Ghost Vortices and How to Turn Them Real

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Ghost vortices constitute an elusive class of topological excitations in quantum fluids since the relevant phase singularities fall within regions where the superfluid density is almost zero.

In this talk, I will present a platform that allows for the controlled generation and observation of such vortices (see figure 1). Upon rotating an imbalanced mixture of two-component Bose-Einstein condensates, one can obtain necklaces of real vortices in the majority component (ψ_a) whose cores get filled by particles from the minority one (ψ_b). The wavefunction describing the state of the latter is shown to harbor several ghost vortices (black crosses) which are crucial to support the overall dynamics of the mixture. Their arrangement typically mirrors that of their real counterpart (black stars), hence resulting in a "dual" ghost- vortex necklace, whose properties are thoroughly investigated in the present paper.

We also present a viable experimental protocol for the direct observation of ghost vortices in a ^{23}Na + ^{39}K ultracold mixture. Quenching the inter-component scattering length, some atoms are expelled from the vortex cores and, while diffusing, swirl around unpopulated phase singularities, thus turning them directly observable.

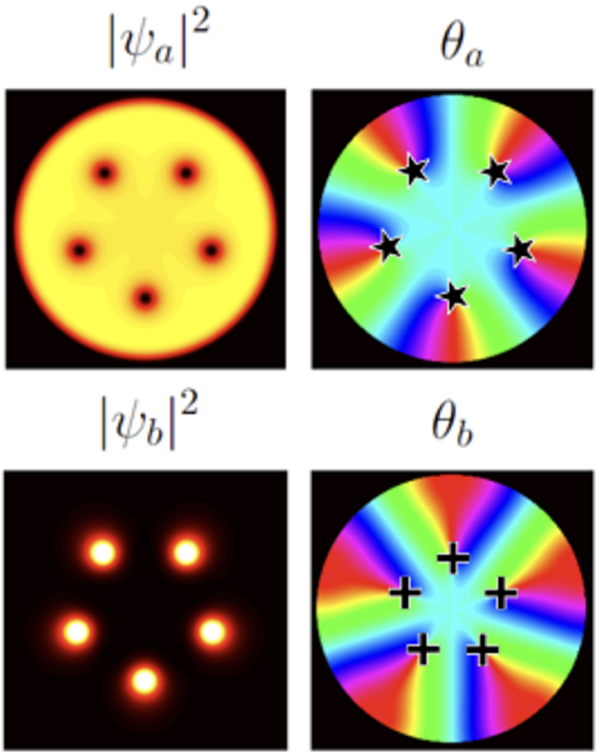

Figure 1: A necklace of real vortices in ψ_a (upper row). The vortices' cores are filled by a second superfluid component, associated to ψ_b (lower row), which is indeed characterized by *ghost* vortices

References

[1] A Chaika, A Richaud and A Yakimenko, arXiv:2303.05403 (2023), Phys. Rev. Res., in print