The Abdus Salam
International Centre
for Theoretical Physics

International Conference on Multi-Condensate Superconductivity and Superfluidity in Solids and Ultra-Cold Gases
14 - 18 May 2018 (Trieste, Italy)

Vortex Molecules in Coherently Coupled Bose-Einstein Condensates: Confinement and BKT Transition

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Abstract:

(1) We show that confinement of half-quantized vortices (HQVs) in two-component Bose-Einstein condensates (BECs) coupled through the Rabi (Josephson) coupling is similar to that of quantum chromodynamics (QCD). We identify a pair of vortices in each component to a baryon and a pair of a vortex and an antivortex in the same component to a meson, and study their dynamics; baryon is static at the equilibrium and rotates once it deviates from the equilibrium, while a meson moves with constant velocity. For both baryon and meson we verify a linear confinement and determine that they are broken, thus creating other baryons or mesons in the middle when two constituent vortices are separated by more than some critical distance, resembling QCD.(Based on Phys.Rev. A97 (2018) no.2, 023613 in collaboration with M.Eto).

(2) We study the Berezinskii-Kosterlitz-Thouless (BKT) transition of two-component Bose mixtures in two spatial dimensions. When the both components are decoupled, half-quantized vortex-antivortex pairs of each component induce two-step BKT transitions. On the other hand, when the both components are coupled through the Josephson coupling, two species of vortices of each component are bind to form a molecule, and in this case, we find that there is only one BKT transition by molecule-antimolecule pairs. Our results can be tested by two-component ultracold dilute Bose-Einstein condensates with the Rabi oscillation, and multiband superconductors.(Based on arXiv:1802.08763 [cond-mat.stat-mech] in collaboration with M.Kobayashi and M.Eto.).