Candidate Statement

I am captivated by the interplay between theory and experiment in quantum information science, condensed matter, and atomic, molecular, and optical physics. I have developed this fascination from my experiences in quantum simulation and experiments with ultracold quantum gases. In May 2021, I will complete my undergraduate studies at Colby College with two Honors Theses on experimental atomic physics and mathematical analysis. My next objective is to expand and subsequently apply my research training to address an important open problem in quantum science. To that end, the Physics Ph.D. program at the University of Chicago is a fantastic option.

My most recent interest is in simulation of quantum many-body systems. At the moment, I am continuing the research started this summer with Dr. Timothy Hsieh at the Perimeter Institute for Theoretical Physics on efficient variational simulation of quantum states that are not adiabatically connected to unentangled product states. Motivated by variational quantum eigensolver algorithms and the Quantum Approximate Optimization Algorithm (QAOA), Dr. Hsieh recently developed a protocol that could target a class of such non-trivial states with perfect fidelity using an L/2-deep QAOA ansatz, where L is the system size. We initially aimed to accelerate this protocol; however, after I discovered that it could also target the ground state of the transverse-field Ising model with random field and couplings, our research focus shifted towards understanding how QAOA provides such a reliable ansatz. Since then, I have further found numerically that an (L+1)- and a modified L/2-deep ansatz could simulate with near-perfect fidelity excited states of this model and the ground state of any disordered Ising Hamiltonian, respectively. My next goal is to explore Dr. Hsieh's conjectures related to this fascinating behavior of the QAOA ansatz. Ultimately, we aim to establish relationships between the current protocol and the ability to target many-body localized states.

My interest in quantum science originated with research experiences in ultracold atom experiments at the Joint Quantum Institute (JQI) and Colby College. In Summer 2019, I joined the Rolston group at JQI to study the long-range interaction between rubidium atoms magneto-optically trapped around an optical nanofiber. There, I built an imaging system for optimizing light polarization in optical nanofibers, which often introduce birefringence and undesirable longitudinal polarizations. I also developed a stand-alone Python program for controlling the entire experiment, removing the group's reliance on the less compatible LabView program. In January 2020, Dr. Hyok Sang Han and I observed a mysterious transient decay flash in the rubidium population that was much faster than even the fastest superradiance mode of the system. The group at JQI is developing a theory for this phenomenon, for it was only recently discovered and is not well-understood in the one-dimensional geometry of our nanofiber experiment.

Since my first year at Colby, I have been working on ultracold potassium experiments under Professor Charles Conover, my advisor and mentor. Applying the experimental techniques I learned at JQI, I am currently working towards a Physics Honors Thesis on lifetime measurements of quantum states in potassium by counting photons emitted from an excited, magneto-optically trapped, atomic cloud of this species. In previous years, I constructed a variety of laboratory apparatus from external-cavity diode lasers to electronics for laser frequency stabilization. I also carried out precision spectroscopy on potassium in Rydberg states to determine its quantum defects and absolute energy levels. At our level of precision, energy shifts due to the millimeter-wave source are significant and thus require data extrapolation to obtain unbiased measurements. Applying Ramsey's separated oscillatory field method, I eliminated this necessity and gave an alternative measurement scheme with comparable precision. I presented this work at Colby's summer research symposium in 2018 and at DAMOP 19.

Outside of physics research, I explore other areas of physics and mathematics and pursue my passion for photography. My attempt to understand massive gravity and its rich history with Professor Robert Bluhm resulted in a collection of detailed expositions of this theory and related topics, which is available on my website. Now, I am self-studying quantum field theory with an emphasis on applications in condensed matter physics. Last year, intrigued by their application in partial differential equations, I began my Mathematics Honors Thesis under Professor Evan Randles on convolution powers of complex-valued functions. We are preparing a manuscript summarizing our new result and will present it at the Joint Mathematics Meeting in January 2021. When I am not working on physics and mathematics, I experiment with and develop my own film-photographic work in my home-made photo lab. These projects, along with my role as a physics and mathematics teaching assistant, extend my toolbox for research as well as teaching.

At Chicago, I would like to focus my efforts on quantum science and expanding my teaching capacity. I have contacted Professor Jonathan Simon and am interested in his research on photonic materials and his collaboration with Professor David Schuster on hybrid quantum systems. In addition, I find Professor David DeMille's experimental work on precision measurements very appealing. Upon receiving my Ph.D., I aim to continue research in quantum science and eventually teach at a research-oriented university. Ultimately, I would like to make impactful contributions to the continually growing body of work in this field. I believe that admission to the Physics Ph.D. program at Chicago is an ideal step towards this goal.

Thank you for your consideration.

October 17, 2020