Statement of Objectives

I am captivated by the interplay between theory and experiment in quantum information science, condensed matter, and atomic, molecular, and optical physics. In particular, I am interested in quantum simulations as well as experiments with ultracold gases for quantum science and fundamental physics. 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 MIT is a fantastic option.

My interest in quantum physics began in my first year at Colby College, where I have been working on ultracold potassium experiments under Professor Charles Conover, my advisor and mentor. Currently, I am working towards a Physics Honors Thesis on precision lifetime measurement of potassium's $5P_{3/2}$ quantum state 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 the Colby Undergraduate Summer Research Retreat in 2018 and at DAMOP 19.

To broaden my experience in experimental atomic physics, I joined Professor Steven Rolston's group at the Joint Quantum Institute (JQI) in Summer 2019 to work on an experiment probing the long-range interaction among 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 is currently not well-understood in the one-dimensional geometry of our nanofiber experiment.

More recently, my interest in quantum information science led me to a research project with Dr. Timothy Hsieh at the Perimeter Institute for Theoretical Physics, which began this past summer and is still ongoing. The project explores efficient variational simulation of non-trivial quantum states that are not adiabatically connected to unentangled product states. Initially, we aimed to accelerate Dr. Hsieh's protocol, which according to numerical results could target the ground state of the uniform transverse-field Ising model with perfect fidelity via a variational ansatz based on the

Quantum Approximate Optimization Algorithm (QAOA). However, after I found that this protocol could also target the ground state of any non-uniform Ising model with random transverse field and couplings, our focus shifted towards understanding how QAOA provides such a reliable ansatz. Since then, I have obtained additional results related to targeting eigenstates of more general Ising Hamiltonians using similar schemes. I am now studying the free-fermion representation of the non-uniform transverse-field Ising model. Ultimately, we aim to prove that the QAOA-based ansatz can indeed target any eigenstate of this model with perfect fidelity, in accordance with numerical results.

Besides quantum physics, I also explore other areas of physics and mathematics. For four semesters with Professor Robert Bluhm, I studied general relativity and massive gravity and wrote detailed expositions of these topics 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 research on convolution powers of complex functions with Professor Evan Randles. Motivated by my numerical evidence, we recently developed a generalization of the polar-coordinate integration formula which aids in the understanding of convolution powers. We will present this result at the Joint Mathematics Meeting in January 2021 and are preparing a manuscript for publication. Moreover, I will write my Mathematics Honors Thesis on this work. These projects, along with my role as a physics and mathematics teaching assistant in which I develop valuable pedagogical skills, enrich my academic experience beyond coursework.

At MIT, I would like to focus my efforts on quantum science and expanding my teaching capacity. I have contacted Professor Martin Zwierlein and am interested in his upcoming experiment on rotating quantum gases to investigate quantum Hall physics. I have also contacted Professor Soonwon Choi, who will be starting at MIT in July 2021. His research on quantum many-body systems and quantum information dynamics aligns directly with my current interests. Finally, I am attracted to both theoretical and experimental aspects of Professor Isaac Chuang's work. 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 MIT is an ideal step towards this goal.

Thank you for your consideration.

October 29, 2020