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New theoretical findings on cold molecules in optical lattices

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There are great expectations for the application of ultra-cold molecules in simulating many-body states and performing high-precision measurements. All these applications are based on optical lattices to hold molecules in fixed spatial locations. Optical lattices are constructed from the interference patterns of counter-propagating laser beams. They provide a periodic potential for ultracold particles. The parameters of the lattice can be externally controlled by tuning the frequency and intensity of the lasers. In addition, the interaction strength between polar molecules can be tuned by external DC electric or magnetic fields. There are many things that have to be found about polar molecules in optical lattices before these goals are reached. In particular, I have focused on determining the most efficient ways to produce molecules from ultra-cold atoms in optical lattices. I will discuss conditions for strong confinement of molecules in a lattice, suppression of undesired perturbations that cause loss of atoms and molecules from the lattice, and control interactions between neighboring molecules. In addition, I will show our results on the differential AC Stark shift of various ro-vibrational levels of the ground-state molecules caused by the optical lattice. The analysis of Stark shifts are essential for selection of vibrational levels with matched polarizabilities as necessary for high-precision frequency measurements. I acknowledge support of this work from a grant of the Army Research Office.