Optical production of polyatomic complex in ultracold regime

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We explore the feasibility of using simple ultracold molecules as building block for larger polyatomic species. We focus on ultracold molecules that can be oriented in space by external fields (static electric or optical fields), and in particular those with small permanent electric dipoles and large quadrupole moments. We have shown in previous studies [1,2] that some heteronuclear bi-alkali diatomic molecules that have been cooled to ultracold temperatures have those properties. The interaction between such aligned molecules can be described by an anisotropic long-range expansion; the interplay between the different power-law contributions can lead to long-range wells that could sustain bound molecular complexes. De-excitation of approaching molecules could populate those complexes, allowing to study regimes often linked to roaming reactions.

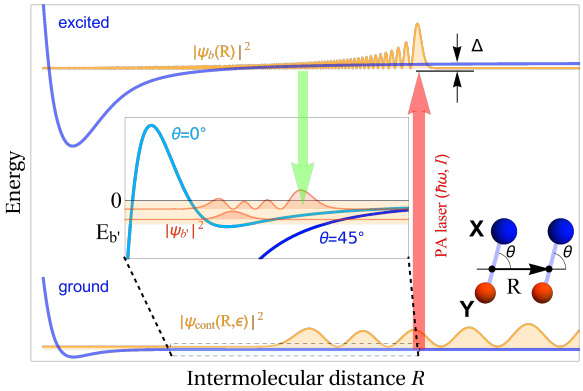

Figure 1: Scheme to produce tetramers; a pair of molecules excited by a laser may decay to form a bound molecular complex into a long-range well.

We present a detailed theoretical analysis for ultracold KRb and RbCs molecules, both of which were cooled and trapped successfully, resulting in production of $(KRb)_2$ and $(RbCs)_2$ complexes (see sktech in Fig. 1). We show that both systems can form rotational-vibrational loosely bound states near the molecular dissociation limit or in deeply bound long-range states, depending on the relative alignment of the interacting dimers. The proposed approach is based on universal properties of polar molecules and the conclusions can be generalized to the formation of polyatomic molecules starting from larger molecules with a favorable ratio of permanent dipole and quadrupole moments.

References

1. Jason N. Byrd, John A. Montgomery, Jr., and Robin Côté, *Phys. Rev. Lett.* **109**, 083003 (2012).
2. Jason N. Byrd, John A. Montgomery, Jr., and Robin Côté, *Phys. Rev. A* **86**, 032711 (2012).