other phenomena. Most of the activity occurs in the state-of-the-art laboratories of the Jamie Whitten National Center for Physical Acoustics (NCPA) on the Ole Miss campus.

Atmospheric Acoustics
The propagation of acoustic waves outdoors involves a wide range of complex phenomena. These include microscopic absorption and dispersion, viscous and seismic interaction with the ground, and scattering from turbulence.

The past decade has seen remarkable advances in our ability to theoretically model sound propagation in the real atmosphere. Several state-of-the-art models are currently being developed and used to predict propagation of audible sound over horizontal distances of several kilometers in the lower atmosphere.

Similar work is ongoing for global infrasound propagation, which involves frequencies down to 0.02 Hz and horizontal distances of several thousand kilometers. Infrasound is proving useful in atmospheric and oceanographic research, as well as for the detection of surreptitious nuclear testing. These problems, as well as diffraction due to barriers and refraction due to velocity of sound gradients, are actively investigated.

Acoustic Metamaterials
Acoustic metamaterials are designed to manipulate sound waves through controlling material properties at subwavelength scales, offering a large degree of applications. Our work is involved in using principles of physical acoustics to develop state-of-the-art metamaterials of useful acoustic properties, e.g., Phononic Metamaterials, Acoustic Metasurfaces, Metascreen-based Passive Phased Array, etc.

Ocean Waves and Acoustics
Sound propagation through oceans is a unique method for underwater communication and imaging, e.g., using sonar to probe the sea floor and locate fish, and to communicate between ships and submarines, and to probe ocean currents, eddies, and fronts. The propagation is strongly affected by spatial-temporal fluctuations introduced by various ocean processes, particularly ocean gravity waves that oscillate within the ocean (internal waves) and on the surface of the ocean (surface waves). These oceanic waves are generated by tidal flow over bottom topography and by wind on the ocean

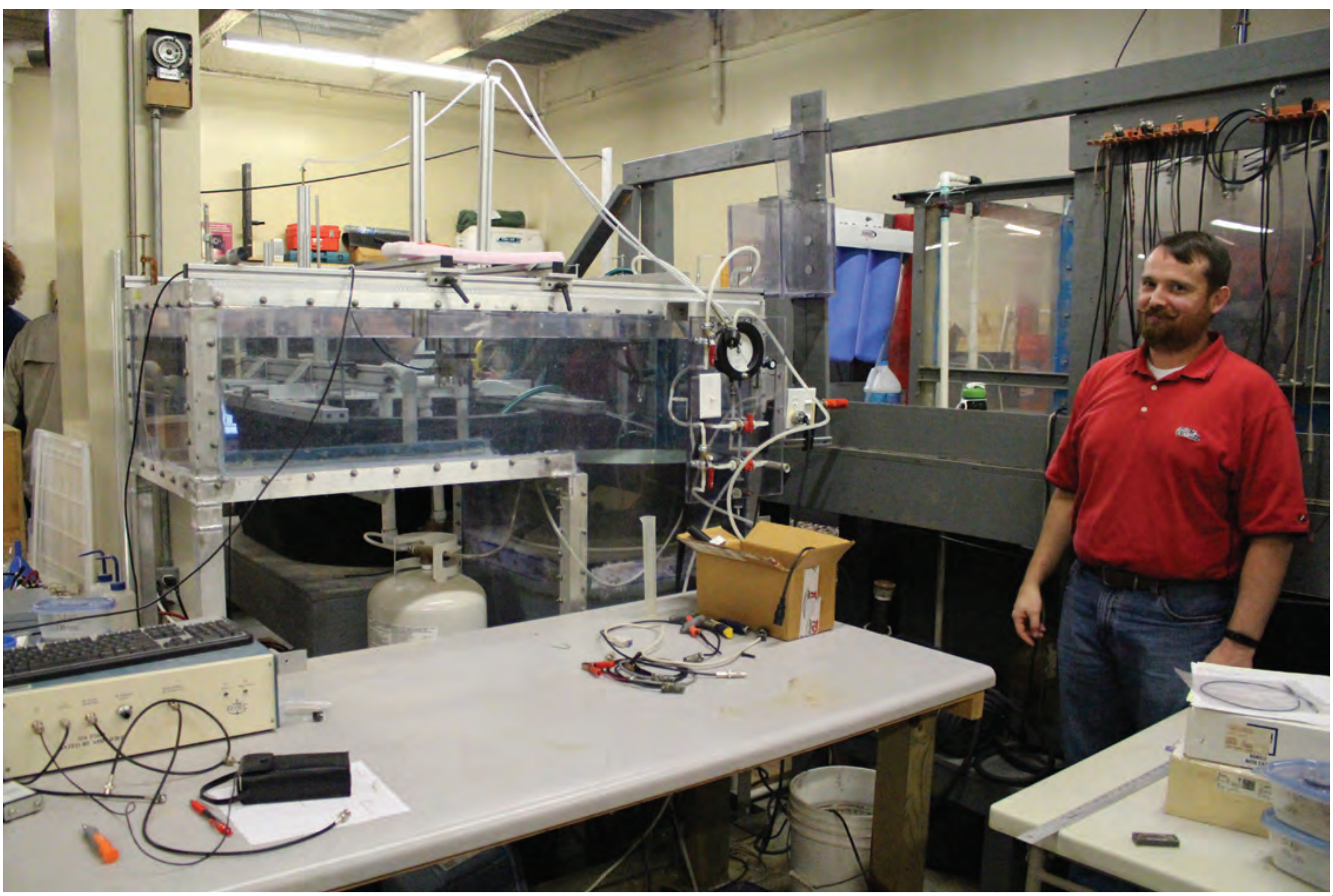
surface. The fluctuations impose a limit to underwater sound communication. Conversely, measurements on propagating sound waves provide a probe for the fluctuation. Our work is involved in combining laboratory, computational and theoretical approaches to model sound propagation in a continuously stratified ocean containing ocean gravity waves, aiming to understand the dynamics of oceanic waves and their effects on underwater sound propagation.

Ultrasonics
Understanding the mechanisms of interaction of ultrasonic waves with human is essential for the development of advanced therapeutic and diagnostic applications in biomedicine. Ultrasound is also used to study the fundamental mechanical properties of biologically evolved materials to discover the way nature has solved many of the structural and functional challenges faced by living organisms.

Bioeffects of Ultrasound
Ultrasound waves in the MHz frequency range can be brought to a tight focus in soft mammalian tissues. The focus occurs remotely on the order of 2 – 20 centimeters from the source. When a focused source is driven at high power, this concentrated sonic energy can be used to therapeutic benefit. The therapeutic effect is delivered without impacting overlying tissues. High temperatures can be generated within the focal region, with surrounding areas remaining largely unaffected. Our work involves the study of ultasound bioeffects.

Tissue Characterization
As a non-invasive probe into the human body, ultrasound is used to acquire diagnostic information non-invasively without inducing significant cellular effects. Interaction of ultrasound with tissues results in scattering, absorption and dispersion, all of which can be linked to tissue microstructure. Determining the fundamental physical and mechanical properties of tissue provides knowledge that is essential for development of advanced diagnostic techniques as well as for understanding the physics of propagation in biological composite materials. Our group is involved in measuring the fundamental ultrasonic properties of various mammalian tissues and finding methods to measure such properties in vivo

Porous Media Acoustics
Sound propagates in porous granular materials via two compressional modes. The slower of these modes



is controlled by the geometry of the pores. By studying this mode, properties of the porous material are determined. Fundamental studies include acoustic scattering from rough porous soils and memory states of pre-strained granular materials.

A major research thrust of this group is the detection of anti-personnel land mines. Airborne sound induces vibration of the ground and the land mine. Differences in the vibrations are detected and imaged using interferometric optical techniques. Measurement techniques include laser Doppler vibrometry and pulsed speckle pattern interferometry.

Resonant Ultrasound Spectroscopy

RUS is an elegant experimental method for determining the full elastic tensor of a single crystal. Elastic constants are a measure of the interaction of the atoms in the crystal lattice and so are sensitive to phase transitions. We specialize in small sample RUS and thin film RUS in which the elastic constants for a thin film on a substrate can be obtained.

Dynamic problems in continuum mechanics: Using high speed video, I have studied the buckling of a thin rod impacted by a projectile—a fancy way of breaking pasta! We have also studied the dynamics of how a rigid rod moves through a viscoelastic gel including transitions from fluid-like flow to solid-like tearing.

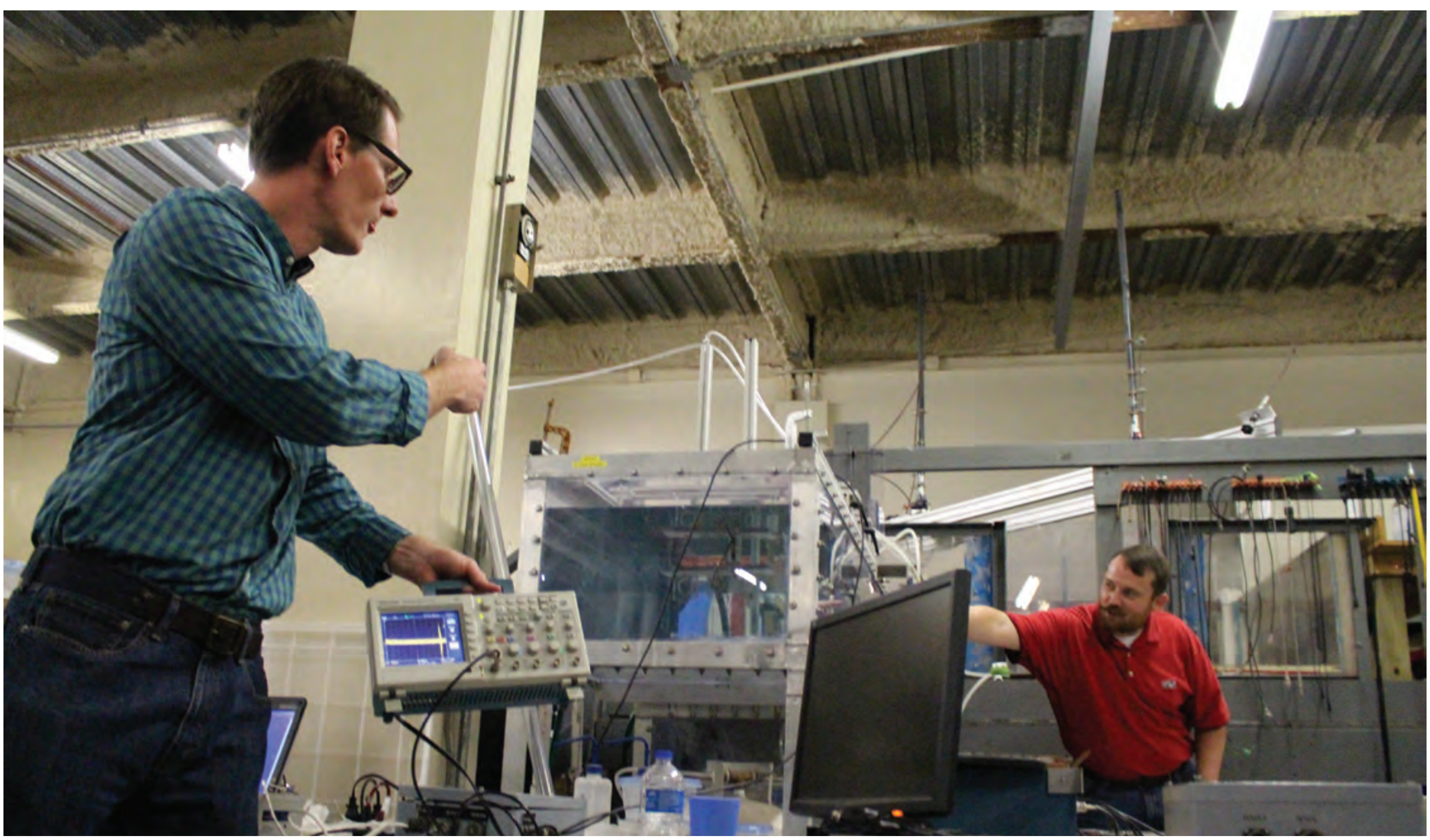
Wind Noise

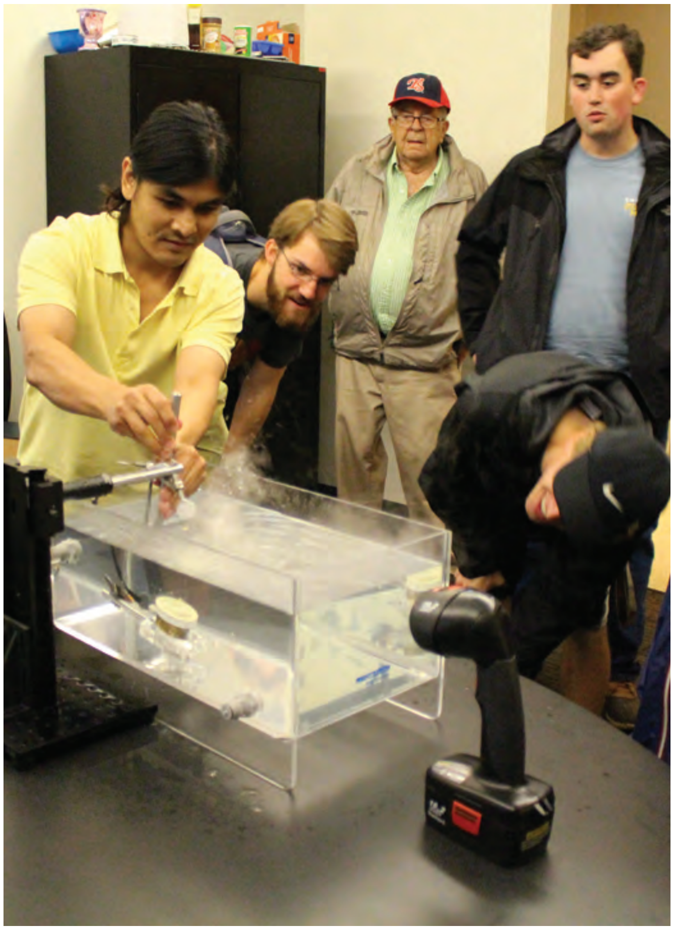
Recent research has concentrated on improving outdoor sound measurements by reducing wind noise in measurement microphones. We are developing quantitative methods of predicting wind noise contributions from measurements of the wind speed fluctuations. This work combines meteorology, fluid dynamics and acoustics to develop and validate theoretical expressions. An extensive measurement program has been very successful in identifying inaccurate and wrong theories that have appeared in the literature.

Aeroacoustics

Aeroacoustics is devoted to the study of aerodynamically generated sound. One important area involves the prediction and reduction of sound generated by commercial aircraft. However, the field is quite broad and also involves study of acoustics associated with complex fluid structure interactions of hypersonic vehicles, like that associated with reusable launch vehicles for satellite repair and space station re-supply.

The field involves theoretical, numerical, and experimental efforts to better understand the physics for





relating flow field pressures fluctuations to the turbulent dynamics of high speed flows that often contain aero-thermal chemical reactions. Contributions from this field often lead to development of aerospace vehicle systems that meet environmental standards and ones that can be optimized for system performance and reliability.

Faculty

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Condensed Matter Theory
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Neutrino Physics

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Quantum Gravity

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Mesoscale Meteorology

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Acoustics of the Earth's Atmosphere

Likun Zhang
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Physical Acoustics
Ocean Acoustics
Fluid Dynamics

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