

Shielding ultracold molecules against losses in collisions

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Ultracold dipolar molecules are excellent candidates for engineering quantum applications and cold, controlled chemistry [1]. Therefore a lot of effort is devoted nowadays to produce ground state ultracold molecules in high densities as well as to understand their properties [2]. One of a main goal is to create a quantum degenerate gas of dipolar molecules such as a Bose-Einstein condensate or a degenerate Fermi gas. This is for now a major missing step for ultracold molecules.

Unfortunately, when the molecules start to collide, whether they are chemically reactive or not, a lot of molecules are lost in the process. Hoping for a long-lived quantum degenerate gas is then compromised unless to shield the molecules from collisional losses. This can be achieved by using a static electric field [3] but also by using microwaves [4,5,6]. By applying a circularly polarized and slightly blue-detuned microwave field with respect to the first excited rotational state of a dipolar molecule, one can [6]:

(i) bring the ratio good to bad collisions $\gamma = \beta^{\text{el}}/\beta^{\text{qu}}$ (elastic over quenching rate coefficient) to high values such that evaporative cooling techniques can be successful,

(ii) suppress the imaginary part of the scattering length and shield the molecules against losses,

(iii) tune the real part of the scattering length to small or large values, positive or negative and control the interaction strength of an ultracold molecular gas.

This theoretical proposal might be a requirement for successful evaporative cooling of molecules and for reaching quantum degeneracy. The ability to control the molecular scattering length is also important for many-body physics applications, as it is already for ultracold atoms.

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References

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