Contribution ID: **18** Type: **Contributed talk**

Thermal fluctuations in multicomponent quantum gases

Monday 2 September 2024 12:20 (20 minutes)

In the study of various quantum phase transitions and excitations in Bose-Einstein condensates (BECs), several key findings emerge across different scenarios. For a spin-orbit-coupled quasi-one-dimensional BEC, temperature-induced transitions from a superfluid plane-wave phase to a supersolid phase are observed, contrasting with the behavior in homogeneous systems. The Hartree-Fock-Bogoliubov theory with the Popov approximation is utilized to analyze collective excitation spectra, particularly focusing on the softening of the spin-dipole mode near the quantum critical point. Furthermore, the collective excitations of a spin-orbit-coupled spin-1 BEC in a trapping potential are studied theoretically at both zero and finite temperatures. Density and spin excitations exhibit distinct behaviors with temperature variations, notably affected by spin-orbit coupling.

Transitioning to a two-dimensional coherently-coupled Bose mixture, a paramagnetic-ferromagnetic quantum phase transition at zero temperature is identified, with subsequent investigations into its behavior at finite temperatures. Stochastic Gross-Pitaevskii formalism is employed, revealing a linear shift of the critical point with temperature and power-law scaling of critical quantities, consistent with thermal critical exponents.

Finally, the role of thermal fluctuations in two-dimensional binary Bose mixtures is explored, particularly focusing on the miscible-immiscible transition. Mean-field Hartree-Fock theory predicts a transition instability at non-zero temperatures due to divergent behavior in spin susceptibility, which is partially confirmed by numerical simulations. However, discrepancies between theory and simulations suggest that mean-field approximations struggle to accurately describe the system near the transition, especially concerning thermal fluctuations.

References

Phys. Rev. A 107, 043301 (2023); Phys. Rev. Lett. 130, 220403 (2023); Phys. Rev. A 109, 033319 (2024); Phys. Rev. Research 3, 013161 (2021)

Short bio (50 words) or link to website

https://faculty.iitmandi.ac.in/~arko/

Relevant publications (optional)

Phys. Rev. A 107, 043301 (2023)[https://journals.aps.org/pra/abstract/10.1103/PhysRevA.107.043301]; Phys. Rev. Lett. 130, 220403 (2023) [https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.130.220403]; Phys. Rev. A 109, 033319 (2024)[https://journals.aps.org/pra/abstract/10.1103/PhysRevA.109.033319]

Career stage

Professor

Author: ROY, Arko (IIT Mandi)

Presenter: ROY, Arko (IIT Mandi)

Track Classification: FINESS