Dipole-Dipole Interaction Strength and Dipole Blockade Radius using Förster Resonances in Rb Atoms

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Dipole blockade [1] is a phenomenon, where due to dipole-dipole interaction between Rydberg atoms the simultaneous excitation of two/multiple Rydberg atoms in a "blockade sphere" [2] is suppressed. Our aim is to find the best experimental parameters necessary to achieve dipole blockade radius of $R_b \approx 50\mu m$, which will be later measured experimentally. We are especially interested in the resonant $1/R^3$ type interaction, which happens in the presence of Förster resonances [3].
With our purpose in mind, we calculate the magnitude of C_6 coefficients for specific Förster transitions in ^{87}Rb of the form $n_a d_{3/2,5/2} + n_b d_{3/2,5/2} \to n_\alpha l_\alpha j_\alpha + n_\beta l_\beta j_\beta$, where the two atoms are initially in the $d_{3/2,5/2}$ states, while the l and j numbers of the final states can take different values. The principal quantum numbers n_a and n_b of the initial states can differ by $\pm1, \pm2, \pm3$, etc., while those of the final states can be the same or different. A large C_6 coefficient is associated with a minimum in the absolute value of the Förster defect δ_k, which we plot as a function of the principle quantum number n_a for the transitions descibed above. We found that in all cases under study, the "δ_k vs n_a" curves show diverging behavior and no minimum of the absolute value of δ_k is observed. However, an interesting case occurs when the initial principal quantum numbers of the two

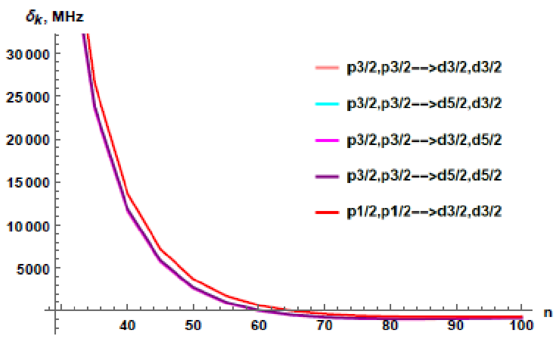

FIG. 1: Förster defect vs principal quantum number where $n_b = n_a + 20$ and $n_\beta = n_\alpha + 19$.

atoms differ by a significant amount e.g. $60p + 80p \to 59d + 78d$ [4]. We extended the study of Förster defect vs principal quantum number for transitions $n_a p_{1/2,3/2} + n_b p_{1/2,3/2} \to n_\alpha l_\alpha j_\alpha + n_\beta l_\beta j_\beta$, shown in FIG. 1. For transition $np_{1/2} + (n+20)p_{1/2} \to (n-1)d_{3/2} + (n+18)d_{3/2}$ the minimum of $\delta_k = 3.47MHz$ is at $n_a = 65$, corresponding to $C_6 = -219000GHz\mu m^6$, and giving a blockade radius of $R_b = 18.21\mu m$. Similar transitions within the d states manifold for principle quantum number $n_a = 75$ lead to $R_b = 18.9\mu m$.
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