Cold alkali-metal vapor cells lined with superfluid helium

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We have recently reported a novel optical pumping environment where very slow spin relaxation of Rb atoms can be achieved: glass cells held at about 2 K, containing ^{4}He buffer gas in saturated equilibrium with ^{4}He films coating the walls [1]. The cell was filled with typically 4 atm of ^{4}He gas at room temperature and a small amount of Rb metal. Atomic Rb vapors were produced effectively at liquid helium temperatures by irradiating the transparent cell walls with a cw laser beam. The lifetimes of the atomic Rb were on the order of 10 s and seemed to be limited by loss on the walls. We performed optical pumping of the Rb atoms and measured an extremely long longitudinal electronic spin relaxation time ($\sim$ 60 s) in this cryogenic environment. This slow spin relaxation would open the door to high precision spin physics studies such as a search for an electric-dipole moment.

The key technique we developed to achieve the cryogenic vapor cells is a laser-induced desorption (LID) method with the assistance of superfluid helium films. This simple but effective technique seems to contain interesting physics and its physical mechanism is currently under investigation. We summarize the properties of the LID method: (1) The cell can be easily loaded with 10^9 Rb atoms. (2) The production efficiency peaks at about a wavelength of 700 nm of a production laser beam and has weak wavelength dependence (a few hundreds nanometers width). (3) The production efficiency decreases with the repetition of the production beam irradiation. It can be recovered by increasing the cell temperature over about 200 K and then cooling again. (4) *The LID method is only effective at temperatures where the helium gas in the cell liquifies and forms a superfluid film.* (5) Rb atomic vapors cannot be produced by irradiating the surface of the bulk Rb metal with a cw laser beam. (6) The LID method seemed to work for potassium. However we have not succeeded yet in producing cesium atoms.

Figure 1 shows the production of Rb atoms by the LID method with a cw laser beam (665 nm, 200 mW) at 1.85 K. The fluorecence emitted by the Rb atoms excited by a probe laser beam (780 nm, 2 mW) is imaged with a intensified CCD camera (0.1 s exposure time). An atomic Rb vapor begins to be desorbed from the walls irradiated by the production beam. Then it is loaded into the cell volume with unique flows. We consider that the sources of atomic Rb vapors are Rb clusters adsorbed on the cell walls.

[1] A. Hatakeyama, K. Oe, K. Ota, S. Hara, J. Arai, T. Yabuzaki, and A. R. Young, *Phys. Rev. Lett.* **84**, 1407 (2000).

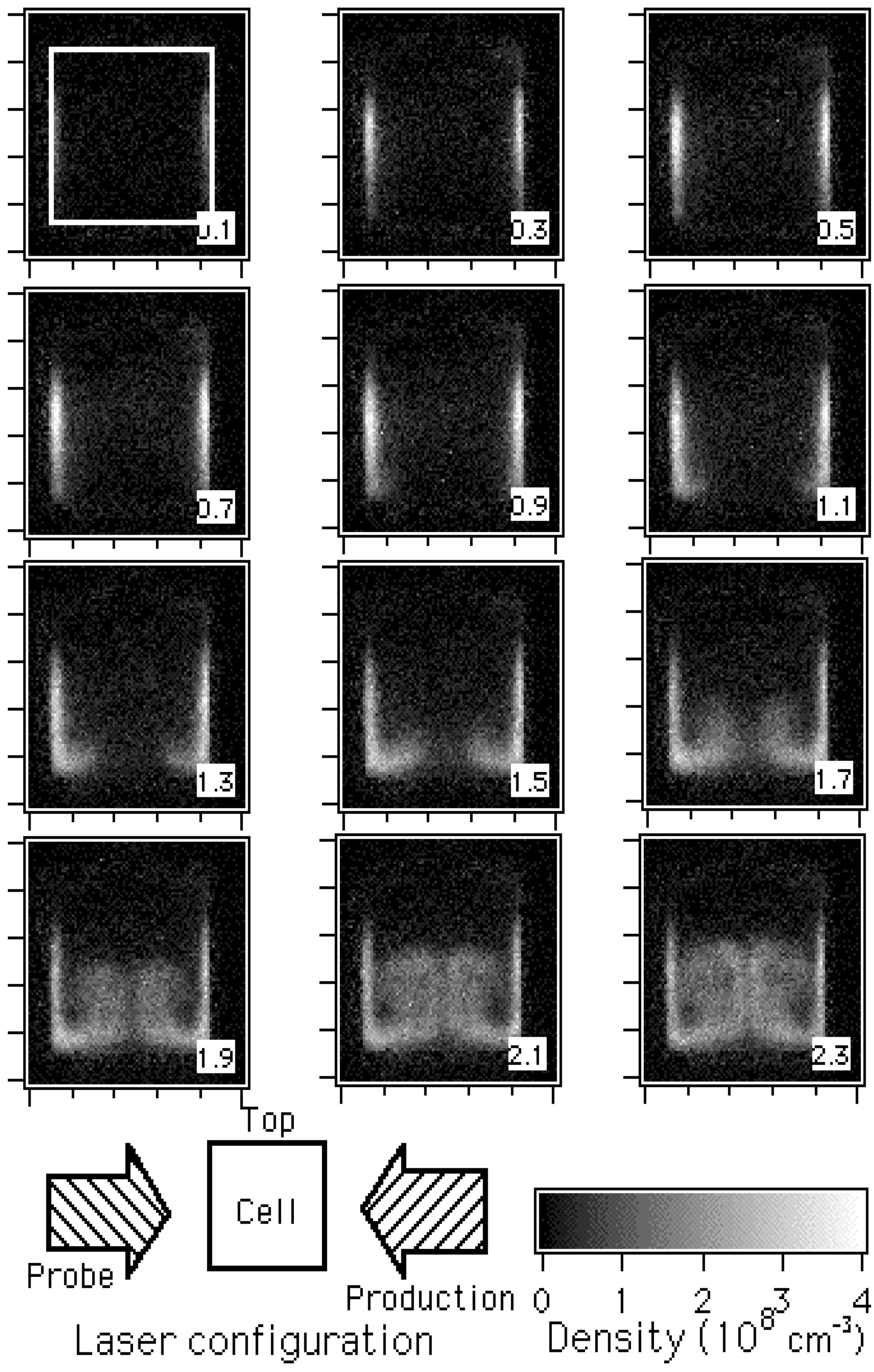

Figure 1: Fluorecence images of Rb atoms produced by a cw laser beam turned on at 0 s. The shape of the cubic cell (2 cm edges) is depicted in the first image. The numbers at the right-bottom corner in the images mean times in second after the production beam is turned on.