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Ultracold high-density samples of rovibronic ground-state molecules in an optical lattice

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Ultracold molecules controlled at the level of single quantum states with respect to all internal and external degrees of freedom will enable a series of fundamental studies in physics and chemistry, ranging from novel quantum gas experiments and cold controlled chemistry to quantum information and quantum simulation. Ultracold molecules trapped in an optical lattice at high density and prepared in their lowest internal quantum state are an ideal starting point for these studies. We create ultracold and dense samples of molecules in a single hyperfine sublevel of the rovibronic ground state while each molecule is individually trapped in the motional ground state of an optical lattice well [1,2]. Starting from an atomic Mott-insulator state with optimized double-site occupancy, weakly bound Cs dimer molecules are efficiently formed on a Feshbach resonance and subsequently transferred to the rovibronic ground state by a stimulated 4-photon process with the Stimulated Raman Adiabatic Passage (STIRAP) technique. The molecules are trapped in the lattice with a lifetime of 8 s. We aim at producing Bose-Einstein condensates of ground-state molecules by adiabatically removing the lattice. Our results, when suitably generalized to heteronuclear molecules, present an important step towards the realization of dipolar quantum-gas phases in optical lattices. I will report on recent progress in Innsbruck on the formation of RbCs ground state molecules.

[1] Science **321**, 1062 (2008)
[2] Nature Physics **6**, 265 (2010)