Few-body Bound States in Dipolar Gases and Their Detection

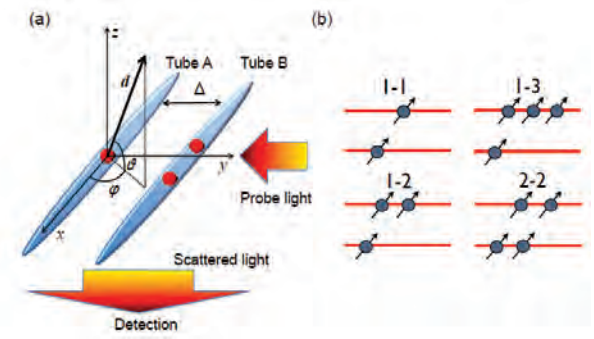

Fig. 1: Setup and various few-body complexes. (a) Setup. The molecules of dipole moment d move in two tubes. The probe and scattered light waves are used for the detection of complexes. (b) Notation for the complexes.

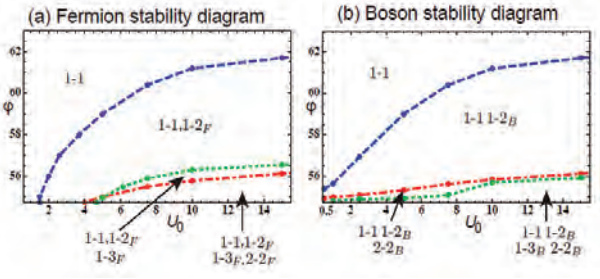

Fig. 2: Full stability diagram for θ=0. Each region is labeled by its stable complexes. For large tilting angle, only the dimer is stable but approaching the magic angle, other complexes become stable. (a) Fermionic molecules. All states except the dimer have the critical interaction strength U0. (b) Bosonic molecules. Close to the magic angle the complexes become stable for any U0.

Few-body bound states play a crucial role in determining the properties of many physical systems. In quantum chromodynamics (QCD) and nuclear physics, quarks bind into nucleons and nucleons into nuclei. In chemistry and biology, chemical reactions are determined by properties of complexes of atoms and molecules. In soft condensed matter physics, self-organization of elementary objects into chains determines the properties of rheological electro- and magnetofluids. A special feature of cold atom ensembles is the possibility to tune the two-particle interaction strength, which controls the properties of few-particle complexes.

Prof. Daw-Wei Wang in National Tsing-Hua University and his collaborators in Harvard University published a paper in Phys Rev Lett. [1] demonstrating the stability of few-body states of ultracold polar molecules with long-range dipole interactions in a low-dimensional setup consisting of two one-dimensional tubes. This geometry can be produced by optical lattices or atomic chip traps. (See Fig. 1) They focus on the regime where intratube interactions are repulsive, so that the binding stems from intertube attraction, and determine the stability of these complexes as a function of the direction and the strength of the dipoles (see Fig. 2). They further show the stability of even larger complexes and also suggest a detection scheme to map out unambiguously the stability of such complexes.

References

[1] B. Wunsch*, N. T. Zinner, I. B. Mekhov, S.-J. Huang, D.-W. Wang, and E. Demler, *Few-Body Bound States in Dipolar Gases and Their Detection*, Phys. Rev. Lett. **107**, 073201 (2011).

Enhancement of Magnetism of Fe by Cr and V

Strong, permanent magnets are extremely important in contemporary industrial applications. They play an essential role in many kinds of electrical products, and they are particularly important for hybrid and electric vehicles. When the magnet is stronger, then the energy efficiency for these vehicles becomes better, and this increased efficiency is helpful given our longstanding concerns regarding the availability of fossil fuels and the effect of emissions on global warming.