Zeeman and Paschen-Back spectra of rubidium *5S-5D* two-photon excitation

Ryohei Itoyama*, Yuta Komiyama*, Taro Mashimo*, Kousuke Shibata*, Satoshi Tojo*[1]

* Department of physics, Chuo University, 1-13-27 Kasuga, Bunkyo, 112-8551, Tokyo, Japan

Synopsis We have studied two-photon spectroscopy of rubidium atoms in a weak magnetic field. We have observed frequency shift and line broadenings. We have observed the Zeeman and Pashen-Back effects at even weak magnetic field less than 50 G which causes changes in two-photon excitation spectra of ultracold Rb atoms in an optical trap in the condition of Paschen-Back regime for precise measurements.

Two-photon transition spectroscopy is one of powerful tools for observation of non-linear phenomena, which is applied for localized spaces with Doppler free measurement [1]. Recently, non-linear phenomena including collision broadenings observed in Rb two-photon spectra in high density of atoms [2].

We study two-photon spectroscopy of gaseous Rb atoms in a weak magnetic field. The atoms are excited from the $5S_{1/2}$ ground state to the $5D_{5/2}$ excited state via $5P_{3/2}$ state. We observe the fluorescence at 420 nm of 6*P*-5*S* transition from the 5*D*-6*P* cascade decay as shown in Figure.1 (a). In order to observe intensity dependence, the laser intensity is controlled in the line range from 50 to 300 mW. We confirm that the signal intensity of the two-photon transition spectra are proportional to the square of the excitation laser intensity. Zeeman splitting can resolve a degeneracy of magnetic sublevels in both ground and excited hyperfine state. [3] We observe two-photon spectra with magnetic field in the range from 0 to 42 G. Figure 1 (b) shows two-photon transition spectra in a homogeneous magnetic field of 9 G and exciting laser intensity of 200 mW at the temperature of 353 K.

We have observed line broadening and frequency shift. The line broadenings and the shift can be quantitatively explained by ac Stark shift due to laser profiles in a focus region and different coupling strength of magnetic sublevels repectively. Especially, we have observed quadratic Zeeman shifts around 10 G and confirmed changes in transition strengths of some magnetic sublevels caused by the Paschen-Back effect which is a translation of a good quantum number from m_F to m_I and m_J basis by the applied magnetic field strength. [4] We confirm quantatively the changes in transition strengths even in a weak magnetic field due to *D* states.

Additionally, we will report on two-photon excitation spectra of ultracold Rb atoms in an optical trap for precise measurement at a range of several μK.

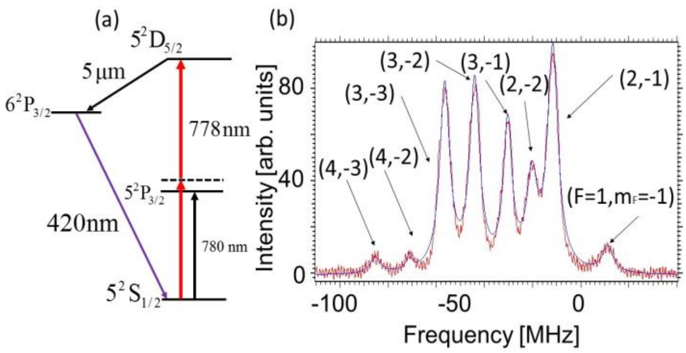

Figure 1. (a) Energy level diagram for ^{87}Rb in $5S_{1/2}$ (F=1) - $5D_{5/2}$ excitation and emission. (b) Zeeman spectra of $5S_{1/2}$ (F=1) - $5D_{5/2}$ (F'=1, 2, 3) transition with magnetic sublevels resolved at 9 G.

References

[1] A. J. Olson, E. J. Carlson and S. K. Mayer, 2006 *Am. J. Phys*. **74**, 218-223
[2]F. Nez, F. Biraben, R. Felder, and Y. Millerioux, 1993 *Opt. Comm*. **102**, 432-438
[3]L. Windholz and M. Musso, 1988 *Z. Phys. D* **8**, 239-249.
[4]F. Biraben, B. Cagnac, and G. Grynberg, 1974 *Phys. Lett. A.* **48**, 469

[1]E-mail: tojo@phys.chuo-u.ac.jp