Contribution ID: **86** Type: **Oral Presentation**

Construction and testing of a magneto-optical trap for laser cooling of rubidium atoms

Tuesday, 9 July 2019 12:40 (20 minutes)

Cold neutral atoms are currently being used in many areas of quantum information processing, such as single photon sources, entangled photon generation, quantum simulations involving cold atoms in optical lattices, etc. Atoms are cooled using a device incorporating laser cooling together with magnetic trapping called a magneto-optical trap (MOT). We describe in this presentation the basic principles of laser cooling and the design, construction and testing of the MOT for cooling of neutral rubidium atoms.
Our system consists of an octagonal vacuum chamber having a number of view ports, plus vacuum pumps, piping, vacuum gauge and valves. Three stages of pumping are used to reduce the pressure from atmosphere down to ˜ 10ˆ(-10) mbar. Rubidium atoms stored in a getter material are released into the vacuum chamber by means of electrical heating. Three pairs of counter propagating laser beams, each pair positioned on opposite sides of the chamber along three orthogonal axes, are used for cooling the atoms in the chamber. Two lasers are used and frequency locked using saturated absorption setups and a PID controllers. One laser is frequency locked to the 5S1/2 (F=2) to 5P3/2 (F=3) cooling transition of rubidium 87. Since the atoms eventually move out of the cooling transition cycle, another laser is locked to the 5S1/2 (F=1) to 5P3/2 (F=2) repumping transition. The cooled atoms are trapped using a pair of anti-Helmholtz magnetic coils positioned on either side of the vacuum chamber. Measurements of the cold atoms have been conducted using CCD cameras. By measuring the fluorescence of the cooled atoms, the number density, size of the atomic cloud, and temperature are inferred. We provide measurements of these.

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Primary author: Dr GOVENDER, Kessie (Cape Peninsula University of Technology)

Co-authors: Mr WYNGAARD, Adrian (Cape Peninsula University of Technology); Mr PENTZ, Rory (Cape Peninsula University of Technology); Mr OPEOLU, Victory (Cape Peninsula University of Technology)

Presenter: Dr GOVENDER, Kessie (Cape Peninsula University of Technology)

Session Classification: Applied Physics

Track Classification: Track F - Applied Physics