L.1: Bose Einstein Condensation of ^{87}Rb atoms

The laser atom-cooling and Bose-Einstein Condensation (BEC) is presently an active area of research because of its richness in physics and applications in atom lithography, atomic-clocks, quantum information, space navigation systems, etc. At RRCAT, we have developed a double magneto-optical trap (MOT) (*Rev. Sci. Instrum., 82, 126108, 2011*) setup widely used for experimental observation of BEC in laser cooled atoms. We observed BEC using this setup by cooling of ^{87}Rb atoms using laser cooling and radio frequency (RF) radiation induced evaporative cooling. The basic setup consists of two magneto-optical trap (MOT) chambers maintained at different pressures connected with each other. In the first MOT (i.e. vapor chamber MOT or VC-MOT), atoms are laser cooled and trapped from Rb vapor at ~$2x10^{-8}$ Torr pressure and then transferred to second MOT (called ultrahigh vacuum MOT or UHV-MOT) at pressure of ~$6x10^{-11}$ Torr. Atoms collected in UHV-MOT are finally transferred to a magnetic trap for further cooling by RF-evaporation.

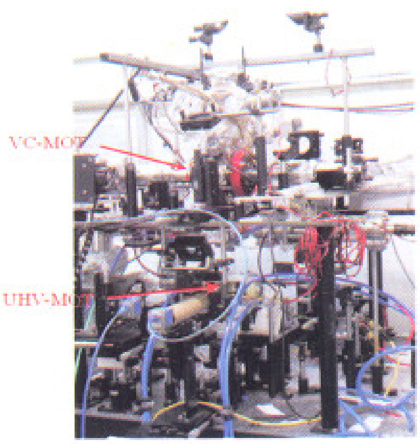

Fig. L.1.1. Photograph of double MOT experimental setup for BEC at RRCAT.

Nearly 10^8 atoms in temperature range of 300-500 μK are collected in VC-MOT while ~2 x 10^8 atoms with similar temperature range are collected in UHV-MOT in 40 s, when VC-MOT cloud is subjected to suitable push-cum-guide beam. Atoms in UHV-MOT are kept in compressed-MOT for 20 ms duration to increase density and further cooled to 50-150 μK temperature in molasses. Before trapping in magnetic trap, atom cloud is subjected to optical pumping to prepare atoms in hyperfine trapping state (F=2, m_F=2) of ^{87}Rb.

Finally, atoms are trapped in a well known quadrupole-Ioffe configuration (QUIC) trap having low spin-flip losses due to finite field at minimum potential in the trap.

At pressure of ~$6x10^{-11}$ Torr in UHV-MOT chamber, we observed life-time of atoms in QUIC trap ~14 s. The atoms in QUIC trap were further cooled by RF-evaporation process. During RF-evaporation, the frequency of RF source was logarithmically scanned from high to low value using a computer controlled synthesizer. After evaporative cooling, the atom cloud was imaged by absorption probe imaging method to measure density profile of atom cloud. As shown in Fig.L.1.2, for appropriate parameters, we observed a sharp peak in optical density profile at the centre of the cloud (bimodal distribution), which is indicative of occurrence of Bose-Einstein condensation in the cloud. Figure.L.1.3 shows its 3D-view. Further work to characterize the BEC cloud in detail is in progress.

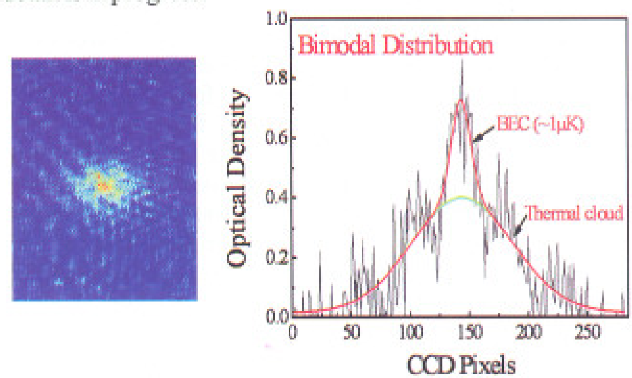

Fig.L.1.2: Absorption image and optical density profile of atom cloud after RF evaporative cooling for RF scan from 17 MHz to 3.5 MHz. The bimodal distribution shown in profile is due to occurrence of Bose condensation in the central region of atom cloud.

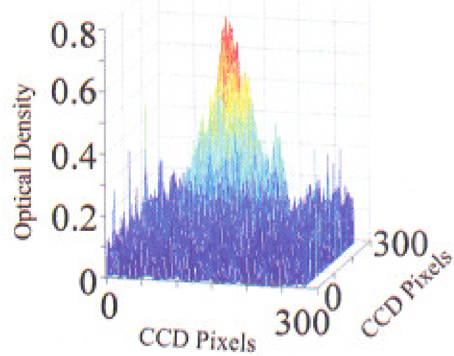

Fig.L.1.3: The 3D-plot of (optical density) absorption image shown in Fig.2. Sharp peak in the centre is signature of Bose-Einstein condensate there.

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Reported by :
S R Mishra (srm@rrcat.gov.in), S P Ram, S K Tiwari, H S Rawat.