Optical fields to control ultracold atomic/molecular collisions

A. Orbán*, O. Dulieu*, and N. Bouloufa-Maafa*[1]

* Laboratoire Aimé Cotton, CNRS, Univ. Paris-Sud, ENS Paris-Saclay, Univ. Paris-Saclay, 91400 Orsay, France,

Synopsis Ways to suppress inelastic or reactive processes between ultracold particles using electromagnetic fields are investigated.

Research focusing on the formation of ultracold atomic and molecular quantum gases is a continuously expanding field due to its envisioned applications such as quantum-controlled chemistry or quantum simulation.

The aim of our theoretical work is to find ways to suppress inelastic or reactive processes between colliding particles in ultracold quantum gases. Using a laser field detuned to the blue of a relevant transition, we propose to couple the initial colliding particle state to a repulsive excited one, thus preventing the particles to come close to each other [1].

We intend to apply this "blueshielding" technique for ultracold quantum gases, close to quantum degeneracy. In this case, due to the extremely small collisional energies (10-100 nK) it is possible to address a single repulsive channel with the laser field, thus ensuring a full control of the suppression efficiency.

The selection of a well-defined molecular state requires the knowledge of the molecular structure down to the hyperfine scale in particular for the electronically excited molecular states. We have developed an asymptotic model [2] relying on an asymptotic description of the molecular hyperfine structure, extended to the short range.

We will present our results in case of the $^{39}K^{133}Cs$ molecule for the first and second excited dissociation limits. We have also performed a full treatment of molecular rotation for these asymptotes. We will compare the possibilities of blue-shielding of ^{39}K and ^{133}Cs collision (heteronuclear molecular case) to the case of Na + Na collision (homonuclear molecular case) [3]. As a first step we consider rotational molecular states for shielding.

Prospects for the generalization to the shielding of molecule-molecule collisions will also be addressed.

References

[1] S. Bali, D. Hoffmann, T. Walker 1994 *Europhys. Lett.* **27**, 273

[2] A. Orbán. R. Vexiau, O. Kriegelsteiner, H.-C. Nägerl, O. Dulieu, A. Crubellier, N. Bouloufa-Maafa 2015 *Phys. Rev. A* **92**, 265

[3] K.-A. Suominen 1996 *J. Phys. B: At. Mol. Opt. Phys*. 29, 5981

E-mail: Nadia.Bouloufa@u-psud.fr