도플러 확장된 루비듐 원자에 대한 투과 스펙트럼 측정

Measurement of transmission spectra for the Doppler-broadened rubidium atoms

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The linear absorption of a laser beam in a Doppler-broadened atomic vapor cell is one of the simplest problems in atomic physics. Although an accurate analytic calculation of the linear absorption has been obtained for a two-level atom, there are few detailed reports of the linear absorption of multilevel atoms, such as the effect of optical pumping playing an important role in determining the absorption coefficients. Recently, two independent studies on the effect of optical pumping on the linear absorption spectrum for Dopper-broadened vapor cells have been reported(1,2). However, a detailed theoretical comparison with experimental data has not been reported.

In this presentation, we present a theoretical and experimental study on linear absorption for the Doppler broadened rubidium vapor cell. The absorption coefficient of a σ^+ (or π) polarized laser beam was calculated as a function of the laser frequency for the various laser intensities. The calculated results were compared with experimental results.

Figure 1 shows the calculated absorption coefficients as functions of the laser detuning and intensity. Figures 1(a) and 1(b) [1(c) and 1(d)] show the calculated absorption coefficients of the π and σ^+ polarized laser beam for the transition from the lower [upper] ground state of the ^{87}Rb atoms, respectively. The temperature was set to 20 ℃. Figures 1(a) and 1(b) show that the absorption coefficients decreased monotonically with increasing intensity. In contrast, the absorption coefficient of the π polarized beam for the transition from the upper ground state (Fig. 1(c)) decreased much more slowly compared with the results shown in Figs. 1(a) and 1(b). However, the absorption coefficient of σ^+ polarized laser beam (Fig. 1(d)) increased and decreases gradually with increasing intensity.

Figure 2(a) and 2(b) show the behavior of the peak values of the absorption coefficient for ^{87}Rb and ^{85}Rb atoms, respectively. The absorption coefficients for the transition from the lower ground state decreased gradually regardless of the laser polarization, as shown in the lower panel of Fig. 2(a). This is because the atoms in the lower ground state ($F_g = 1$) were optically pumped to the upper ground state ($F_g = 2$), resulting in an decrease in absorption. This mechanism can explain the very slow decrease in the absorption coefficient for the π

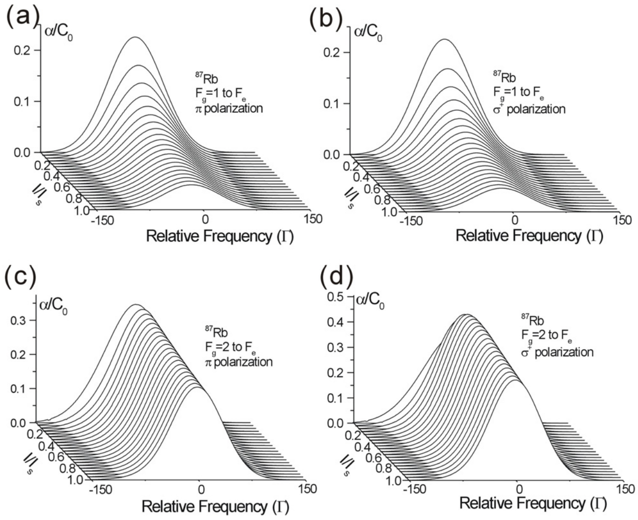

Fig. 1: Typical absorption spectra

polarized laser beam for the transition from the upper ground state. The very slow decrease was attributed to the rare occurrence of optical pumping to the $F_g=1$ ground state compared with that from the $F_g=1$ to $F_g=2$ ground state due to the large transition strength of the cycling transition, $F_g=2 \rightarrow F_e=3$. In the case of σ^+polarization (transition from the upper ground state), the absorption coefficient increased until $I/I_s \simeq 1/5$ and decreased gradually with increasing laser intensity.

The experimental results and comparison with calculated results will be discussed in the presentation.

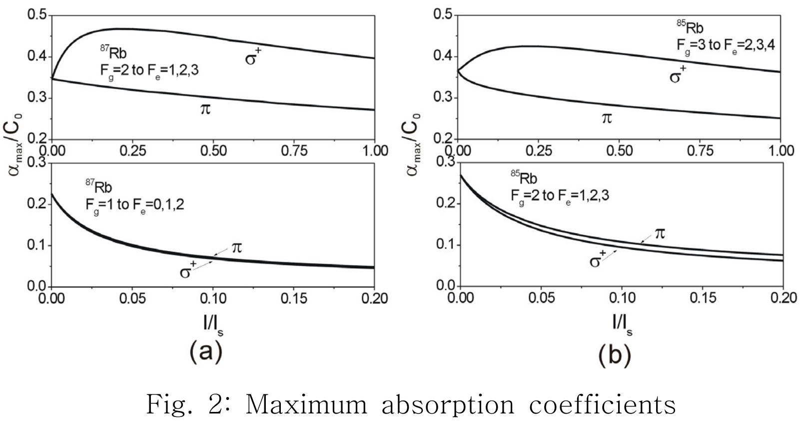

Fig. 2: Maximum absorption coefficients

References
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