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Finite range interaction Gaussian as a probe for harmonically trapped Bose gas in effective quasi-two dimensions

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A system of harmonically trapped N=16 spin-0 bosons in quasi-2D symmetrical x-y plane interacting repulsively via a finite range Gaussian potential is studied under an externally impressed rotation about the stiffer z-axis. The exact diagonalization of N-body Hamiltonian matrix in each subspace of quantized total angular momentum 0<L<4N is performed beyond the Lowest Landau level approximation [1]. We considered the interaction-range parameter σ =0.30, 0.50 and 0.75 to study the finite-range effects on the many-body ground state of the rotating system. It is observed that with increase in interaction range σ, the quantum mechanical coherence extends over more and more particles within the system size resulting in an enhanced stability of the ith vortical state with angular momentum L(Ωci) leading to a delayed onset of the next vortical state L(Ωc(I+1)) w.r.t rotational angular velocity. For a given vortical state, there is an increase in the critical angular velocity L(Ωci) with increasing σ. There is decrease in length of plateaus with increasing σ in stability line. We observed that more number of stable micro-plateaus evolved with increases in the interaction range σ. We also observed that the nucleation of vortical states is independent of interaction range σ. With increase in σ, there is no notable change in von-Neumann entropy (S1) [2] and the degree of condensation (Cd) in the slow-rotating regime 0< L< N; however, for moderately rotating regime with L< 2N, the significant variation in S1 and Cd are observed [3]. Quantitatively, the degree of condensation increases and von-Neumann entropy decreases for increasing σ. We also have observed that there is cross-over in von-Neumann entropy S1 (degree of condensation Cd) over interaction range σ for given angular momentum L-state. We also plot iso-surface density plots for conditional probability to study the nucleation of vortex states. Which is one of the signatures of rotating Bose gas, we report that with the increase in interaction range σ, the probability density starts accumulation at the edge of vortices and p=2-fold diagonally symmetric state emerged into singly quantized vortical state for the system size [4]. We also noticed that the vortical state entry in the Bose-gas condensate is favored by the higher σ. It is found that the finite-range effect has more impact on the unstable states as compared to stable states for given set of parameters. Subsequently, the breaking of rotational symmetry of the system in the unstable L-states is observed and this effect becomes more prominent at larger values of σ.

References

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