Improved double Magneto-Optical Trap

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At the first stage to create a Bose-Einstein condensate (BEC) of rubidium atoms, a double magneto-optical trap (MOT) has been widely used for collecting a large number of atoms ($\sim 10^9$) in ultrahigh vacuum($\sim 10^{-11}$ torr). In a standard double MOT, the atoms are first captured in the first MOT from a background gas and multiply transferred to the second MOT in ultrahigh vacuum using resonant laser pulses (sometime with a guiding magnetic field). So far, a typical loading time of the second MOT is few tens of seconds, which is limited by a relatively low flux of atoms ($< 10^8$ atoms/s). We have demonstrated *continuous* loading of atoms using a cw resonant pushing beam with no guiding magnetic field. We obtained a flux of 3.7×10^8 atoms/s, allowing us to collect 10^9 atoms in the second MOT in only 3 s.

The experimental setup of our double MOT system is illustrated in Fig1. The vacuum system consists of two parts, an upper chamber (with six ICF70 viewports) and a lower octagon glass cell. The vacuum pressure of the upper chamber (filled with rubidium gas) is about 10^{-8} torr and that of the lower cell is about 10^{-11} torr (inferred from a trap lifetime of 600 s limited by background gas collisions). A taper-shaped tube connects upper and lower parts, allowing good differential pumping (the tube has a length of 60 mm and an inner diameter of 4 mm (10 mm) at the top (bottom) of the tube). The atoms captured in the upper MOT are continuously pushed to the lower MOT located 26 cm below as follows. We focus a cw weak (10μW) resonant push beam to the center of the upper MOT and extract a cw atomic beam. At the focus point, the push beam has a waist of 100 μm and an intensity of 300 mW/cm^2, which is much larger than the saturation intensity (1.6mW/cm^2). On the other hand, at the position of the lower MOT, the push beam has a waist of 3 mm and an intensity is 0.3 mW/cm^2, which is well below the trapping laser intensity of the lower MOT (2 mW/cm^2 per each beam), therefore the lower MOT is hardly affected by the push beam.

Fig.2 shows a loading profile of the second MOT obtained by detecting the fluorescence of trapped atoms with a calibrated photo diode. The initial loading rate is 3.7×10^8 atoms/s. After 20 s loading, the number of atoms saturates at 4.5×10^9, which is presumably limited by intra-trap binary collisions.

We believe this simple and fast loading technique facilitates experiments to create rubidium BECs, and hopefully leads to realization of cw atom lasers.

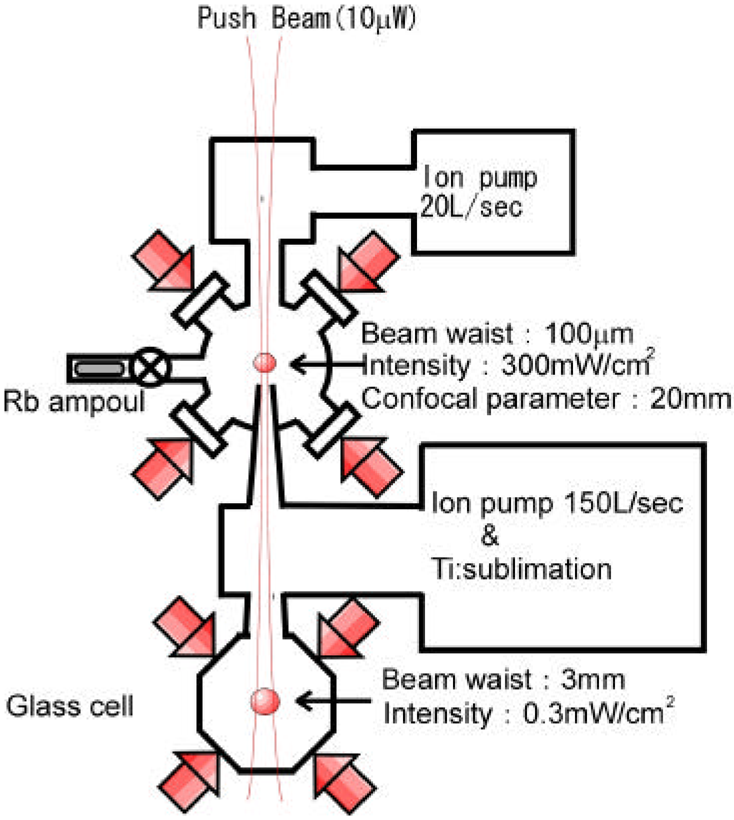

Fig 1 double MOT system with a cw push beam

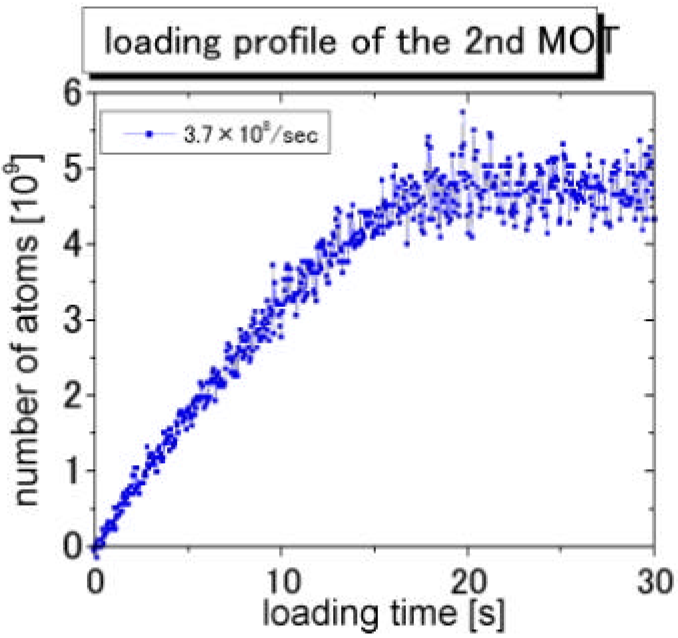

Fig 2 Loading profile of the 2nd MOT