제만 효과를 이용한 저온 원자빔

Cold Atomic Beam Extracted by Zeeman Effect

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There is a considerable interest in the generation of a cold atomic beam(1,2) having a narrow velocity spread that can be used in various experiments in physics such as ultrahigh resolution atomic and molecular spectroscopy, atom optics, atom interferometry, study of solid surfaces, and low energy collision experiments. The invention of the techniques of laser cooling has stimulated developments in the production of cold and bright atomic beams. Various techniques have been used to extract atoms from magnetio-optical traps(MOTs) loaded in a vapor cell. The moving molasses technique is also suitable for extracting cold atoms.

In the present work we load a cold atomic Rb trap directly from a vapor cell, and we extract cold atoms with the moving molasses technique by homogeneous magnetic field. The flux intensity is about 10^9 atoms/s. The mean launching velocity is very low and tunable from 1 to 2 m/s. This beam has a longitudinal temperature of 20-30 μK, which represents the lowest velocity spread

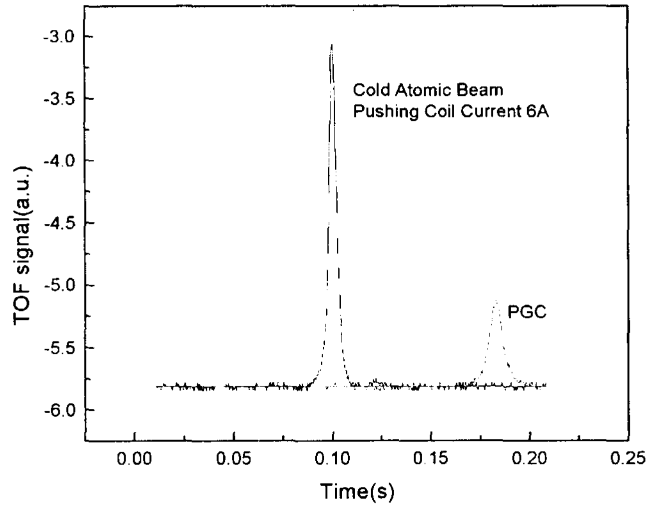

Fig. 1 Fluorescence signal measured in the detection region 16.3cm below the MOT. One is for case of the 6A pushing coil current, the other is for that of no current.

obtained so far in a cold atomic beam.

Our MOT uses three retroreflected cooling beams, two of which are in the horizontal plane at 45 degree with respect to the vertical direction The third cooling beam is parallel to the horizontal axis. The atoms are further cooled down by the polarization-gradient cooling (PGC).

Cold atoms after PGC are launched downward in a rather simple way by just varying rapidly the current of vertical directional Helmholtz coils(pushing coils), so that the frequency difference between the upgoing and the downgoing cooling laser can be obtained due to the atomic Zeeman shift. The entire process is equivalent to the moving molasses scheme, and consequently during launching the temperature of atoms is not much increased. The average velocity of the launching atoms is dependent on the magnetic field strength of pushing coils and the duration time of that field. The number of launched atoms are detected by observing the fluorescence with a photomultiplier, which is excited by a horizontally placed probe laser that is 16.3cm below the center of MOT.

Fig. 1 shows typical signals for an atomic beam with 6A pushing coils current and no current. The fluorescence is proportional to the number of atoms arriving in the detection zone at a certain arrival time, which depends on their initial velocity distribution. From this signal we can analyze the atomic beam flux, the longitudinal average velocity, the longitudinal velocity width and divergence.

In Fig. 2 we notice that the longitudinal velocities are proportional lineally to the pushing coil currents, and the longitudinal temperatures are not so much increased in these pushing coil currents. The longitudinal velocity width is around 0.03, which is the lowest for the cold atomic beam.

In conclusion, we have demonstrated experimentally a novel method to produce a cold atomic beam width a very narrow velocity spread.

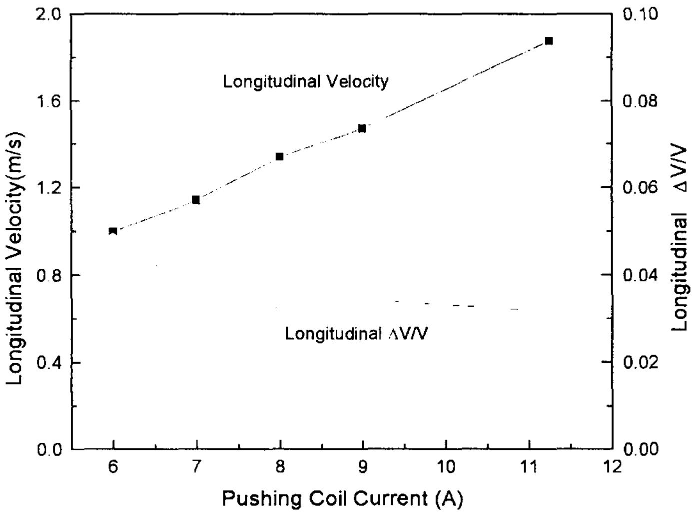

Fig. 2 Mean launching longitudinal velocity and longitudinal velocity width

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2. Y. Fukuyama, H.Kanou, V. I. Balykin, K. Shimizu, Appl. Phys. B 70, 561 (2000)