Supersolids are an exotic phase of matter combining the contrasting characteristics of spontaneous continuous translational symmetry breaking in solids and frictionless flow in superfluids. Supersolids were predicted more than fifty years ago in the context of solid Helium [1, 2, 3] and were first observed in the context of ultracold atoms where cavity-mediated interactions [4, 5], dipolar interactions [6, 7, 8, 9], or optically induced spin-orbit coupling [10, 11, 12] can produce spontaneous translational symmetry breaking in a superfluid Bose-Einstein condensate.

Here, we present the use of optical dressing in a Bose-Einstein condensate of $^{41}$K to produce spin-orbit coupling in a regime where the single particle dispersion relation features two minima at distinct momentum. Matterwave interference between two Bose-Einstein condensates at rest at the minima of the dispersion relation gives rise to density modulations which constitute the spontaneous breaking of translational symmetry and thus allow the realization of the so-called supersolid stripe phase [10]. Previous realizations of the supersolid stripe phase have been limited to low values of the density contrast due to unfavorable interactions between the bare spin components [10, 12] and heating [11]. We identify a pair of Feshbach resonances in $^{41}$K [13] which allow us to tune interactions such that we can reach coupling strengths and thus density modulation contrasts an order of magnitude larger than in previous experiments. We employ quantum gas magnification techniques to magnify the density modulations and achieve a spatial period larger than our optical imaging resolution. We demonstrate that the fringe spacing increases with the optical intensity of the Raman coupling beams, in contrast to a shallow optical lattice where the fringe spacing is given by the lattice wavevector. Our system provides a new platform for exploring the supersolid stripe phase in spin-orbit coupled Bose-Einstein condensates, and should allow us to investigate the collective crystal modes of the system.

References

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