Invited talk

Exploring quantum Hall physics with ultracold dysprosium atoms

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Ultracold atomic gases offer a versatile platform for exploring rich phenomena in quantum matter. In particular, topological states akin to those found in the quantum Hall effect can be engineered by simulating orbital magnetic fields—an approach greatly facilitated by the use of synthetic dimensions.

In this talk, I will present our experimental realization of a quantum Hall system using ultracold gases of dysprosium atoms. By leveraging the atom's large internal spin ($J = 8$), we encode a synthetic dimension and couple it to atomic motion via two-photon optical transitions, which generates an effective magnetic field. We observe hallmark signatures of quantum Hall physics, including a quantized Hall response and gapless, chiral edge modes.

I will then describe a more intricate experiment designed to probe spatial entanglement by simulating the so-called entanglement Hamiltonian. Using the Bisognano-Wichmann theorem—which relates the entanglement Hamiltonian to a spatially deformed version of the original system—we implement this deformation along the synthetic dimension.

Lastly, I will discuss our recent investigation into a topological phase transition, induced by introducing an additional lattice potential. I will highlight the system's behavior in the critical regime and explore the emergent features associated with the transition.