Absorption Spectroscopy of ^{85}Rb Atoms at 420 nm: Pressure Broadening with N_2 Buffer Gas and Saturation Intensity

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Absorption spectroscopy of Rb atoms in the traditional near-infrared D_1 (795 nm wavelength) and D_2 (780 nm) transitions is mature. In contrast, the blue wavelength Rb transitions are not well explored. Here, we present absorption spectroscopy measurements of ^{85}Rb in the $5^2S_{1/2}$-$6^2P_{3/2}$ (420 nm) transition with data on pressure broadening due to N_2 buffer gas and absorption saturation due to high optical intensity. To the best of our knowledge, there is no literature on the effects of N_2 in this atomic transition.

A custom built blue-violet external cavity diode laser was used to perform absorption spectroscopy measurements on ^{85}Rb vapor in the $5^2S_{1/2}$-$6^2P_{3/2}$ transition at 420.18 nm. These vapor cells are antireflection coated and contain N_2 buffer gas at various pressures, ranging from no buffer gas to 200 torr. Figure 1(a) is an example ^{85}Rb absorption spectra, here in 6 torr of N_2 buffer gas at 100 °C. The absorption oscillator strength in this transition line is smaller than that of D lines by an order of magnitude. Absorption spectra are analyzed accounting for all six hyperfine transitions between ground and excited state (F_g=2→F_e=1,2,3; F_g=3→F_e=2,3,4) using Voigt profiles. The pressure broadening coefficient is then extracted, as shown in Fig. 2(b), and found to be approximately 20 MHz/torr. This is smaller than the coefficients of He (45-50 MHz/torr) and Ar (25-30) buffer gas for the same transition line that were previously reported,[1] and it fits the trend of N_2 coefficient being smaller than He and Ar in D lines.[2]

Saturation of absorption cross section due to high optical intensity is measured using a cell without buffer gas and at 100 °C as shown in Fig. 1(c). Using a 3 energy level system model, the saturation intensity is found to be 150 mW/cm^2, which is set by the relaxation time due to collision with the cell walls (30 μs) but not by the excited state ($6^2P_{3/2}$) lifetime (on the order of 100 ns).

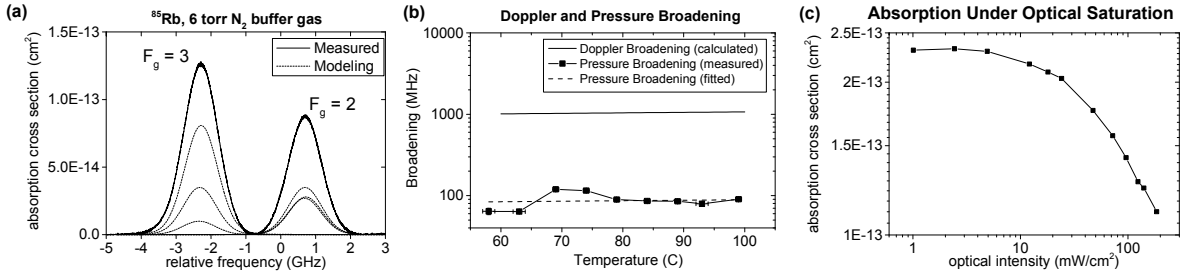

Fig. 1. (a) Absorption spectra of ^{85}Rb in 6 torr of N_2 buffer gas and at 100 °C in the $5^2S_{1/2}$-$6^2P_{3/2}$ transition (420 nm). The dashed curves represent the individual hyperfine transitions. (b) Doppler and pressure broadening in 6 torr of N_2 buffer gas as a function of temperature. (c) Peak absorption cross section of ^{85}Rb, without buffer gas and at 100 °C, as a function of optical intensity.

[1] D. Aumiler, T. Ban, and G. Pichler, "High-resolution measurements of the pressure broadening and shift of the rubidium $5^2S_{1/2}$–$6^2P_{3/2}$ line by argon and helium", Physical Review A, vol. 70, no. 3, p. 032723, 2004.

[2] M. D. Rotondaro and G. P. Perram, "Collisional broadening and shift of the rubidium D_1 and D_2 lines ($5^2S_{1/2}$→$5^2P_{1/2}$, $5^2P_{3/2}$) by rare gases, H_2, D_2, N_2, CH_4, and CF_4", J. Quant. Spectrosc. Radiat. Transfer, vol. 57, no. 4, pp. 497–507, 1997.