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Stark beats of Ar 11d[3/2]$_1$ Rydberg state

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Introduction

The Ar 11d[3/2]$_1$ state is known to be strongly perturbed by the 7d'[3/2]$_1$ state. Therefore, the irregularity of the electric field dependence of the Stark effect is expected.

In this study, Stark splittings between magnetic sublevels of Ar 11d[3/2]$_1$ Rydberg state were measured by applying Stark quantum beat (SQB) spectroscopy. This method is a very useful technique for investigation of slight Stark splitting between magnetic sublevels. The SQB is caused by quantum interference effects in coherently prepared magnetic sublevels of an excited state, and appears in fluorescence time spectrum. The SQB of rare gases has been measured previously[1,2].

Experiment

The SQB measurement was performed by using PF ring single bunch operation. We used Stark plates which could rotate around the light axis and applied a static electric field to the interaction region. SQB spectra were obtained with linearly polarized radiation angled approximately +45˚ to the direction of an electric field at several different field strengths. This situation makes it possible to excite to the M=0 and $|M|$ =1 superposition state. From the limitations of the radiative life time and repetition time of the excitation light pulse, energy splitting which could be measured in this study was more than 3 x10^{-4}cm^{-1} (~10MHz) .

Results

Figure 1 represents the fluorescence decay curves of the Ar 11d[3/2]$_1$ Rydberg state. The energy splitting of these magnetic sublevels could be evaluated from the beat frequency which depends on electric field strength. Four identified beat frequencies, which were obtained by Fourier transform of SQB spectra are shown in figure 2 with respect to electric field strength. If only the SQB of the 11d[3/2]$_1$ Rydberg state is considered, a single beat frequency series which corresponds to splitting between the M=0 and the $|M|$ =1 sublevels must be identified, since only fluorescence emitted from Rydberg states of total angular momentum J=1 were observed and Ar atom has no hyperfine structure. Therefore, it is supposed that such multiple beat frequency series result from state mixing which is caused by Stark effect between 11d state and other states, for example 11f state. In order to explain the present results, precise theoretical calculations of the Stark structure are required.

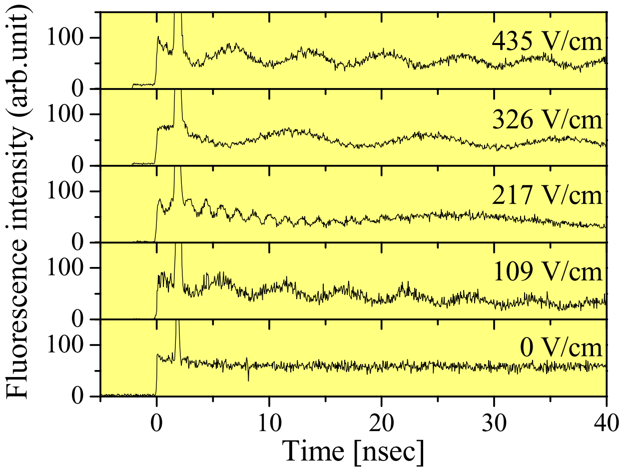

Figure 1. SQB spectra of the 11d[3/2]$_1$ Rydberg state.

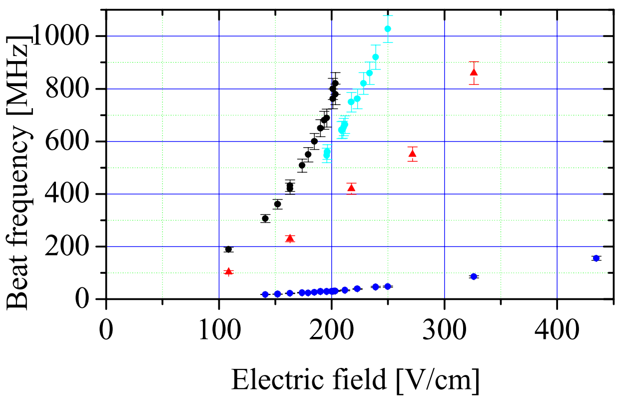

Figure 2. Electric field dependence of the beat frequency.

References

[1] Y. Morioka, T. Aoto, and H. Yoshii, Phys. Rev. A **64**. 053409 (2001)

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