State selection in ^{87}Rb beam by laser optical pumping

A.I. Magunov[1,2], V.G. Palchikov[2]

[1]A.M. Prokhorov General Physics Institute of Russian Academy of Sciences, Moscow, Russia
[2]State Scientific Center "National Research Institute for Physical-Technical and Radiotechnical Measurements (VNIIFTRI)", Mendeleevo, Moscow Region, Russia

Email: magunov@fpl.gpi.ru, vitpal@mail.ru

With modern advances of the laser technique applied to rubidium atom in frequency standards[1], new opportunities for increasing the efficiency of optical pumping for rubidium beams appear[2].

In this paper the optical pumping efficiency of the lower sublevel ($5^2S_{1/2}$ F_g =1 M=0) for the "clock" transition $F_g = 1$ M=0 ↔ F_f =2 M =0 in rubidium standards is analyzed in detail.

The criteria for most efficient pumping schemes are as follows:

- Maximum population of the Zeeman sublevel ($F_g = 1$ $M = 0$);
- Optimization of possible optical transition schemes for the pumping.

According to our approach[3] we considered the sequence of laser-induced transitions between different hyperfine levels of the D_2 line of ^{87}Rb atoms.

Our results in the following:

1. The optical pumping of the $F_g = 1$ M=0 level can be performed using simultaneous transitions $F_g = 1$ ↔ F_e =1 and $F_f = 2$ ↔ F_e =2 with the pumping efficiency about 6;
2. With the preliminary pumping using the transition $F_f = 2$ ↔ F_e =1 the pumping efficiency for the $F_g = 1$ $M = 0$ level increases up to 8.2.
3. The last value of the pumping efficiency can be increased further by additional transitions.

Finally, such an increase of the lower level population should results in a significant increase of the signal-to-noise ratio in rubidium frequency standards.

---

[1] Yu. Ovchinnikov, G. Marra, "Accurate rubidium atomic fountain frequency standard", Metrologia, vol. 48, p. 87-100, 2011.

[2] P.D. Kunz, T.P. Heavner, S.R. Jefferts, "Progress on a portable rubidium fountain frequency standard", Proc. of 41st Annual Precise Time and Time Interval (PTTI) Meeting, November 16-19,2009, Santa Ana Pueblo, New Mexico (USA), p.531-536.

[3] A.I. Magunov, V.G. Palchikov, "Laser selective pumping of magnetic hyperfine sublevels in cesium atom", JETP, vol. 118, n. 4, 2014.