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Atom-molecular oscillations of a Bose gas in an optical lattice

DANIEL HEINZEN, The University of Texas at Austin

A Bose gas in an optical lattice can undergo a quantum phase transition between a superfluid and a "Mott insulator" state [1]. We have created a Mott insulator state of ^{87}Rb atoms in an optical lattice with a controllable number of atoms per site, and measured its stimulated Raman photoassociation spectrum. We found that higher density samples exhibited a two-peaked spectrum arising from photoassociation in sites with two and three atoms, respectively. The splitting between these peaks provides a measurement of the atom-molecule scattering length. Raman photoassociation of a sample with a central core of Mott insulator with two atoms per site induced macroscopic coherent oscillations between an atomic and a molecular gas, as predicted by Jaksch *et al.* [2]. Our result implies that at the point of minimum atom number, we have created a molecular quantum gas with one molecule in each lattice site. In addition, we have carried out Bragg spectroscopy of the gas [3], and found evidence of a gap in the excitation spectrum of the insulating state. This work was carried out in collaboration with C. Ryu, Emek Yesilada, Xu Du, and Shoupu Wan. We acknowledge the support of the R.A. Welch Foundation, the N.S.F., and the D.O.E Quantum Optics Initiative. [1] Markus Greiner *et al.,* Nature **415**, 39 (2002). [2] D. Jaksch *et al.*, Phys. Rev. Lett. **89**, 040402 (2002). [3] D. Van Oosten *et al.*, cond-mat/0405492 (2004).