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Rotating BEC in a ring trap

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Since its experimental realization, BECs in ultracold gases have been invaluable tools in exploring the physics of superfluidity, and in particular, the physics of rotating superfluids. Contrary to the classical expectation, a rotating superfluid does not develop a rigid body velocity field. Instead, the fluid is irrotational in any closed loop taken in the fluid, with exception of lines of vanishing density where circulation is quantized. These lines are called vortices, an entirely quantum phenomenon. If the rotation rate is increased, a vortex array forms in the bulk of the gas in a triangular, Abrikosov-like configuration. However, typically ultracold gases BECs are confined in harmonic oscillator type potentials, which sets a limit for the rotation rate: if the rotation frequency exceeds the trap frequency, the gas deconfines from the trap and it is no longer possible to experimentally probe it. (1) This fact prompted research for potentials that provides a stronger than harmonic confinement. One such a potential that was attracted much attention from the community is the bubble trap potential, where the gas is confined to the surface of an ellipsoid. (2) In a number of situations, this trap can be adequately described by a displaced harmonic oscillator type potential, or ring trap. (3) In our work, we investigate the physics of rotating, weakly interacting BECs in ring trap potentials by employing numerical methods and a variational wavefunction. We show that the variational wavefunction can describe with satisfaction the condensate when it contains a multiply charged vortex or a small vortex array. We investigate whether the condensate displays a multiply charged vortex, a vortex array or a hybrid scenario by varying the interaction strength and the rotation speed. Using our variational wavefunction, we make predictions of the expected frontier in the parameter space between vortices of different charges. Finally, by employing sum rules we calculated the frequency of monopole collective modes, comparing our prediction numerically and finding good agreement. In the future, we plan to extend our calculations to quadrupole modes, which can be used as a method for indirect detection of vortices. We also plan to calculate the continuous transition between a multiply q-charged vortex and q vortices of charge 1, therefore completing our picture of the phase diagram.

Palavras-chave: BEC. Atomic physics. Superfluids.

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