Prediction and Observation of the Universal Hall Response in Strongly Interacting Fermions

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The Hall effect originates from the motion of charged particles in a magnetic field and has deep consequences for the description and characterization of materials, far beyond the context of condensed matter physics. Understanding the Hall effect in interacting systems still represents a fundamental challenge. Here [1] we directly observe the build-up of the Hall response in an interacting quantum system by exploiting controllable quench dynamics in an atomic quantum simulator, see Figure 1. By tracking the motion of ultracold fermions in a two-leg ribbon threaded by an artificial magnetic field, we measure the Hall response as a function of synthetic tunnelling and atomic interactions. We unveil an interaction-independent universal behaviour above an interaction threshold, in clear agreement with theoretical analyses [2-3]. We will also discuss measurements of the Hall voltage. Our approach and findings open new directions for the quantum simulation of strongly correlated topological states of matter.

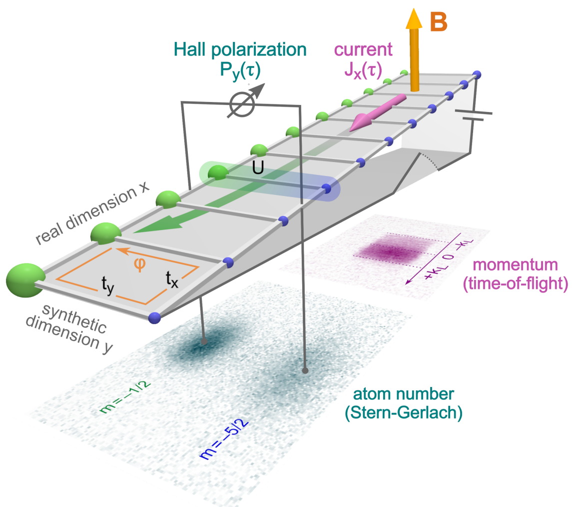

Figure 1: A synthetic ladder is realized by trapping fermionic ^{173}Yb atoms in a 1D optical lattice and coupling their nuclear spin states via a two-photon Raman transition, simulating an effective magnetic field described by an Aharonov-Bohm phase φ per unit cell. The longitudinal current and the Hall polarization are measured with time-of-flight imaging and optical Stern-Gerlach detection, respectively (typical acquisitions are shown in the two images below the ladder).

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