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Baylor
Statement of Purpose

In August 2015, I began studying Astrophysics at the University of New Mexico (UNM). I was eager to be involved in research and at the start of my first year, I inquired if there was a faculty member interested in working with a freshman. I was extremely fortunate to have Dr. Rouzbeh Allahverdi, Professor of Physics and Astronomy, accept me into his group. To prepare me for work at their level Dr. Allahverdi began by tutoring me in advanced physics topics, such as Classical Mechanics, followed by Quantum Mechanics during my sophomore year. This resulted in my first oral presentation, *Dark Matter as Probe of the Very Early Universe,* at the 2017 UNM Physics Day. During my junior year we began researching the scenario of early matter domination in the very early universe before Big Bang Nucleosynthesis and how it could affect the production of dark matter, a topic that would become my senior honors thesis. This work culminated in my talk at the 2018 UNM Physics Day, *Non-Standard Cosmological Histories*. For my honors thesis we worked on models of one and two field EMD phases, generalizing them to an EMD phase consisting of a distribution of mass densities. We studied specific cases of primordial black holes and string theory scalar fields as possible EMD candidates.

During my sophomore year, I was selected to join the Air Force Research Laboratory (AFRL) mentorship program at Kirtland Air Force Base, where my mentor was Captain P.J. Moran of the Directed Energy Directorate. In 2017, Cpt. Moran offered me the opportunity to work as a Research Assistant in the USAF's Advanced Laser Lab, under the direction of Dr. Greg Pitz. I was first assigned to the Supersonic Cesium Dimer Laser experiment, which resulted in an internship that summer with the Directed Energy Directorate under the auspices of Cpt. Moran and Dr. Pitz, Principal Investigator. During this internship I designed, built, and conducted an experiment to prove the concept of a cavity dumped Cs based pulsed laser. My experiment was the first to demonstrate the functionality of this laser and my results were published in an AFRL technical memorandum within the Department of Defense (DoD). During my junior year, I worked with Dr. Pitz creating theoretical models of Fiber Lasers. In my senior year, I worked at the Star Fire Optical Range, Kirtland AFB, on sodium guide star diagnostics and deep space observations. This work continued until I graduated in May 2019.

The summer before my senior year at UNM, I was fortunate to have been selected for an internship at the CERN Institute, Geneva, Switzerland. I was chosen to work on the AEGIS experiment under the direction of Dr. Michael Doser, who assigned me three different research projects over the course of the internship. The first used Compton Scattering as a tool for mapping a beam of antiprotons. This project was conceived by Dr. Doser as a possible solution for addressing the problem where traditional methods of mapping particle beams cannot work with antimatter. My work consisted of theoretically calculating the cross section for this interaction and creating a potential design of that experiment. I was able to prove this concept could be successful and I created a rudimentary design for the experiment. My report, *Compton Scattering as a Tool for Mapping a Beam of Antiprotons,* was published on the CERN server. The second project on which I worked was modeling the C_2 Anion Fluorescence Spectrum. The AEGIS project was experimenting with using C_2 anions as a possible method for sympathetically cooling antiprotons for the creation of ultra cold antihydrogen. It was my responsibility to model the fluorescence spectrum of C_2 anions for their experiment. This resulted in my second report on the CERN server, *C_2 Anion Fluorescence*. My model was used in their experimental analysis. The third project was data analysis of Rydberg Positronium, wherein I analyzed experimental data and compared the data with previous results.

At the beginning of my Senior year, I began working with Dr. Sally Seidel, Professor of Physics, and Dr. Martin Hoeferkamp, Research Engineer, both of the UNM ATLAS group. We were researching 3D silicon particle detector upgrades to the ATLAS vertex detector and tracking system. My responsibilities consisted of characterizing the 3D silicon particle detectors in order to determine the radiation hardness. I also conducted irradiation experiments at the Los Alamos National Laboratory (LANL) LANSCE facility. I was selected to present our work at the 2018 Annual Meeting of the Four Corners Section of the American Physical Society (APS). I presented *Development and Characterization of New 3D Radiation Hard Silicon Particle Detectors for the HL-LHC*.

I had the opportunity to continue community service work while I attended UNM. Having received so much from my experience with the AFRL/UNM mentorship program, I was pleased when I was selected to become a student mentor at the beginning of my junior year. I was assigned two students over two years. It was an amazing experience and I worked hard to be as good a mentor to those students as Cpt. Moran had been to me. I took seriously my responsibilities teaching, supporting, and counseling the students assigned to me. I also enjoyed my work as a volunteer in the UNM Observatory. I operated the telescope and instructed members of the student body and general public on the telescope and cosmic events, answering whatever questions they posed.

After graduating from UNM in May 2019 with my BS in Astrophysics, I was accepted to the Air Force Institute of Technology (AFIT), Wright-Patterson Air Force Base, Dayton, OH. I am working on a Master of Science in Applied Physics, with a focus on Plasma and Nuclear Physics, under the direction of Dr. John McClory. My Master's Thesis will be a *New Class of Heavy Ion Plasma Drivers for Plasma Jet Driven Magnetoinertial Fusion*. I am working on producing Magnetohydrodynamic (MHD) models of a Magnetoplasmadynamic (MPD) thruster, longitudinal magnetic nozzle, and longitudinal drift compression and transverse focusing with the added difficulty of using the MPD thruster to induce a negative velocity tilt. My research will also investigate the effectiveness of the plasma pulses produced by this driver when compressing a magnetized target of D-T plasma to produce fusion conditions. The goal of this research is to produce an MHD model of the driver and the fusion compression for the Plasma Liner experiment (PLX) at LANL, to create a design of an experiment of the driver for LANL, and create a possible fusion reactor design.

The summer of 2019, I was given the opportunity to join Dr. Cleaver's research group while working toward my Master of Science at AFIT. Working in Dr. Cleaver's group has exposed me to dynamic wormholes, accelerating and non-accelerating Natario warp drives, traversable wormhole curvature invariants, and swampland string theory. I have been specifically working on two research projects. The first is a study of dynamic traversable wormholes in collaboration with Dr. McNutt; the second is the entropy of traversable wormholes in collaboration with Dr. Bahram, which we are in the process of publishing. We are also in the initial stages of a project with stacked Casimir plates to experiment with anti-gravity physics, a project I am scheduled to start working on next summer. There are also projects in fusion propulsion and fusion physics we are preparing to start, as well. I have greatly enjoyed my time with Dr. Cleaver's group and look forward to joining them at Baylor next year.

In June 2020, I began working with Howe Industries, based in Phoenix, AZ. I am currently working on the Pulsed Plasma Rocket Engine. This engine accelerates a pulse of plasma through a magnetic nozzle. I am responsible for creating an MHD model of the magnetic nozzle and the solenoidal barrel. This project is currently in the NASA NIAC Phase 1, with the intention of moving to the Phase 2 proof of concept experiment once Phase 1 has reached completion.

The research I have conducted throughout my years in college has engrained in me an excitement about all aspects of Astrophysics. However, my work has also given focus to the specific direction I wish to take: Theoretical and Computational Astrophysics with a focus on Gravitational Theory, Theoretical Cosmology, and Particle Physics, as well as Theoretical and Computational Plasma Physics. I would like to study the most exotic realms of the Universe, such as negative energy density fields (including wormholes, warpdrives, anti-gravity fields), core collapse supernova, black holes, gravitational waves, and high energy plasma environments; and use the physics we learn from studying these environments to drive humanity's efforts in space exploration through research into Breakthrough Propulsion Physics. Specifically, I would like to study faster than light propulsion, fusion propulsion concepts, and fusion energy concepts; as well as other advanced propulsion concepts including antimatter drives and production techniques. While working toward my PhD, I will continue my studies in these areas, both theoretically and experimentally. I want to conduct this research not only to understand the theory, but to also apply what I learn to help mankind explore the stars. After I earn my PhD, I plan to work with NASA, USSF, national research laboratories (such as Los Alamos, AFRL, and NRL), and scientific research universities.

Having had the opportunity to work with Dr. Cleaver and his group this past year, I feel strongly that Baylor University is the best environment in which to pursue my PhD.

I thank you for considering my application.