Two-photon assisted collisions in gases of ultracold polar molecules.

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Besides electric field [1] or microwave [2, 3] shielding, optical shielding for ultracold molecules has been proposed by using a photon detuned to the blue of an electronic molecular transition [4], aiming to create a repulsive long-range potential curve for the molecular pair suitable for preventing unwanted losses from the molecular trap due to the so-called sticky collisions. While appealing due to its simplicity, this scheme faces the challenge of photon scattering, as molecules exposed to an off-resonant laser continuously scatter photons, leading to unwanted heating in ultracold gases. To address this issue, a two-photon scheme was proposed [5], where individual molecules are exposed to two lasers tuned to a two-photon Raman resonance, thus protecting them from unwanted photon scattering.

We will present a quantitative analysis of the two-photon optical shielding scheme [6]. We begin by exploring the two-photon transition within the framework of a collisional process, using time-independent scattering theory. This approach allows us to calculate the elastic β^{el}, inelastic β^{inel} and loss β^{loss} collision rates as a function of the Rabi frequency of each of the lasers (Ω_1, Ω_2) and the detuning Δ.

This scheme involves both the ground and the excited electronic states of the molecules. However, by applying the multi-level adiabatic elimination, we built an effective system with an effective coupling between the rotational states of the ground electronic state as the electronic excited state is eliminated. To validate the adiabatic elimination, we examine its effects on energy and collision rates, identifying the regime of validity as $\Delta >> \Omega_1, \Omega_2$.

We will analyze the calculated collision rates and present the effect of the parameters on the process, concluding with an evaluation of the efficiency of the shielding process for the parameter space explored.

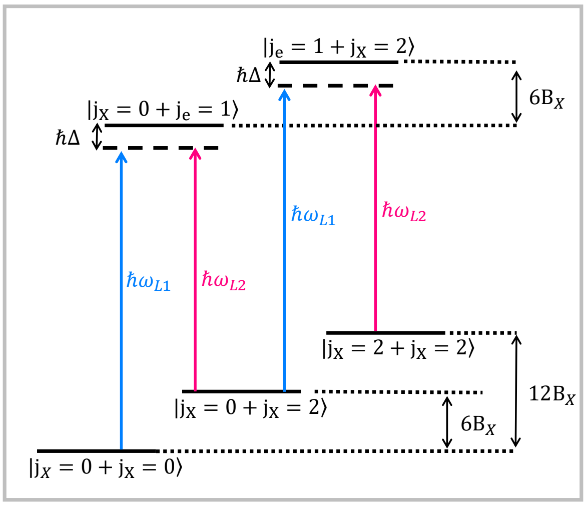

Figure 1: Two-photon coupling scheme showing the consecutive excitation of each molecule, with the other acting as a spectator in the asymptotic limit.

References

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