# Transport of a Bose-Einstein condensate of rubidium with optical tweezers

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We are working on a new experiment of Bose-Einstein condensates (BEC) with Rubidium 87. Since the techniques for making BEC are mastered now, we have built a less sizeable and more stable apparatus with more optical and mechanical access. Indeed the cell, where the condensate is produced, is connected to a "science chamber" and we aim to transfer the condensate with optical tweezers (Fig. 1). This technique has already been tested by the MIT group with sodium atoms with the purpose of transferring condensates into a macroscopic wire trap [1]. By separating the place of condensate production from the place of study, we not only gain in optical and mechanical access but we can also better control the magnetic fields. In particular, the field of the magnetic trap will not cause problems.

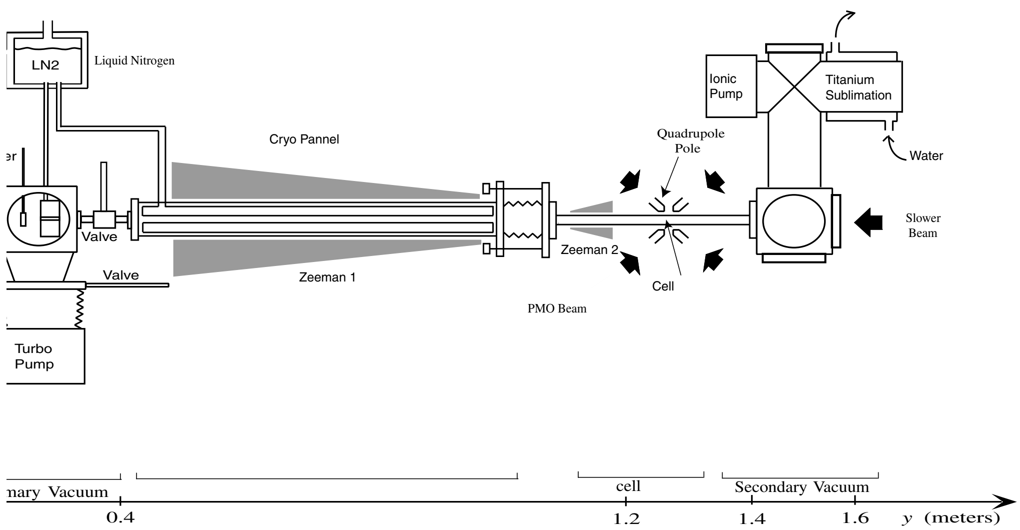


Figure 1: Experimental Setup

The trapping chamber is loaded by an atomic beam, which is slowed down from 300 m/s to 30 m/s thanks to the Zeeman slowers. At the moment, all the optics for conventional laser cooling is installed and the atom beam tested and we are now building the Magneto-Optical Trap (MOT). The magnetic field used for the MOT is produced by integrated circuits placed on both sides of the two pairs of poles which create the quadrupole field of the Ioffe-Pritchard magnetic trap. These poles are made in laminated iron silicate and are excited by coils of copper wire (Fig. 2). Using coils with ferromagnetic core allows us to reach a large magnetic field gradient with reasonable current [2].

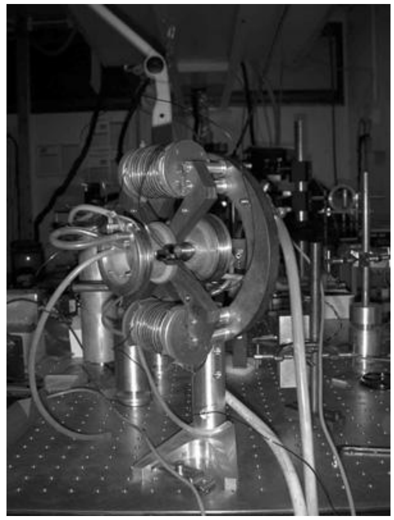

Figure 2: Electromagnet

Once the atoms are transferred from the MOT to the Ioffe-Pritchard trap where they will be compressed, two routes for condensation will be possible. Either we can do forced radio-frequency evaporative cooling in the magnetic trap and then transfer the condensate in the dipole trap of the optical tweezers or we can directly do the evaporation in the hybrid magneto-optical trap.

The optical tweezers consist in an infrared diode laser (1.08 $\mu$m) focused on the atoms. The diode intensity is amplified by an optical fiber amplifier, which guarantees a reasonable stability in power. The stability criterion is important since any heating must be avoided during the translation of the optical trap. The amplified beam passes through two acousto-optic modulators before being focused with a set of lenses. Typically, an optical power of 1 W with a beam waist of 20 $\mu$m give a 140 $\mu$K depth trap whose radial and axial sizes are 1 $\mu$m and 75 $\mu$m respectively. The associated frequencies are 1 kHz and 15 Hz respectively. The use of acousto-optic modulators allows a fine control of the intensity and position of the beam since they deflect light in both transverse directions. Finally, the displacement of the condensate outside the trapping chamber is provided by translation of the beam waist.

Complementary to the study of transport, the tweezers should be convenient for studying the condensate behavior in exotic optical trap. In that case, it deals with low amplitude displacements along the transverse directions. For instance, an effective double well potential should be interesting to perform atomic interferometry experiments [3].

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[2] B. Desruelle, V. Boyer, P. Bouyer, G. Birkl, M. Lécrivain, F. Alves, C.I. Westbrook and A. Aspect, *Euro. Phys. J. D.* **1** 2 255-258 (1997).

[3] M.R. Andrews, C.G. Townsend, HJ. Miesner, D.S. Durfee, D.M. Kurn and W. Ketterle, *Science* **275** 637 (1997).