# 4 - 7 Laser Cooling and Trapping of Rubidium Atoms

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Atomic physics is developed by the realization of Magneto-Optical Trap (MOT)[1] which helps scientists achieve the miracles of Bose Einstein condensation[2], atomic frequency standard[3] and ultra-cold plasma[4]. We built a rubidium MOT system and used it to cool and trap as many as $10^6$ $^{87}$Rb atoms with a density of $10^{10}$cm$^{-3}$ and a temperature of 500 μK.

The MOT consists of three systems: the vacuum system, the laser system and the control system. The vacuum system is carefully designed to obtain a vacuum as high as $5\times10^{-9}$ mbar. Rubidium atoms are evaporated into the vacuum chamber by heating the pure rubidium metal to 40°C. The laser system is stabilized by the saturated absorption spectroscopy[5] with a bandwidth less than 1 MHz. In order to cool the atoms, two laser frequencies are required: one is tuned a few megahertz below the cooling transition $[5s_{1/2}(F{=}2) \rightarrow 5p_{3/2}(F'{=}3)]$ of $^{87}$Rb atom, and the second one is tuned on the repumping transition $[5s_{1/2}(F{=}1) \rightarrow 5p_{3/2}(F'{=}2)]$. On the other hand, a pair of anti-Helmholtz coils is used to generate a gradient magnetic field to compensate the Doppler Shift of the atoms. The scheme of the MOT is shown in Fig. 1(a). The cold atoms will emit fluorescence in the center of the trap, which is detected by a CCD monitor as seen in Fig. 1(b). Both the fluorescence imaging and the absorption imaging[6] are captured and used to simulate the density and temperature of the cold atomic cloud. The imaging time sequence of the laser, coils and detectors are synchronized by the control system with a precision of 1 μs.

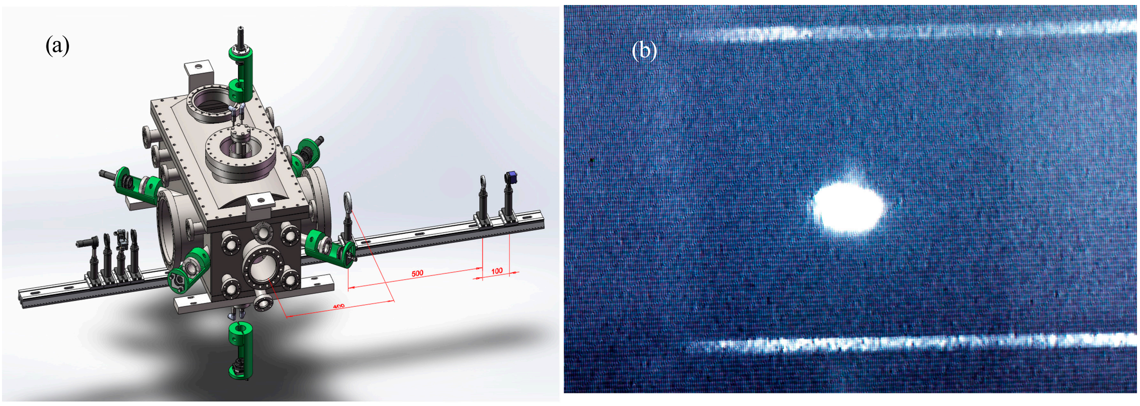


Fig. 1 (color online) (a) The vacuum chamber and laser scheme of the Magneto-Optical Trap. (b) the fluorescence image of the cold Rb atomic cloud in the MOT.

In summary, we have built the MOT system and successfully trapped $10^6$ rubidium atoms in space of 1 mm$^3$ down to a temperature of 500 μK. On the next step, another laser will be introduced to ionize the cold atoms to create ultra-cold plasma, and its properties and dynamics will be studied experimentally.

## References

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