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Solid State Analogs in Bose-Condensed Gases[1]

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Bose-Einstein condensates in optical lattices have proven to be a powerful tool for emulating a wide variety of physical systems. Although our Rubidium condensates are a million times less dense than air, in several regards they also act like solids. In this talk, I demonstrate this behavior in three different experiments. First, similar to a piece of glass, the refractive index of the condensate changes the momentum of a photon propagating through it. This systematic shift of the photon recoil momentum due to the index of refraction was measured with a two-pulse light grating interferometer, and has important ramifications for precision measurements of the fine structure constant, α. Second, a 1D light crystal is shown to create a lattice band structure that allows two atoms traveling at the same velocity to collide and scatter into two different velocity states (which is impossible in free space), allowing us to demonstrate parametric generation and amplification of ultracold atom pairs. Finally, the Superfluid-Mott Insulator transition was studied in a 3D lattice using microwave spectroscopy. Using a density dependent shift to the clock transition, we were able to spectroscopically distinguish sites with different occupation numbers, and to directly image sites with occupation number from 1 to 5, revealing the shell structure of the Mott Insulator phase. This work was performed at MIT, under the direction of David E. Pritchard and Wolfgang Ketterle

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