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Synthetic gauge fields for ultracold atoms

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Ultracold atoms represent a unique system in which to investigate quantum many-body physics with unprecedented experimental control. The properties of these systems can be tailored to realize model many-particle Hamiltonians, familiar from condensed matter physics, in their most pure and essential form. Magnetic fields, and gauge fields in general, play an important role in collective phenomena in electronic systems, leading to iconic phenomena such as the fractional quantum Hall effect. More complex, matrix valued, gauge fields can be used to describe spin-orbit coupling: itself an essential ingredient in many topological insulators, and in spintronic devices. Given the charge neutrality of ultracold atoms it is not immediately obvious how such physics could be explored in a cold atom context. In this talk I will describe the experimental techniques we use to engineer artificial gauge fields for ultracold neutral atoms using Raman transitions. I will also describe the latest results from the NIST group.