Vortex Dynamics in Strongly Interacting Superfluids

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Abstract

Interactions can play a determinant role in low dimensions for topological and chiral states of matter by giving rise to interesting emergent phenomena such as quasiparticle fractionalization and quantum phase transitions. Recent experimental evidence from Floquet engineered ultracold atomic systems, have provided a starting point for observing correlated vortex structures of the Laughlin bosonic Hall effect [1] and Meissner states [2]. Motivated by these experimental advances, we have investigated the quantum dynamics of large vortices in strongly interacting superfluids. For one quantum of flux and close to half-filling, the change in sign of the Hall conductivity [3] suggests an abrupt change in vortex response and dynamics, due to effective strong quantum fluctuations. In this contribution we will present some preliminary results on vortex dynamics in the presence of strong correlations for different filling factors, giving rise to chiral vortex motion and non-trivial trajectories near to half-filling (Figure 2). We provide a mapping to a dual effective free theory explaining our observations. These results motivate novel transport measurements to delve into the phenomenology of single and multi-vortex dynamics in state-of-the-art bosonic platforms.

References

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[2] A. Impertro, S. Hugh, S. Karch, J. F. Wienand, I. Bloch, M. Aidelsburger, Nature Physics, 21, (2025) 895-901

[3] N. H. Lindner, A. Auerbach, D. P. Arovas, Physical Review Letter, 102(7) (2009) 070403

Figures

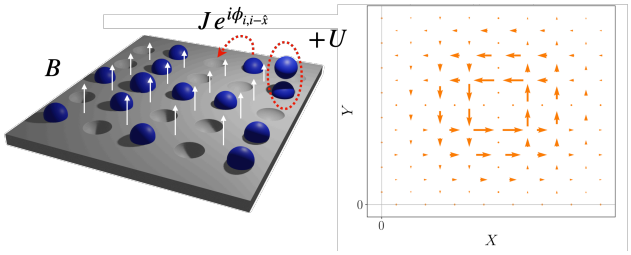

Figure 1: Interacting bosons on a lattice with synthetic magnetic field (left) develop a current vortex configuration, in the presence of one flux quantum threading the entire lattice (right)

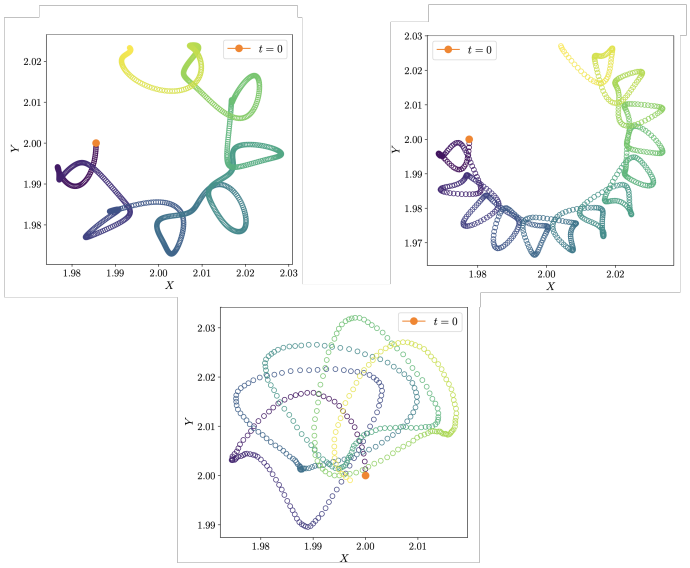

Figure 2: Different vortex dynamics in real-time below (up row) or above (bottom row) half-filling for strong interactions.