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Light induced gauge fields and spin orbital coupling in cold atomic gas[1]

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Here I present our experimental work synthesizing gauge fields for Bose-Einstein condensates (BECs). I will first summarize our earlier work creating a scalar (abelian) gauge field (akin to the electromagnetic vector potential) and then focus in detail our current work creating a matrix valued (although still abelian) gauge field. I will discuss this gauge field in the language of spin-orbit coupling where it consists of an equal sum of Rashba and Dresselhaus couplings. Specifically, we couple two internal states of rubidium 87 with a pair of "Raman" lasers and load our BEC into the resulting adiabatic eigenstates. In agreement with theory, we observe that below a critical coupling strength our BEC has well defined spin degrees of freedom and acts like a spin-orbit-coupled spin-1/2 Bose gas. As a function of the Raman laser strength, a new exchange-driven interaction between the two dressed spins develops, which drives a (quantum) phase transition from a state where the two dressed spin states spatially mix, to one where they phase separate. Our 3D mean field theory accurately locates the critical laser strength for this transition. Going beyond this simple modification to the spin-dependent interaction, we show that in the limit of large laser intensity, the particles act as free atoms, but interact with contributions from higher even partial waves.

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