Prediction and Observation of Universal Hall Responses 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. In this colloquium, I will discuss how such phenomenon can be investigated exploiting controllable quench dynamics in an atomic quantum simulators [1], see Figure 1. By tracking the motion of ultracold fermions in a two- and three-leg ribbon threaded by an artificial magnetic field, we measure the Hall response as a function of synthetic tunnelling, atomic interactions and current carrier density n. I will discuss how such experiments unveil an interaction-independent universal behavior above an interaction threshold, in clear agreement with theoretical analyses [2-3]. I will then discuss how these experiments can also measure the Hall voltage [4-5], providing the first experimental demonstration of the $R_{\mathrm{H}} \propto 1/n$ scaling of the Hall constant in a strongly correlated quantum simulator.

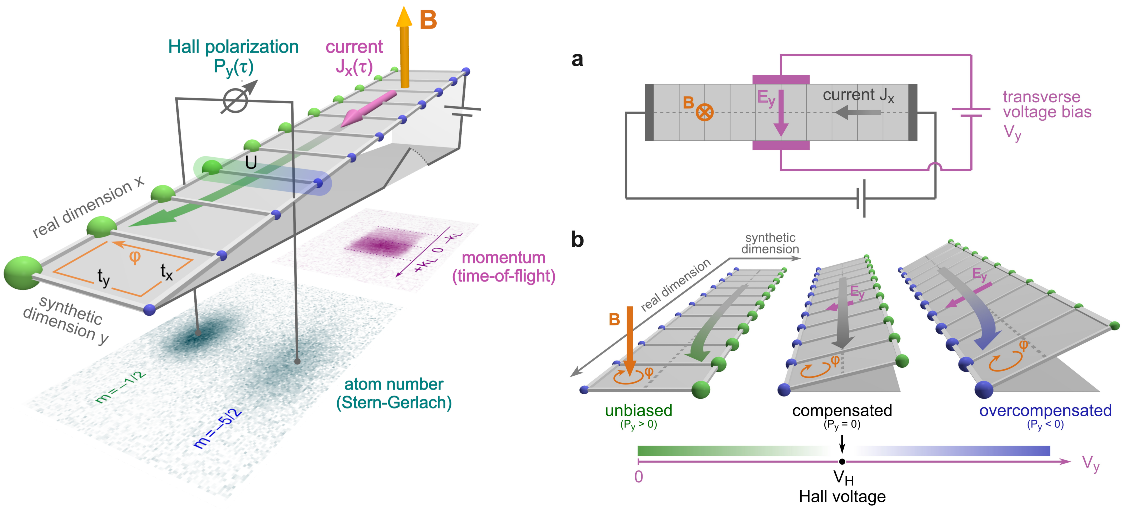

Figure 1: **Left)** A synthetic ladder is realized by trapping fermionic ^{173}Yb atoms in a 1D optical lattice and coupling their nuclear spin states via a two-photon Raman transition, simulating an effective magnetic field described by an Aharonov-Bohm phase φ. The longitudinal current and the Hall polarization are measured with time-of-flight imaging and optical Stern-Gerlach detection, respectively (typical acquisitions are shown below the ladder). **Right)** Experimental protocol to measure the Hall Resistance. A transverse field E_y is applied such to compensate for the transverse Hall polarization, leading to the measurement of the Hall voltage and the related Hall resistance.

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