Vortex Arrays, Thermal Effects and Critical Temperature Shifts in Rotating Bose-Eintein condensates.

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The interplay between rotation and thermal fluctuations in Bose-Einstein condensates (BECs) leads to intricate vortex lattice dynamics with strong analogies to type-II superconductors and other quantum fluids. In this work [1], we investigate how rotation influences the critical temperature of a BEC, revealing distinct behaviors depending on system constraints. Using numerical simulations based on the Stochastic Rotating Ginzburg-Landau equation, we demonstrate that in a fixed trapping potential there is a negative shift in the critical temperature, caused by the cloud expansion. Conversely, when the volume is constant, the shift is positive as the vortex lattice suppresses thermal fluctuations and stabilizes the condensate. The melting of the vortex lattice is observed as a thermally driven transition that proceeds from the periphery inward, as shown in Fig.1, where increasing temperature causes a gradual loss of lattice coherence. To further understand this process, we introduce a vortex-energy model that captures the role of vortex interactions, positional energy, and the ordering imposed by rotation. The model successfully reproduces key features of the melting transition and the thermodynamic response of the system. Our findings provide new insights into rotating quantum fluids and may have broader implications for other systems.

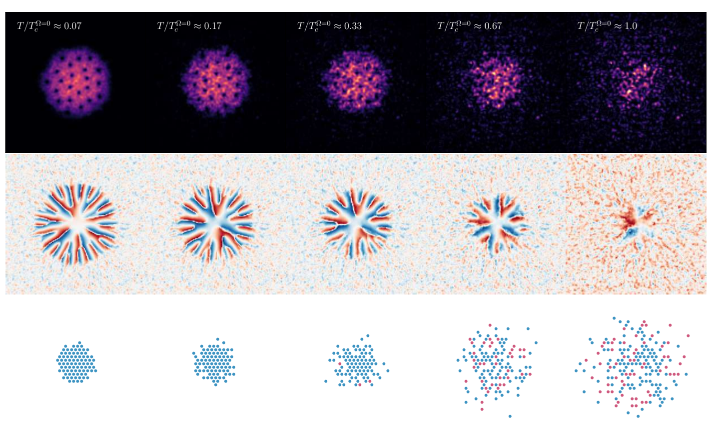

Figure 1. Top : $\rho(x, y, z = 0)$ with increasing temperature. Middle : phase of ψ, averaged along the rotation axis, for the same configurations. Blue corresponds to $-\pi$ and red to π. Phase shifts are caused by quantized vortices. Bottom : Vortex-energy model with increasing T. Blue vortices are parallel to the rotation axis, red vortices are anti-paralell.

Références

1. J. Amette Estrada, M. E. Brachet, P. D. Mininni, *Physical Review A*, **111**, 023304 (2025).