OPTICAL MANIPULATION OF A COLD ATOMIC BEAM FROM A RUBIDIUM FUNNEL

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Fabrication of nanostructures has increasingly become a focus of research in recent years. Neutral atom lithography is a potential technique employed to achieve this goal and has demonstrated stable and useful sub 100 nm one- and two-dimensional structures [1]. The advantages of atom lithography include quick, parallel deposition rates, high regularity and potentially low production costs. However, techniques that utilise decelerating atomic beams using radiation pressure generally yield broad (several m/s) longitudinal and transverse velocity distributions. Therefore, many atom optical elements will suffer from chromatic aberration.

To overcome this problem, we apply the principles of a magneto-optical trap (MOT) in two dimensions [2][3][4][5][6]. Using this "atomic funnel" we have produced a continuous slow beam of Rb atoms with a tunable mean velocity in the range 2-8 m/s. The temperature of the atoms is typically 45-55 μK in the moving frame, which corresponds to velocities of a few cm/s. The beam shows a high degree of collimation (divergence $\sim$28 mrad half-angle) and low longitudinal velocity spread ($\Delta v_l/v_l$) with a typical flux of $7.3(7)10^8$ atoms/s.

A simple atom optical diffraction grating is used to manipulate the cold atomic beam in analogy with light. In first instance we will consider treating each grating element as an individual lens. In order to achieve this our initial set-up incorporates a 2 ps modelocked Nd-YLF laser of 1.4 W average power at a repetition rate of 100 MHz. As the laser is operating at 1047 nm the scattering rate of the atoms will be neglible. The grating is constructed by setting up a simple Michelson interferometer where the two beams are combined under an angle. By varying the intersection angle, the grating period and grating width change. This atom optical element is based on the phase change of the atomic wave function in a potential field [7][8]. As the atoms travel through the beam the ground state is reduced in energy due to the ac-Stark effect. This leads to a phase change of the atomic wave function that is largest near the centre of the light beam where the atoms interact with the light for the longest time. The focal length of the lens is proportional to the kinetic energy of the atoms, the detuning and the beam waist and inversely proportional to the intensity of the dipole beam.

We calculate a focal length of 1-700 mm. These lengths depend very much on the initial velocity of the atoms leaving the MOT, which can be varied between 2 and 8 m/s, and the width dimension of each dipole lens in, which can be varied between 8 and 100 μm. The spot size of the focused atoms depends proportional on the transversal velocity spread. Therefore the low velocity spread of our atomic beam will reduce chromatic aberration and the observed spot size. Several foci should be observed in initial experiments because of the grating features above mentioned.

We will discuss the results achieved and describe potential applications of this technique.

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