Physics Colloquium

Two-Body & Many-Body Physics in the Ultracold Regime

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Abstract:

State-of-the-art *ab initio* methods of quantum chemistry have found numerous applications in many areas of atomic, molecular, condensed matter, and nuclear physics. During the last decade they have been applied with success to interpret precision experiments on two-body and many-body processes in atomic gases in the ultracold regime. In this talk I will present recent examples of successful applications of the *ab initio* methods to describe two-body processes in atomic optical lattices leading to the formation of unusual chemical bonds and to observations of exotic optical transitions in diatomic molecules, as well as to many-body processes in one-dimensional harmonic traps of identical fermionic spin-1/2 atoms.

The first part of my talk will be devoted to a combined theoretical and experimental study of weakly bound rovibrational levels of ultracold diatomic strontium molecules near the atomic intercombination line Sr(3P1). Some physical properties of these levels, such as the lifetimes or Zeeman shifts, are fully determined by the internal symmetries of the molecular wave functions, and cannot be related to any atomic property characterizing the atomic dissociation limit Sr(1S0) + Sr(3P1). In particular, I will show that by using state-of-the-art *ab initio* methods of quantum chemistry one can precisely characterize the subradiant states of the Sr2 molecule, and quantitatively describe (strongly forbidden) molecular magnetic-dipole and electric-quadrupole transitions to subradiant excited states proving their unusual asymptotic behavior. I will also show how the nonadiabatic mixing between the excited state molecular potentials leads to anomalously large linear, quadratic, and higher Zeeman shifts of weakly bound Sr2 molecules [2,3] as opposed to a very small magnetic field effect on the Sr(3P1) atom.

In the second part of the talk I will address possible applications of the state-of-the-art many-body methods of quantum chemistry to investigate spin-1/2 fermions, interacting via a two-body contact potential, in a one-dimensional harmonic trap. In particular, I will show how quantum chemists systematically check the convergence of the total and correlation energies with the size of the single-particle basis set and with the level of excitations included in the many-body wave function [4], related to the BCS pairing and to describe the transition from a few-body to many-body regime, and even to the thermodynamic limit [4,5].

Friday, September 4th, 2015
4:00 – 5:00 pm
Goudsmit Conference Room, LP 208