THE INFLUENCE OF COHERENT EFFECTS ON ANGULAR MOMENTUM DISTRIBUTION DEPENDENCE ON MAGNETIC FIELD IN ^{85}Rb: MAGNETOOPTICAL SIGNALS WITHOUT THE DOPPLER EFFECT

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In the present work we show results from a theoretical investigation of angular momentum alignment-to-orientation conversion (AOC) by observing laser-induced fluorescence (LIF) signals of rubidium atoms at D1 excitation. The AOC is created by combined action of linearly polarized exciting laser radiation and an external magnetic field. This can be detected by observing circularly polarized light as circularity is direct evidence of angular momentum orientation. Due to the nonlinear dependencies of the energies of ground-state and excited-state magnetic sublevels, the angular momentum alignment, created by linearly polarized light, can be partially converted to orientation. The excitation and observation geometry for creating and observing AOC stands as follows: the magnetic field **B** defines the quantization axis and the exciting linearly polarized laser radiation **E** forms an angle of π/4 with respect to the magnetic field **B**, observation direction is in the direction perpendicular to both **E** and **B**.

The theoretical model is based on the optical Bloch equations and uses the density matrix formalism. The theoretical model takes into account all transitions, the mixing of magnetic sublevels in an external magnetic field, the coherence properties of the exciting laser radiation, and also includes averaging over the Doppler profile [1]. In the present work, however, the averaging over the Doppler profile is omitted in order to observe individual magnetic sublevel transitions, thus enabling us to understand the origins of features observed in the modelled LIF signals. We used the theoretical model to calculate two opposite circularly polarized light components (σ^+ and σ^-) and their difference. In order to explain the various effects contributing to the line shapes of these signals we manipulate our theoretical model in the following manner:

i – we switch on and off the coherent effects by setting the non-diagonal density matrix elements to zero. We do this by increasing the relaxation rate $\gamma_{\text{non-diagonal}}$ of only these elements with the ratio of $\gamma_{\text{non-diagonal}}/\gamma_{\text{diagonal}} = 10^9$ with respect to the γ_{diagonal} which is the normal transit relaxation rate experienced by diagonal elements. This allows us to observe the influence of transfer of coherences from the ground state to the excited state.

ii – we can extract additional information from the density matrix by performing the state multipole expansion. Explicitly the ρ^1_1 state multipoles – which directly indicate the orientation of the angular momentum in the transverse plane.

iii – the non-diagonal elements are attributed to the coherences between magnetic sublevels. The Δm=1 coherences are the matrix elements with indexes m, m+1 e.g. ρ_{12}. By observing the dependencies of these elements with respect to the magnetic field, we can deduce which magnetic sublevels contribute to the orientation of the angular momentum at specific magnetic field values.

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[1] M. Auzinsh et al., Nonlinear magneto-optical resonances at D1 excitation of 85Rb and 87Rb for partially resolved hyperfine F levels, Phys. Rev. A 79, 053404 (2009).