Dipolar Collisions of Ultracold Ground-state Bosonic Molecules

Dajun Wang

Department of Physics, The Chinese University of Hong Kong, Hong Kong SAR, China

Dipolar collisions between ultracold polar molecules is an important topic both by its own right from the fundamental point of view and for the successful exploration of many-body physics with strong and long-range dipolar interactions. However, due to the difficulty in making ultracold sample of ground-state polar molecules, experimental data in this topic is largely absent. Here we report the investigation on dipolar collisions between ultracold ground-state sodium-rubidium molecules.

In the first part, we induce the electric dipole-dipole interaction between ^{23}Na^{87}Rb molecules by external electric fields. With induced electric dipole moments as large as 0.7 D, we observed, as shown in fig. 1, a step-wise enhancement of losses as manifestations of couplings between different partial waves induced by the increasingly stronger anisotropic dipolar interactions [1] . For measurements with samples of several different temperatures, we find good agreements with the model based on four-body complex formation following the encounter of two molecules [2].

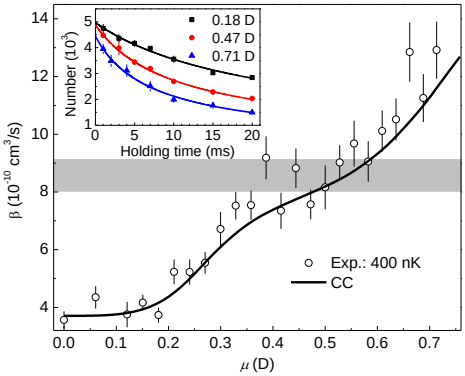

Figure 1: Loss rate constant β of ground-state ultracold ^{23}Na^{87}Rb molecules versus the induced dipole moment μ. The inset shows several example number loss measurements at different μ.

In the second part, we investigate resonant dipole collisions between different rotational states of ultracold bosonic ^{23}Na^{87}Rb molecules. In a mixture of two rotational states with opposite parities, dipolar interaction naturally arises without the need for external electric fields. The strength of this resonant dipole interaction can be tuned by preparing molecules in different rotational Zeeman states with microwave spectroscopy. In our experiment, the effect of the resonant dipole interaction and its state dependence are revealed by measuring the loss rate constants of different mixtures.

Our results shed new light on the understanding of complex molecular collisions in the presence of strong dipolar interactions and also demonstrate the versatility of controlling molecular interactions with electric fields.

[1] Mingyang Guo, Xin Ye, Junyu He, Maykel L. Gonzalez-Martnez, Romain Vexiau, Goulven Quemener, Dajun Wang, 2018 *Phys. Rev. X* **8** 041044

[2] Xin Ye, Mingyang Guo, Maykel L. Gonzalez-Martnez, Goulven Quemener, Dajun Wang, 2018 *Sci. Adv.* **4** eaaq0083