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Collisions of Ultracold moleecules prepared in a quantum state superposition

The advent of ground-state controlled ultracold dipolar molecules in dense gases has opened many exciting perspectives for the field of ultracold matter. When the molecules are dipolar, their extremely controllable properties have inspired many theoretical proposals for promising quantum applications, such as quantum simulation/information processes, quantum-controlled chemistry and test of fundamental laws.

Ultracold molecules can be used to probe chemical reactions with an unprecedented control at the quantum level. This was done recently with the chemical reaction $KRb + KRb \longrightarrow K_2 + Rb_2$ at ultracold temperatures. All the fragments of an ultracold chemical reaction, from reactants to products, including intermediate complexes, can now be observed [1]. The state-to-state rotational distribution of the products can be measured [2] and the rotational parities of the molecular products can be controlled with a magnetic field [3, 4].

We explore here the study of ultracold chemical reactions of KRb molecules prepared in a quantum superposition of states using microwaves. We aim at computing the corresponding observables such as the two-body cross sections or rate coefficients, typically for the elastic, inelastic and reactive processes. We will explore the behavior of those observables, for different preparations monitored by the detuning and Rabi frequency of the two microwaves.

[1] M.-G. Hu et al., "Direct observation of bimolecular reactions of ultracold KRb molecules", Science 366, 1111 (2019)
[2] Y. Liu et al., "Precision test of statistical dynamics with state-to-state ultracold chemistry", Nature 593, 379 (2021)
[3] M.-G. Hu et al., "Nuclear spin conservation enables state-to-state control of ultracold molecular reactions" , Nat. Chem. 13, 435 (2021)
[4] G. Quéméner et al., "Model for nuclear spin product-state distributions of ultracold chemical reactions in magnetic fields", Phys. Rev. A 104, 052817 (2021)

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