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Realizing artificial magnetic fields via optical lattice immersion[1]

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Ultracold atoms in optical lattices are one of the top candidates for performing direct quantum simulations of fundamental condensed matter phenomena such as the quantum Hall effect. While numerous proposals have been made for how to simulate the effect of a magnetic field on trapped neutral atoms, these typically have very stringent experimental requirements in order to access relevant parameter regimes. Here we describe an alternative scheme in which atoms trapped in a static optical lattice are immersed into a rotating Bose-Einstein condensate (BEC). We show that the interaction with a rotating BEC induces a controllable phase twist on the hopping term for the impurity atoms in the lattice. Crucially this scheme does not require any careful balancing of the centrifugal term in contrast to directly rotating the lattice. For a 1D ring-shaped setup we examine analytically the dependence of this phase twist on BEC's angular velocity and the coupling of impurity atoms to BEC phonons. These findings are further generalized to a 2D lattice submerged in a 2D BEC which is moderately rotating and harmonically confined. In this case the artificial magnetic field is inhomogeneous and we discuss how its spatial dependence can be controlled by varying the trapping potential of the BEC. In earlier work on static immersions we showed that the coupling of the impurity atoms to BEC phonons leads to a cross-over from coherent to incoherent transport of the impurity atoms and to an attractive interaction between impurity atoms causing clustering effects. We discuss some preliminary work investigating how the nature of these effects change in a rotating setup.

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