Asymptotic physics with subradiant and superradiant states of ultracold molecules

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We present a combined theoretical and experimental study of weakly bound rovibrational levels of ultracold strontium molecules near the atomic intercombination line. Some physical properties of these levels, such as the lifetimes or Zeeman shifts, are fully determined by the internal symmetries of the wave functions. For instance, the symmetry of the electronic wave function specifies if the excited state has a superradiant or subradiant character.

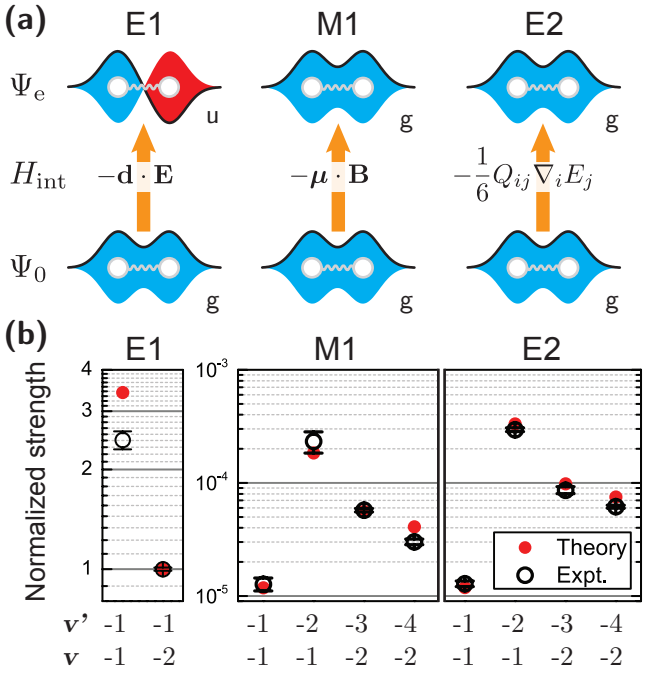

Figure 1: *Optical transitions to superradiant and aubradiant molecular states of Sr_2*

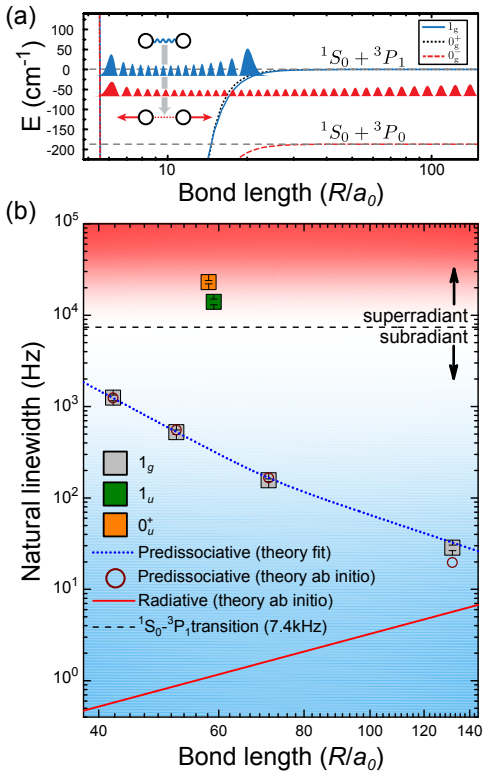

Figure 2: *Natural linewidths of weakly bound subradiant and superradiant molecular states of Sr_2*

We precisely characterize [1] the subradiant states of the Sr_2 molecule, and show how their properties are strongly affected by the nonadiabatic and relativistic effects. In particular, we show that the observed finite lifetimes of the subradiant states are limited by the gyroscopic predissociation due to the nonadiabatic Coriolis coupling in the short range of the interatomic potential. We quantitatively describe and compare strongly forbidden magnetic-dipole and electric-quadrupole transitions to subradiant excited states proving their unusual asymptotic behavior and relativistic nature.

We also demonstrate how the nonadiabatic mixing between the excited interaction potentials leads to anomalously large linear, quadratic, and higher Zeeman shifts of weakly bound Sr_2 molecules [2,3]. All these phenomena are illustrated with the results from high-precision measurements and state-of-the-art *ab initio* calculations.

References

[1] B. H. McGuyer *et al.* Nature Physics **11** 32 (2015)
[2] B. H. McGuyer *et al.* Phys. Rev. Lett. **111** 243003 (2013)
[3] B. H. McGuyer *et al.* arXiv:1503.05946