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Melting vortex matter in a two-dimensional BEC

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The ground state of a rapidly rotating superfluid is familiar as a triangular lattice of quantised vortices filling the condensate. This lattice of vortices can be considered an emergent chiral vortex matter, defined by the vortex interaction energy, angular momentum, and vortex number. In this picture, a continuum of equilibrium states of vortex matter is accessible, provided there is suitable decoupling between the vortices and other degrees of freedom in the superfluid, allowing the system to remain in metastable states [1]. The minimum energy crystal represents only one potential configuration. 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 analogously to vortices in an incompressible fluid, and the vortex density maps to the density of the quantum Hall droplet.

In this work, we explore the low-energy states of vortex matter in a quasi-2D uniform BEC superfluid. Starting from the minimum energy state corresponding to the triangular lattice, which resembles a crystalline solid, we observe the melting of the lattice under systematic heating resulting from small-scale vibrations of the trapping potential. We observe several predicted features of the lattice melting transition, including excess density at the edge of the vortex cluster, spatial squeezing of the density distribution, and persistent crystallization at the cluster edge [3].

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Primary author: NEELY, Tyler (University of Queensland)

Co-authors: Mr GLASSPOOL, Charles (University of Queensland); DAVIS, Matthew (University of Queensland); REEVES, Matthew (University of Queensland)

Presenter: NEELY, Tyler (University of Queensland)

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