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Quantised pumping in optical lattices: interactions and edge modes

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The concept of a topological 'Thouless' pump involves the quantised motion of particles in response to a slow, cyclic modulation of external control parameters. Similar to the quantum Hall effect, the Thouless pump is of fundamental interest in physics because it links physically measurable quantities, such as particle currents, to geometric properties of the experimental system, whose topology can be robust against perturbations and thus technologically useful. So far, experiments probing the interplay between topology and inter-particle interactions have remained relatively scarce.

This poster presents recent experimental results on topological pumping in Hubbard-regime optical lattices. Sensing the bulk response of the atomic cloud, we find that quantisation remains robust against weak and moderate interactions, compared to the single-particle band gap. Yet, strong repulsive interactions lead to a breakdown of quantised pumping (ref. 1).

The dynamical lattice potential, generated from a single laser source at 1064nm, allows us to observe quantised pumping for more than 100 adiabatic cycles. In this long-distance regime, we discovered a reversal of quantised drifts (ref. 2), resulting from the underlying harmonic confinement. The reversal can be understood as an adiabatic transfer between bands of opposite Chern number via a topological edge mode. Interestingly, the presence of Hubbard interactions causes a second edge to emerge in the system.

Our experiments suggest that topological pumps are promising platforms to gain insights in interaction-driven topological transitions, as well as topological quantum matter.

References
(1) arXiv:2204.06561 (to appear in Nature Physics)
(2) arXiv:2301.03583

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