Motivation Letter

Precision instrumentation has long been a fascination for me. The drive to constantly improve performance is a tendency I observed while growing up during the technology boom of the 2000's. Over time, these observations developed into personal pursuits including my early college interest in acoustical engineering and my current goal of earning a PhD in physics. Initially, I joined Belmont University and its well-known audio engineering program with an intent to develop precision analog studio equipment. However, second semester of my freshman year, I enrolled in Introduction to Physics which required the textbook *College Physics* by Sears and Zemansky. To my surprise, the more I was exposed to physics, the deeper my interest grew. Three years after changing my major, I believe pursuing a Masters in Quantum Science and Technology at the University of Barcelona will be a significant step towards my long-term goal of earning a PhD in physics, and then researching quantum metrology in a national lab or industry.

Relevant Research Background: Summer 2020 Internship

Summer of 2020, I participated in a ten-week Science Undergraduate Laboratory Internship (SULI) at Oak Ridge National Laboratory (ORNL) under the supervision of Dr. Ben Lawrie and Dr. Raphael Pooser. The initial project plan was to explore the fundamental physics of four-wave-mixing processes, dual homodyne detection of squeezed states, and new variations of quantum microscopy and quantum sensing. As Covid-19 continued to rise in America, ORNL graciously extended the opportunity to participate in the internship remotely. In this new context, our top priority was to calculate the theoretical noise limit of an ultralight dark matter accelerometer while using squeezed light.

Recently, researchers at the University of Maryland have proposed a novel method for ultralight dark matter detection. [1] In their work, they suggest that improvements could be made using squeezed light. Given Dr. Lawrie and Dr. Pooser have extensive experience with quantum sensing, we set a goal to calculate the power spectral density read out of an ultralight dark matter accelerometer using a truncated nonlinear interferometer. We also considered the effect of single mode ponderomotive squeezing as an alternate solution. By the end of the summer, we derived the case for single mode amplitude input squeezing and ponderomotive squeezing on a single arm interferometer.

Personal Interest in the University of Barcelona

I was immediately intrigued with the Master in Quantum Science and Technology program after watching the Information Session recording. This program provides not only a fantastic selection of core quantum courses, but multiple research opportunities which align with my interest. In particular, I would be eager to join Prof. Dr. Morgan Mitchell's research group in Atomic Quantum Optics. His recently published article describes the quantum limits of detection solely referencing dimensioned physical quantities. [2] This article leaves an open question - whether or not this limit could be beaten with quantum metrology methods through strongly interacting spin systems. This is just one example of the many fascinating research opportunities provided by the ICFO and University of Barcelona. I would be honored to pursue the Master in Quantum Science and Technology degree in Barcelona. Thank you.

References

[1] Carney, Daniel, et al. "Ultralight Dark Matter Detection with Mechanical Quantum Sensors." *ArXiv.org*, 13 Aug. 2019, arxiv.org/abs/1908.04797.

[2] Mitchell, Morgan W. "Scale-Invariant Spin Dynamics and the Quantum Limits of Field Sensing." *New Journal of Physics*, vol. 22, no. 5, 2020, p. 053041., doi:10.1088/1367-2630/ab81b8.