Literature Report

From a very young age I have been interested in what lies beyond our solar system. Ultimately, the order exhibited at the largest scales captivated my interest because its evolution dictates the fate of our entire reality. This philosophical implication, and the implication which cosmology has for understanding our own place in the Universe, fills me with constant curiosity and is what first drew me to study the subject. I have continued to be fascinated with cosmology because I find it incredible that we can describe the behavior of the entire Universe with the knowledge of only a few fundamental physical processes. Driven by this fascination, my interest has grown to the point that I want to dedicate my life to a career researching cosmology. I have forgone opportunities for a career in engineering and graduate study in astrodynamics to pursue this desire, but I have never regretted this choice; in fact, I feel even more confident that I have found my passion.

My research interests, as I stated in my cover letter, are best described as the intersection of cosmology, fundamental physics, and computing. More to the point, I want to use computational methods to study the impact of physical theories in the context of cosmology. For example, I am very interested in simulating cosmological observables to differentiate competing theories. In practice this has many applications, such as modeling the primordial density power spectrum, the growth rate of structure, or the Baryon Acoustic Oscillation peak in the angular-distance correlation between galaxies. The opportunity to pursue research into simulating and modeling the detection of any of these observables will be possible as part of the observational cosmology project in preparation for the enormous amount of wide-field survey data that will be produced by the Large Synoptic Survey Telescope (LSST). It has long been an ambition of mine to participate in such a research collaboration. This comes from the impact major scientific endeavors, like Planck and ATLAS, had on my own aspirations to pursue a career in physics and astronomy. Seeing how these projects have shaped our understanding of the Universe has made it a personal goal of mine to contribute to a scientific collaboration with similar implications during my lifetime. I believe the LSST offers exactly this opportunity and the rare chance to explore all of my interests while incorporating my entire skill-set for the purpose of conducting cosmological research.

Due to my strong desire to conduct research in cosmology, I contacted Professor Peiris to discuss the project in further detail. She presented the project as having many potential directions for research, like those I mentioned above, but stressed they would all center around developing computational methods for data analysis, specifically searching for cosmological signals within the staggering amount of data the LSST will generate. I have always enjoyed data analysis due to its resemblance to a computational treasure hunt and I have long been interested in computational approaches to solving problems. This interest began as far back as high school, when I wrote my first codes to solve for a projectile's motion in introductory calculus, but the importance of computing for research became clear during my very early studies of cosmology when I learned about the Millennium Simulation. This showed me the impressive power of computing for research and the sheer amount of information that this field must handle. It is not lost on me that data management will be one of the most important considerations to achieve success with this project.

It was explicitly stated in my discussion with Professor Peiris that many of the additional details of the project will not be decided upon until the candidate has been selected. However, from experience, I have some thoughts about how I would conduct my involvement in this project to increase the likelihood for success. The first thing I would suggest would be to immediately set in place a plan for dialogue between myself and Professor Peiris. This would include scheduled meetings and also a plan for regular dissemination of my work, such as monthly written reports. I know that regular discussion and documentation of my work increases my efficiency and helps me maintain a clear focus. This would also promote an efficient conversion of work into communicable scientific material, i.e. for preparation of journal articles. Additionally, I believe the continual practice of preparing my research for another audience would help develop my ability to describe these ideas in a tractable way. As the adage goes, your research is only as good as your ability to communicate your results. Furthermore, being an effective scientific communicator is especially important to me because I want to someday teach these ideas to both university students and the general public.

Secondly, I would seek to establish additional mentorship from other researchers at the OKC and within the CoPS group, as I have already with Professor Edvard Mörtsell. I believe this high concentration of talented researchers at Albanova is one of the most important reasons Stockholm University has been able to produce such high quality research. The ability to have discussions with so many researchers and learn the methods they employ make this environment especially conducive to growth as a researcher at any stage of academia, but even more so as a doctoral student. Additionally, I would aim to participate in working group discussions and attend the regular colloquium presentations. Involvement in these activities would introduce me to many areas of research, even outside the CoPS group, which may foster novel approaches to solving problems by introducing the techniques of these different fields. This mirrors my own experience of utilizing tools from my foundation in the fields of engineering, mathematics, physics and astronomy to inform the approach I take to solving problems. This foundation has been greatly beneficial to my continued education and research pursuits.

As evidence of this foundation and its effect on my success, I completed my undergraduate studies with three Bachelor of Science degrees in aerospace engineering, mathematics, and physics including a minor in astronomy, all while graduating with the highest academic honors awarded by my institution. During my Master of Science education I have maintained this level of success, also achieving upper-level grades, with a upper-B average over all master degree coursework. As a notable part of this extensive coursework, with specific relevance to this project, I have taken three observational astronomy laboratory courses. This has provided valuable experience conducting observations and working with broadband photometric data, the type of data that will be produced by the LSST. Importantly, this has also made me aware of the types of environmental and systematic noise, such as cosmic ray contamination, that affects the quality of the reduced end-user data.

Beyond the standard curriculum for these programs, I have added several elective courses that align with my interests to pursue further graduate study. These courses include differential geometry, partial differential equations, two graduate courses on cosmology, and a course on general relativity. I am more than willing to admit some of this material was more difficult than I anticipated. This is referring specifically to my coursework in general relativity. It was challenging, but I have not let this deter my pursuit of any studies contingent upon my understanding of this material. After completing this course, I took it upon myself to improve this deficiency and ultimately undertake a thesis project on structure formation in bigravity. This study has been highly reliant on my understanding of general relativity. I believe my success in calculating the bigravity linear structure formation, including completing the entire derivation of the perturbation equations by hand beginning with application of the variational principle to the massive bigravity action, is evidence of my improved comprehension and ability.

In addition to this formal education and prior to my research education at Stockholm University, I worked as a research assistant for five semesters at the Asteroid Deflection Research Center at Iowa State University. While working there, I supported research for NASA's Innovative Advanced Concepts program and I was funded by a competitive scholarship from the NASA Iowa Space Grant Scholarship and Fellowship program. From the beginning, I contributed to primarily computational research efforts that included multi-physics modeling of the Yarkovsky Effect, optimal energy transfer modeling, and smoothed-particle hydrodynamics simulation for subsurface nuclear disruption of an asteroid. For each of these projects I was a co-author on a scientific conference paper. Furthermore, I completed individual research focusing on another aspect of computational modeling, computational geometry. I applied the Delaunay triangulation technique of finding nearest neighbors and a spring-damping relaxation algorithm to constructing an optimally spaced particle mesh given a fixed boundary geometry. This work resulted in an invited talk at the Iowa State Undergraduate Research Symposium.

For all the above reasons, I believe I would be an exceptional candidate for the position in observational cosmology. My passion to understand the structure of the Universe has fueled my desire to pursue a career in academia and eventually conduct cosmology research of my own. The experiences I gained over several years as a research assistant, during my present thesis work on bigravity structure formation, and throughout my extensive coursework have prepared me to succeed at the doctorate level. These factors, complemented by the continued mentorship of faculty such as Prof. Hiranya Peiris and the many other specialists at the Department of Physics and CoPS, will provide all the guidance I need to become a successful researcher in my own right.