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I.I. Rabi Prize Talk: Artificial gauge fields in multi-level atoms

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We used Raman lasers to induce artificial gauge fields or spin-orbit coupling in the three-level system formed by the f=1 electronic ground state manifold of rubidium-87. In this colloquium I will report on two effects of this laser-coupling. I will explore the itinerant magnetic phases present in a spin-1 spin-orbit coupled atomic Bose-Einstein condensate (BEC); in this system, itinerant ferromagnetic order is stabilized by the spin-orbit coupling, vanishing in its absence. We first located a second-order phase transition that continuously stiffens until, at a tricritical point, it transforms into a first-order transition. These measurements are all in agreement with theory. We engineered a two-dimensional magnetic lattice in an elongated strip geometry, with effective per-plaquette flux about 4/3 times the flux quanta. We imaged the localized edge and bulk states of atomic Bose-Einstein condensates in this strip, with single lattice-site resolution along the narrow direction. Further, we observed both the skipping orbits of excited atoms traveling down our system's edges, analogues to edge magnetoplasmons in 2-D electron systems. Our lattice's long direction consisted of the sites of an optical lattice and its narrow direction consisted of the internal atomic spin states: a synthetic dimension.