Dark-hollow beam guiding of a continuous low-velocity atomic beam

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Optical beams with zero central intensity can be called dark hollow beams (DHB) and have been used in various studies of neutral atom manipulation in recent years. In a blue detuned DHB, atoms experience a dipole force towards the beam center and can be confined along the beam under appropriate conditions. Several recent experiments have demonstrated atom guiding and atom transverse cooling in a DHB [1, 4]. Possibilities of atom guiding and Sisyphus cooling in a DHB have been discussed in the literature [5].

We report experimental observations of dark-hollow-beam guiding, focusing, and splitting of a continuous, low velocity atomic beam generated in a magneto optical trap. Our experiments were carried out in a standard 87Rb magneto-optical trap (MOT) and a low-velocity rubidium atomic beam was generated by placing a 1 mm black spot in the center of the vertical returning trapping and cooling beam as first demonstrated by Lu et al [6]. Two extended-cavity diode lasers were used as the trapping laser and repump laser respectively. With a simple optical axicon set up [7], a Ti:Sapphire laser beam was converted into a DHB of power 250 mW.

The loading and guiding characteristics of the low-velocity Rb beam can be manipulated by beam shaping of the DHB. We varied the dark center diameter of the DHB in a range of 0.1 mm to 1 mm and moved the DHB waist above or below the MOT. Our results show that when the DHB waist is below the MOT, the guided atomic beam converges; when the DHB waist is above the MOT, the guided atomic beam diverges.

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