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Design, development and characterization of a magneto-optical trap for laser cooling of Rubidium atoms: a project at the Cape Peninsula University of Technology

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Laser cooling of neutral atoms have opened up a new area of research into ultra-low temperature physics of quantum systems. These systems have shown potential in many areas of quantum information processing, such as single photon sources, entangled photon generation, quantum simulations using cold atoms in optical lattices etc. We describe in this presentation the theory of laser cooling and the development and characterization of a device to cool and trap neutral Rubidium atoms.

The system consists of an octagonal vacuum chamber having a number of view ports, vacuum pumps, piping, vacuum gauge and valves. Three stages of pumping (i.e. rotary, turbo and ion pumping,) are used to reduce the pressure from atmospheric down to ~ 10^(-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 of the atoms in the chamber. The lasers are frequency locked, using a saturated absorption setup and incorporating a PID controller, to the 5S1/2(F=2) to 5P3/2(F=3) transition of Rb87. Because the atoms eventually move out of the cooling transition cycle a re-pumping laser is also incorporated and tuned to 5S1/2(F=1) to 5P3/2(F=2) transition.

The cooled atoms will be trapped using a pair of anti-Helmholtz magnetic coils positioned on either side of the vacuum chamber. Measurements will be conducted using optical sensors such as CCD cameras and avalanche photo detectors for measuring the light emitted by the trapped atoms. By measuring the fluorescence of the cooled atoms, the number density, size of the atomic cloud, and temperature can be inferred. We provide preliminary measurements of these, in addition to details of the performance of the saturated absorption setup and of the laser control for Doppler cooling.

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