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.

Computational Hydrodynamics and Nuclear Theory

Duration: 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 can be used to simulate relativistic quantum fluids. I meet regularly with my adviser to discuss my results and ask questions, but otherwise I work independently.

Liquid Crystal Materials Research Center

Duration: 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 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 one another if their defects can annihilate one another to achieve a lower-energy state, and repel otherwise. 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 conducted experiments and analyzed data mostly independently. I am a coauthor on a paper being submitted for publication on this topic.

Optical Remote Sensing Laboratory

Duration: 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 had to develop 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.