A Magnetic Guide for Neutral Atoms

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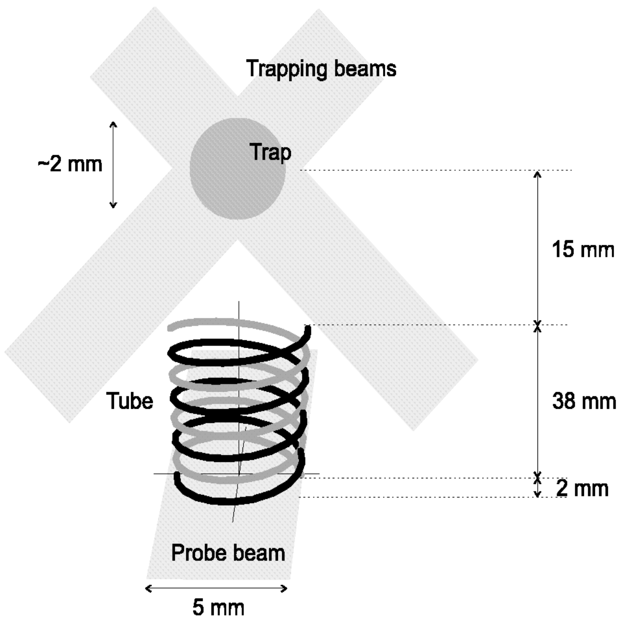
Since the development of sources of cold neutral atoms, many optical elements have been developed based upon the interaction of an atoms permanent magnetic dipole moment with a spatially varying magnetic field. We report on the development of a magnetic guide for caesium atoms (see [1]). Our magnetic tube consists of two identical, interwound wire solenoids. The currents in the two solenoids are of equal magnitude but are oppositely directed. The magnetic field produced by this arrangement is approximately zero inside the tube and increases exponentially near the wires. Atoms in positive magnetic substates are repelled by the field gradient near the wires and are therefore trapped by the tube. Several other groups have demonstrated guides based on similar principles [2]-[4]. The tube dimensions and experimental configuration are illustrated in the diagram below.



Experimental Setup

The wires have a diameter of 0.8 mm, with centres also separated by 0.8 mm.

We tested the tubing using caesium atoms cooled in a magneto-optical trap. After loading the MOT for 3.7 s, the trapping field was turned off and the atoms further cooled in optical molasses for 20 ms. The trapping lasers were then chopped, allowing the atom cloud to expand ballistically as it fell under gravity towards the tube mouth. Time of flight measurements made by passing the atoms through a resonant probe beam positioned slightly above the tube indicated a typical trap temperature of 20 μK.

A resonant probe laser beam of width equal to the tube width was positioned 2 mm below the bottom of the tube. This beam produced an absorption signal proportional to the number of atoms falling through it. The fraction of atoms falling through the tube was measured by comparing the absorption in the case where the tube was switched off with the absorption when the current was switched on as the atoms reached the top of the tube.

Each data point below is based on five consecutive measurements, each consisting of one measurement with the tube off, and one with the tube on. With a tube current of 1 Amp, an increase in absorption of approximately 400% was observed.

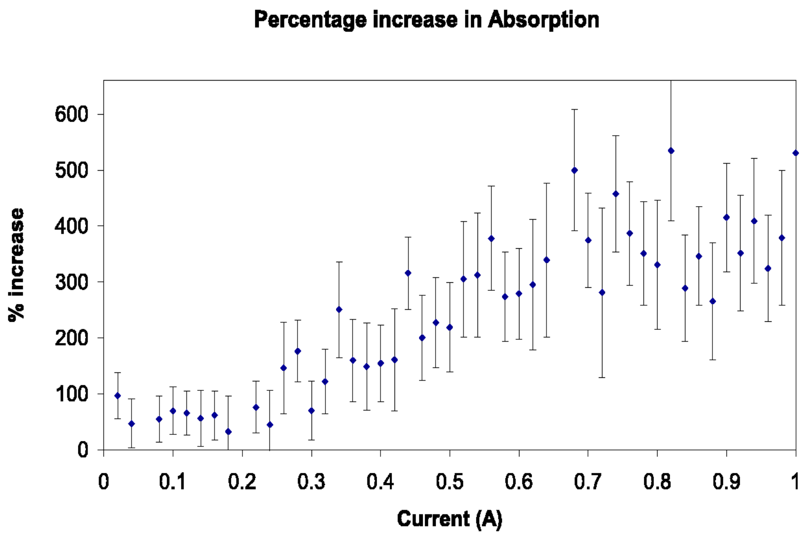


Figure 1: Absorption increase vs. tube current

We expect that this tubing will prove to be a useful tool for transporting cooled atoms since it prevents ballistic expansion of atoms after they are released from a trap. In contrast to atom guide designs using permanent magnets, the magnetic field of our tubing can be switched off by switching the currents; hence the tube can be placed close to a magnetic trap without affecting the trapping efficiency.

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[3] Dekker NH, Lee CS, Lorent V, Thywissen JH, Smith SP, Drndic M, Westervelt RM, Prentiss M. *PRL* **84(6)**, 1124 (2000).
[4] Denschlag J, Cassettari D, Schmiedmayer J. *PRL* **82(10)**, 2014 (1999).