Atomic Fountain towards a single atom trap
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The past few decades have witnessed the development of very robust technique, known as magneto-optical trap(MOT), for cooling and trapping of neutral atoms using lasers and magnetic fields. This technique can easily produce cooled atoms to a temperature range of nano-kelvins(1). These laser cooled and trapped atoms have found applications in various fields, such as ultrahigh resolution spectroscopy, precision atomic clocks, very cold atomic collision physics, Bose-Einstein Condensation, the Atom laser, etc. Particularly, a few isolated atoms of very low temperature are needed in the cavity QED studies in the optical regime. One can obtain such atoms from a MOT using the atomic fountain technique. The widely used technique for atomic fountain is, first to cool and trap the neutral atoms in MOT. And then launch them in the vertical (1, 1, 1) direction with respect to cooling beams, using moving molasses technique. Recently, this technique combined with the cavity-QED has opened an active area of basic research. This way atoms can be strongly coupled to the optical radiation in the cavity and leads to various new effects. Trapping of single atom after separating it from MOT in the high Q-optical cavity is actively initiated presently(2,3). This will help to sharpen our understanding of atom-photon interaction at quantum level and may lead to the development of single-atom laser. Our efforts to develop an ^{85}Rb-atomic fountain is in progress.

In this paper, we describe the details of our setup for atomic fountain. Fig. 1 shows the schematic diagram of our optical setup used for obtaining cooling laser beams at the pre-stable frequencies. The basic laser source is TUI DL100 laser system at λ=780 nm. This system is frequency stabilized by means of Doppler-free saturation spectroscopy. The short-term laser stability of the laser is measured to be 1 MHz. The frequency of laser can be shifted by desired amount using accousto-optic modulators (AOM's). This light is splitted into two beams, which are both frequency shifted with two independent double pass AOM's. Each beam is further divided into two set of three beams moving (each having intensity nearly 5 mW/cm^2) upward and downward directions in the vapour cell. Fig. 2 shows the schematic of the vacuum chamber used in our set-up. The chamber is divided into two parts; the upper chamber (UHV 10^{9} torr) and the lower chamber (high vacuum 10^{8} torr) separated by a narrow hollow tube. The ^{85}Rb atoms needed for the atomic fountain are first captured in the MOT (lower chamber), and then further cooled in the optical molasses before being launched.

During the cooling and trapping operation, the two set of three beams are kept near resonant with $5^2S_{1/2}$ F=3↔$5^2P_{3/2}$F'=4, a closed transition of ^{85}Rb. The repumping light for the MOT, resonant with $5^2S_{1/2}$F=2↔$5^2P_{3/2}$F'=3 transition of ^{85}Rb is generated by another frequency stabilized laser. The quadrupole magnetic field in the vapour cell is applied using the anti-Helmholtz coils (magnetic field gradient in z-direction nearly 30 Gauss/cm). Nearly 10^7 atoms are captured in the MOT in a few hundred of milliseconds from the background vapour. After trapping, the atom are further cooled for few milliseconds in the optical molasses. This leads to the temperature of atoms to a few micro-kelvin range. During optical molasses the laser beams are far detuned and magnetic field is switched off. In atomic fountain, these cooled atoms are launched to the upper chamber using moving molasses method, in which the lower beams are detuned relative to the upper beams in order to create moving molasses. This will accelerate the atoms in the vertical direction.

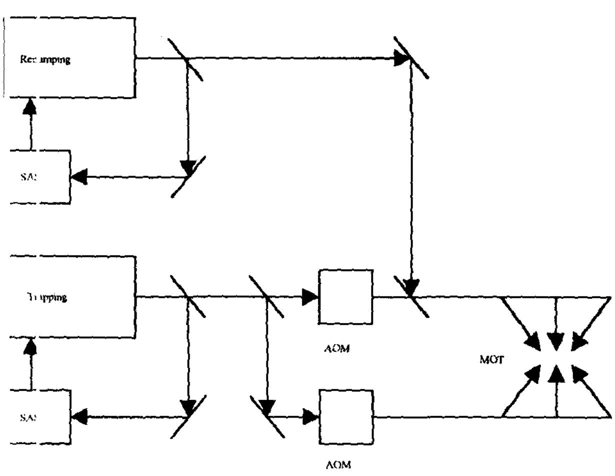

Fig 1. laser beam setup for atomic fountain

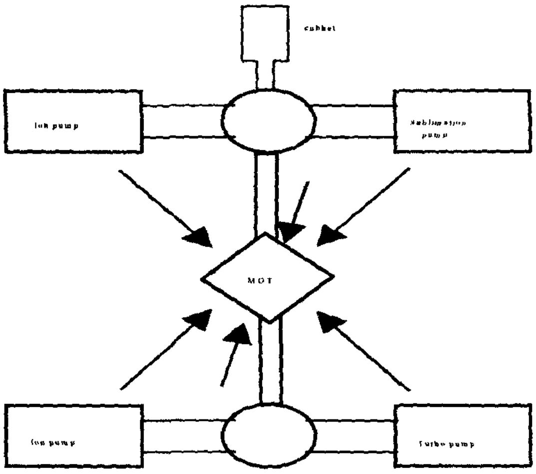

Fig 2. vacuum system

The preliminary results on the density, temperature of cold atoms in our setup will be presented. Means to vary the entrance velocity of the atoms to upper chamber and atom flux in fountain will also be discussed. This is supported by Creative Research Initiatives of the Korean Ministry of Science and Technology.

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