Abstract

Vortices in a Bose-Einstein condensate are modelled as spontaneously symmetry breaking minimum energy solutions of the time dependent Gross-Pitaevskii equation. In a non-rotating axially symmetric trap, the core of a single vortex precesses around the trap center and, at the same time, the phase of its wave function shifts at a constant rate. The precession velocity, the speed of phase shift, and the distance between the vortex core and the trap center, depend continuously on the value of the conserved angular momentum that is carried by the entire condensate. The number of vortices increases with increasing angular momentum, and the vortices repel each other to form timecrystalline Abrikosov lattices. Poincaré index formula states that besides vortices there are also saddle points, and the difference in the number of vortices and saddle points can never change. But unlike vortices the saddle points can also attract each other, they can join and become combined into timecrystalline degenerate critical point configurations. But when the number of saddle points becomes sufficiently large there is a transition, and instead of attracting each other, the saddle points start repelling each other, and pair up with vortices. The ensuing structures rotate around the trap

center, in regular arrangements akin Abrikosov lattices.