Melting of vortex lattice in a two-dimensional BEC

T. W. Neely[a], M. T. Reeves[b], G. Gauthier[a], M. J. Davis[a,b], H. Rubinsztein-Dunlop[a]

[a] *ARC Centre of Excellence for Engineered Quantum Systems, University of Queensland, Brisbane, AU.*

[b] *ARC Centre of Excellence for Future Low-Energy Electronics Technologies, University of Queensland, Brisbane, AU.*

The ground state of a rapidly rotating superfluid is an Abrikosov lattice of quantised vortices, which is akin to a crystalline solid and defines the zero-temperature state of a two-dimensional system of chiral vortex matter. At sufficiently higher energies, the lattice melts and can be approximated as a strongly correlated vortex liquid. These states of vortex matter have gained prominence in the theory of the fractional quantum hall effect, where the 2D electron gas moves analogous to vortices in an incompressible fluid, and the vortex density maps to the density of the quantum hall droplet.

The development of quasi-2D BEC superfluids in optical box potentials has resulted in new experimental systems for exploring the dynamics of point-like vortices [**?**, **?**]. In this work, we experimentally observe the low energy phases of chiral vortex matter, including the predicted excess edge density at the vortex cluster edge [**?**]. The experiment initialises a vortex lattice in a disc-shaped BEC by rearranging 19 optically-pinned vortices to realise a vortex crystal of arbitrary size. The vortices are then released from the pins, and the vortex lattice melts as it gains energy from a bath of phonons in the BEC that results from small-scale vibrations of the optical trapping potential. After several seconds of hold time, a robust signature of the edge density overshoot is observed. At longer hold times, the crystal melts fully. While facilitating the exploration of low-energy vortex configurations, this work also demonstrates an adaptable experimental technique for creating arbitrary arrangements of vortices, paving the way for experiments in more complex trap geometries.

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