[redacted]

Research Statements

This information is vital to the overall evaluation of your application.

1. Field of Interest and the Role of Computational Science

Please describe your chosen research area and what contributing role computational science will play. Computational science involves the innovative and essential use of high-performance computation, and/or the development of high-performance computational technologies, to advance knowledge or capabilities in a scientific or engineering discipline.

My background and interests lie in computational physics applications -- specifically numerical cosmology. One of the greatest hurdles of many physics problems, including those in cosmology, is the inability to solve systems of equations analytically. Moreover, behaviors of such systems, even those with known solutions, can be unpredictable. One of the primary tools in combating these difficulties is simulating the problem at hand. This technique has become increasingly dependent upon high-performance computing. For example, to test the expansion equations and precision of the cosmological constants that describe the evolution of our universe, large N-body simulations are required; under [redacted] at Argonne Labs, I designed and implemented such simulations on the Intrepid, Mira, and Titan supercomputers, getting firsthand exposure to applied parallel programming and GPU acceleration of this computationally intensive problem. Furthermore, the understanding of Dark Matter Halo and Galaxy Cluster formation can only be tackled with higher resolution simulations that account for hydrodynamical and other short-range effects. These newfound computing powers let us probe phenomena non-existent in the laboratory and answer thrilling questions as to the origin and formation of the universe. Importantly, the fact that few groups currently utilize such computing power, further opens the door to new possibilities and discoveries in an innovative direction.

2. Research Using High-Performance Computing and/or Large Data Analysis

What new science or engineering would high performance computing or large data analysis and management enable in your area of interest and why do you think this is the case? In particular, what are the challenges that need to be addressed to make this advancement?

For a recent discussion of potential impact on a number of important applications, see http://www.ipd.anl.gov/anlpubs/2012/11/72183.pdf

Max words is 300

Originating from the application of computer science, numerical cosmology is a fascinating and promising new field in physics. This field will demand large data analysis, as the Sloan Digital Sky Survey (SDSS) and the forthcoming Large Synoptic Survey Telescope (LSST) will continue to provide enormous datasets. Further, the increased precision of such endeavors will need to be matched by new large-scale simulations to confirm the accuracy of our current theories. For example, the measurement of error of

the cosmological constants will be significantly reduced by the LSST. Moreover, in depth treatment of smaller scale interaction needs to be modeled to achieve the desired accuracy. Beginning in March at Argonne, I will be writing a parallel "Particle In Cell" code for solving hydrodynamic equations at these scales, and will continue this work into my graduate career and defense work at Los Alamos National Laboratory as the algorithm can be applied to any physical fluid system. This method is currently unused in cosmology and will provide the necessary resolution to gaseous evolution simulations. There are - and will be - challenges in both the application of physics and computer sciences: First, as one cannot fully simulate every detail of the theory, the determination of appropriate physics to be employed or, more importantly, which physics to throw out, will need to be addressed. Second, as the simulations will be complex, priority will need to be placed on both efficiency and speed. During my time at Argonne Laboratory, our team began to examine and address some of these issues. In addition to employing and understanding efficient algorithms, we have utilized GPU acceleration to quicken computation. As LSST and SDSS provide vast datasets for comparison, a new generation of simulations can be confirmed easily, deepening our understanding of the origins and formation of the universe.

3. Program of Study

The fellowship program of study requirement is designed to give you a breadth of competency in fields outside your own that will enhance your ability to perform computational science research. Please describe (in no more than 300 words) how you expect that the courses listed in your planned program of study outside your chosen discipline will contribute to your own research in the future. Describe why you chose these courses and how they will impact your research plans.

Almost all computational physics applications, including those in numerical cosmology, are described by partial differential equations that must often be solved numerically. Subsequently, "ACM 210a Numerical Methods for PDEs" will be applicable to any of my computational physics endeavors.

Testing numerical cosmological theories requires launching ensembles of simulations and statistically interpreting their results. Regression testing, model comparison, estimation, and the other elements of "ACM 118 Methods in Applied Statistics and Data Analysis" will apply directly to my future work and broadly to any data or simulation analysis I might encounter.

Regardless of the type of simulation, program optimization is essential to creating efficient code. Mathematical optimizations such as branch and bound methods, steepest descent, and parameter space searches, reduce processing time and increase the number of simulations that can be performed. Therefore, "ACM 113 Introduction to Optimization" is one of my selected applied mathematics courses.

As concurrency is a vital part of any multiprocessor computer, and, most importantly, supercomputers, "CS139ab Concurrency in Computation" will be essential to coding these high performance machines.

Although I already have extensive experience in both GPU acceleration and parallel

coding, acquiring the visualization skills of OpenGL in "CS179 GPU Programming" will advance and promote my understanding of cosmology through the graphical presentation of data.

Combining my experience with the knowledge gained from the classes above will provide excellent tools to continue my numerical cosmology work on high performance supercomputers.

4. List of publications

Please include a list of publications authored or co-authored by the applicant.

[redacted]

[redacted]

Program of Study

Listed are the courses in science and engineering, applied mathematics, and computer science that you agreed to take on your proposed Program of Study.

University: California Institute of Technology

Course number	Course Title	Credit hours	Term and Year	Grade	Academic Level
Science/Engineering					
Ay 190	Computational Astrophysics	9.0Q	Winter 2014		G
Ph 236a	Relativity	9.0Q	Fall 2014		G
Ph 236b	Relativity	9.0Q	Winter 2015		G
Mathematics and Statistics					
ACM 113	Introduction to Optimization	9.0Q	Winter 2014		G
ACM 118	Methods in Applied Statistics and Data Analysis	9.0Q	Spring 2014		G
ACM 210a	Numerical Methods for PDEs	9.0Q	Spring 2015		G
Computer Science					
CS139a	Concurrency in Computation	9.0Q	Fall 2014		G
CS139b	Concurrency in Computation	9.0Q	Winter 2015		G
CS179	GPU Programming	9.0Q	Spring 2015		G

[redacted]

Other Planned Courses

Listed are the other courses you plan to take that you believe are particularly pertinent to your proposed or current research in the areas of Mathematics, Science and Engineering, and Computer Science.

Course number	Course Title	Credit hours	Term and Year	Grade	Academic Level
Science/Engineering					
Ay 127	Cosmology and Galaxy Formation	9.0Q	Fall 2014		G
Ph 236c	Relativity	9.0Q	Spring 2015		G
Mathematics and Statistics					
ACM 210b	Numerical Methods for PDEs	9.0Q	Fall 2016		G
Computer Science					
CS 139c	Concurrency in Computation	9.0Q	Spring 2015		G

[redacted]

Laboratory and Research Experience/Other Employment

Begin with current or most recent employment. Please include employer, dates employment started and ended, position, and nature of work.

Continuously, beginning Mar 2009: Department of Energy Employee. [redacted]

Mar 2009 - Present: Los Alamos National Laboratory, onsite and remote Researcher - ISR-1 (International Space Response) division. Ionospheric EMP propagation simulation. Satellite constellations and EMP response. Ground-Satellite communication and flight software. Implemented NASA International Reference Ionosphere database. Model and regression testing. Data Fitting and Compression Algorithms. [redacted]

Jun - Sep, 2011: Argonne National Laboratory, onsite Researcher - HEP (High Energy Physics) division. Large scale parallel FFT data distribution code, implemented on Mira and Intrepid S\supercomputers as well as NERSC machines.

Jun - Sep, 2012: Argonne National Laboratory, onsite Researcher - HEP (High Energy Physics) division. GPU acceleration kernels of short range forces for implementation on Jaguar/Titan at Oakridge. Increase Efficiency of parallel Dark Matter Halo property algorithms.

2011 and 2012 academic years: University of California at Los Angeles - Teaching Assistant/Grader/Tutor.

Academic Awards and Honors

Include undergraduate and graduate honors (if applicable).

2013 Will Graduate Summa Cum Laude with a B.S. double major in Mathematics and Physics (with departmental honors)
2012 Team finalist for the Gordon Bell Award (supercomputer performance category)
2012 UCLA Winstein Award for Excellence in Particle or Nuclear Physics
2011 Award from Los Alamos Award Program (LAAP) for Excellence in Research
2010-Present Member of the Golden Key International Honour Society
UCLA Dean's List 2009, 2010, 2011, 2012

Extracurricular Activities

Include technical societies and service organizations.

President and Founder of the Ping Pong and Chess clubs at SFCC.
Member of the Student Government at SFCC.

Co-Founder of Paintball Club and team at UNM-LA.
Member of the UCLA SPS (Society of Physics Students).
Volunteer as a facilitator and translator to incoming Chinese students at UCLA
Volunteer Assistant to the Speaker of the New Mexico House of Representatives Ben Lujan
Other hobbies include bike riding, rock climbing, tennis, scuba and skydiving.