Abstract:
Optical Lattice Clocks based on ultracold strontium atoms have recently recorded the historic best in both precision and stability [1]. At the same time progress in strontium quantum gas experiments has been rapid, yielding numerous exciting results [2-4]. This work will focus on a new design of the strontium system that has both precision measurements enabled by the clock laser, and quantum gas functionality [5].

Prospectus:
In general, most groups interested in the study of quantum gases do not have a laser stabilized to the requirements dictated by an optical clock. It also true that most optical clocks are not capable of cooling to the regime where quantum gas experiments are possible. We wish to change that, enabling the precision measurements made possible by a clock laser in a strontium quantum gas. This will enable the investigation of weaker interactions of exotic states then previously possible.

One of the principal limitations in the regard is the short vacuum lifetime of the chamber used on the strontium clock. With a vacuum lifetime of around one second, the current system is far from the minute scale lifetime required for sufficient evaporative cooling [6-8]. This will require a new chamber to be designed and built capable of this increased cooling. The project is currently still in the planning phase, but usage of novel pumping techniques (as compared to most quantum gas experiments) is likely [9].

My personal contributions to this project cover several different areas. As the length of interrogation becomes longer, going from around a second to several minutes, the scientific impact of breaking laser lock increases. I have designed and am currently implementing a current control loop filter to try and maintain this lock more efficiently for diode lasers [10]. I have also investigated different techniques for constructing an ECDL laser in an attempt to increase the available power for the atom preparation system. My current work is constructing a model for investigating the Dick effect [11] in many particles clock in an attempt to reduce it by digital filtering [12].
Bibliography:
Some references are included because they provide excellent background on different topics relevant to the research.