Transcript Request Confirmation:

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| **Request # 001561095** |  | **Request Date:** |  | **All CU Careers** |
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**Research Activities**

**List past and present research activities associated with your interests in mathematics, science, or engineering in which you regularly participate. Explain the duration, degree, and significance of your involvement, including what responsibilities you had in the project. In the absence of formal research experience, describe briefly any other skills or accomplishments, i.e., posters, presentations, publications, etc., significant and relevant to this application.**

Hydrodynamics and Nuclear Theory

April 2013 - Present, 10-15 hours/week

Dr. Paul Romatschke, University of Colorado – Boulder

The Nuclear Theory group is focused on the theoretical study of quarks and gluons in nuclear collisions, quark-gluon plasmas, and neutron stars, with particular emphasis on relativistic hydrodynamics and the fluid properties of quark-gluon plasma. I am writing hydrodynamic simulations of a strongly-interacting cold quantum fluid, the unitary Fermi gas, based on a discrete fluid dynamics method known for its superior handling of strongly-interacting fluids. These simulations are of standalone interest in the study of unitary Fermi gases, and fit into the Nuclear Theory group because of similarities with quark-gluon plasmas. I am currently fitting simulation results with analytical solutions and experimental data. In the future I hope to simulate nuclear collisions and quark-gluon plasmas and to contribute to developing efficient algorithms in relativistic hydrodynamics.

Liquid Crystal Materials Research Center

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

Dr. Ivan Smalyukh, University of Colorado – Boulder

The Smalyukh group is interested in the self-assembly of particles in liquid crystal into stable micro- and nano-materials whose properties can be controlled by experimental conditions. I researched the interactions between micrometer-sized particles dispersed in liquid crystal. Particles in a liquid crystal field deform the continuous alignment of liquid crystal molecules and cause topological defect structures with higher energy than the continuous field. These defects cause particles either to attract of repel. The strength and range of these types of interactions can be used to analyze the energetic characteristics of these topological defects, and determine the effectiveness of self-assembly of these types of particles. I am a coauthor on a publication ([1]) being submitted to Physical Review Letters on this topic. In addition to conducting experiments and analyzing data for this paper, I also developed a strong interest in theoretical topology while doing research in this group, and became involved in writing simulations of liquid crystal dynamics.

Optical Remote Sensing Laboratory

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

Dr. Joseph Shaw, Montana State University – Bozeman

The Optical Remote Sensing Laboratory is involved in infrared cloud detection for optical earth-space communication and artic climate science. In 2013 I was involved in zero-emissions research, and I am a coauthor on a paper in preparation ([2]) demonstrating the use of airborne imagers to detect leaks at vegetated CO2 sequestration sites. I designed the set of quantitative image analysis algorithms that do automated data processing for this system by determining the orientation of the airborne imager relative to the ground. In 2012 I contributed to the lab’s Aurora detection network by designing an optoelectronic system based on photodiodes (instead of photomultiplier tubes) to detect the Aurora.

[1]. M.B. Pandey, T. Porenta, J. Brewer, A. Burkhart, S. Zumer, and Ivan I. Smalyukh. “Chirality-mediated symmetry breaking and self-assembly of dipolar nematic colloids with tangential surface anchoring”.

[2]. Joseph A. Shaw, Paul W. Nugent, Sean Nicolaysen, and Jasmine Brewer. “Balloon-borne multispectral imaging of vegetation to detect CO2 gas leaking from underground”.

**Nominee Answers:**

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.

**Professional Aspirations**

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 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. I am interested in PhD programs at MIT and Princeton. After a postdoc I hope to become a researcher at a university or national laboratory.

I am pursuing a research career in mathematical physics. I am interested in PhD programs in theoretical high energy and plasma physics at MIT and Princeton. Following a postdoctoral position, I hope to become a researcher at a university or national laboratory. My academic choices reflect my research interests in physics and my fascination with mathematics. I am enrolled in a graduate-level plasma physics course this semester, and plan to take high energy physics and graduate Math Physics. Although I will not obtain a degree in mathematics because I do not have the time to complete the liberal arts core, I intend to complete the mathematics degree curriculum before I graduate. 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 am pursuing a research career in mathematical physics. I am interested in PhD programs in theoretical high energy and plasma physics at MIT and Princeton. Following a postdoctoral position, I hope to become a researcher at a university or national laboratory. My academic choices reflect my research interests in physics, my fascination with mathematics, and my interest in computer science. I am enrolled in a graduate-level Introduction to Plasma Physics course this semester, and plan to study high energy physics and graduate Math Physics in my remaining semesters. Although I will not obtain a degree in mathematics because I do not have the time to complete the liberal arts core requirements, I intend to complete the mathematics degree curriculum before I graduate. 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 i

**Motivation for Research Career in Math, Science, or Engineering**

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

Give a special example!!!

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, and became deeply invested in understanding the theoretical and mathematical context of my results. I particularly enjoyed writing simulations, because they gave me a chance to understand the correlation between the theoretical background of the discipline and what was observed in experiment. I worked with a graduate student in the group to develop simulated images, similar to images we could take experimentally, based on liquid crystal theory. I enjoyed the process of exploring new ways to use theoretical and computational methods to inform our experiments, and found that the deductive research process of continual testing and revision appeals to me.

My motivation for a career in research stems largely from my enjoyment of the deductive process of research that I was exposed to in this group. The process of exploring new ways to use theoretical and computational methods to inform experiment was something I found very appealing.

I found the deductive process of research

The experiments informed the simulations, which in turn could be used to inform new experiments. I found this deductive process of research very appealing.

I found this deductive process of research, of learning and exploring and finding new ways to explore, very appealing because all problems lead to new problems, etc.

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.

**Personal Information**

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. These experiences have positively impacted the way I understand my environment and myself because they have encouraged me to look beyond my gender 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. This versatility is an asset to my approach to problem-solving in the sciences and mathematics.

This adaptability is an important aspect of my approach to research in the sciences and mathematics because it allows me to look at a problem in several different ways.

As a result I have developed and clarified an identity based on my interests and sense-of-self instead of on my gender. These experiences as a whole have positively impacted the way I understand my environment and myself. 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. This adaptability affects not only *Stress the adaptability…* How?