Quasiparticle approach to molecules interacting with quantum solvents

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Synopsis We show that molecules immersed in superfluid helium form recently predicted angulon quasiparticles. This allows to substantiall simplify the theoretical problems concerned with matrix isolation spectroscopy.

Understanding the behavior of molecules interacting with superfluid helium represents a formidable challenge and, in general, requires approaches relying on large-scale numerical simulations. Here we demonstrate that experimental data collected over the last 20 years provide evidence that molecules immersed in superfluid helium form recently-predicted angulon quasiparticles [1, 2, 3]. Most important, casting the many-body problem in terms of angulons amounts to a drastic simplification and yields effective molecular moments of inertia as straightforward analytic solutions of a simple microscopic Hamiltonian. The outcome of the angulon theory is in good agreement with experiment for a broad range of molecular impurities, from heavy to medium-mass to light species [4].

Furthermore, we show that the angulon theory is able to describe non-adiabatic rotation of molecules excited by a short laser pulse, as observed in experiments of Stapelfeldt's group [6].

These results pave the way to understanding molecular rotation in liquid and crystalline phases in terms of the angulon quasiparticle.

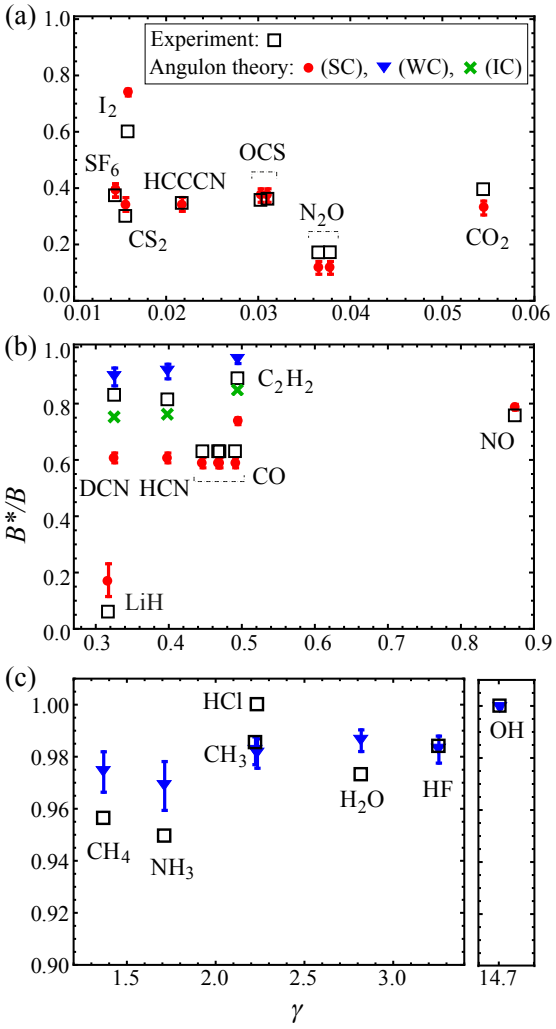

Figure 1. Renormalization of the molecular rotational constant, B^*/B, as a function of the coupling parameter γ [4]. The panels correspond to (a) heavy molecules, (b) medium-mass molecules, and (c) light molecules. Experimental data (empty squares) are compared with the angulon theory in the strong-coupling regime (red circles), and the weak-coupling regime (blue triangles). Green crosses show the intermediate-coupling interpolation between the strong- and weak-coupling theories.

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References

[1] R. Schmidt, M. Lemeshko 2015 *Phys. Rev. Lett.* **114**, 203001

[2] R. Schmidt, M. Lemeshko 2016 *Phys. Rev. X* **6**, 011012

[3] E. Yakaboylu, M. Lemeshko 2017 *Phys. Rev. Lett.* **118**, 085302

[4] M. Lemeshko 2017 *Phys. Rev. Lett.* **118**, 095301

[5] Yu. Shchadilova 2017 *Physics* **10**, 20

[6] B. Shepperson, A. A. Søndergaard, L. Christiansen, J. Kaczmarczyk, R. E. Zillich, M. Lemeshko, H. Stapelfeldt 2017 arXiv:1702.01977