Research activities

Computational Hydrodynamics and Nuclear Theory

April 2013 - Present, 10-15 hours/week

Principal Investigator: Dr. Paul Romatschke

I am writing hydrodynamic simulations of strongly-interacting quantum fluids in order to study their theoretical material properties. I am implementing a set of algorithms based on a discrete fluid dynamics method, the lattice Boltzmann equations, known for its superior handling of turbulent or strongly-interacting fluids. I am currently developing a set of simulations of the unitary Fermi gas both as a viscous isothermal fluid and as a viscous thermal fluid, and am comparing my results with analytic hydrodynamics solutions and several sets of experimental data. My adviser has developed some relativistic fluid dynamics algorithms based on the lattice Boltzmann equations that may be used to extend my work to simulations of relativistic quantum fluids.

Liquid Crystal Materials Research Center

August 2012 - May 2013, 10-15 hours/week

Principal Investigator: Dr. Ivan Smalyukh

I was involved in the experimental study of interactions between micrometer-sized particles in liquid crystal materials. Particles in a liquid crystal field deform the continuous alignment of liquid crystal molecules relative to one another and cause topological defect structures with higher energy than the continuous field. Particles in liquid crystal attract if their defects can annihilate one another to achieve a lower-energy state, and otherwise repel. The strength of these types of interactions can be used to analyze the energetic characteristics of these topological defects. I used fluorescence imaging to study the 3-dimensional structure of the defects involved in my experiments. I then used laser trapping methods to move particles close to one another in liquid crystal fields and studied the energy of their interactions using video microscopy. I also became involved in writing simulations of liquid crystal dynamics while in this group. I was not the only researcher on this project, but the primary researcher was a visiting scientist who left shortly after I arrived, so I largely conducted experiments and analyzed data independently. I am a coauthor on a paper being submitted for publication on this topic.

Optical Remote Sensing Laboratory

May - August of 2012 and 2013, 40 hours/week

Principal Investigator: Dr. Joseph Shaw

In 2013 I designed a set of algorithms to quantitatively analyze data from an airborne imaging system used to detect leaks at carbon dioxide sequestration sites. Carbon dioxide leaks are associated with vegetation stress, which we monitored optically using an imaging system suspended from a blimp. My responsibility was to design algorithms that allowed data to be analyzed automatically. Airborne imaging is a natural technique for monitoring leaks, but the data analysis is complicated by the fact that the imager does not have a uniform distance to the ground or orientation relative to it. Blimp imaging also has the challenge that high-quality cameras would likely be damaged, so we used inexpensive imagers and developed a number of calibration methods to compensate for the fact that they were not designed for quantitative imaging. I am a coauthor on a paper being submitted for publication on this topic. In 2012, I designed, built, and calibrated a system to detect the aurora borealis. Both summers I worked mostly independently.

What are your professional aspirations? Indicate which area(s) of mathematics, science, or engineering you are considering making your career and specify how your current academic program and your overall educational plans will assist you in achieving this goal.

I am pursuing a career as a researching mathematical physicist, and am specifically interested in both theoretical high-energy and plasma physics. My academic choices outside of physics reflect my fascination with mathematics, and many of my choices in the past demonstrate an interest in computer science. I plan to complete the comprehensive mathematics curriculum here in my remaining three semesters. I believe that a strong mathematical background will be centrally important to a career in theoretical physics, and furthermore believe that the deductive creativity that proof-based mathematics encourages will continue to improve the way I think and solve problems in all analytical endeavors. I also think that my experience with computational methods will serve me well as a physicist, because the computer is one of our most powerful tools to advance the work of previous generations.

Describe an activity or experience that has been important in clarifying or strengthening your motivation for a research career in science, mathematics, or engineering.

My experience in the Liquid Crystal Materials Research Center strengthened my resolve to pursue a career in scientific research. I found the freedom and challenge of solving real problems very rewarding. I became deeply invested in my research and in understanding the theoretical context of my results. This experience clarified my sense of direction in research because I realized during this time that I was captivated more by the theory and mathematics that predicted the outcome of these experiments than by the experiments themselves. I particularly enjoyed writing simulations of liquid crystal dynamics, because it gave me a chance to understand the math and see how changes in the state of the system would theoretically change the result. It was exciting to see in theory what I had been observing in the microscope for most of a year. I had a very positive experience in this group, but left to concentrate on the theoretical aspects of condensed matter physics.

Goldwater Scholars will be representative of the diverse economic, ethnic, and occupational backgrounds of families in the United States. Describe any characteristics or other personal information about yourself or your family that you wish to share with the selection committee.

In almost all of my endeavors I have found myself a female in heavily male-dominated fields. I am a physicist, a mathematician, a drummer, a skateboarder, and I play hacky sack. There have certainly been situations in which I felt isolated for this reason, but as a whole these experiences have positively impacted the way I understand my environment and myself. Being consistently unable to identify with my peers according to gender has encouraged me to develop and clarify an identity based on my interests and sense-of-self. I believe that this identity allows me to interact more genuinely with the people around me and has made me more adaptable to strange circumstances and environments.