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Bose mixtures at finite temperature: magnetism and condensation phenomena

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I will review recent works on the study of both repulsive and attractive Bose mixtures at finite temperature using exact path-integral quantum Monte-Carlo numerical methods. Repulsive mixtures in the quantum degenerate regime undergo a first-order ferromagnetic transition as a function of the interspecies coupling constant. The magnetic behavior close to the point of phase separation is found to contradict predictions based on mean-field and perturbative theories. Attractive mixtures are investigated focusing on the regime of interspecies interactions where the ground state is in a self-bound liquid phase, stabilized by beyond mean-field effects. Calculations of the isothermal curves in the pressure vs density plane are reported for different values of the attraction strength and the extent of the coexistence region between liquid and vapor is established. A similar behavior is observed both in 3D and 2D geometries. In particular, the transition to the superfluid state occurs in a discontinuous way as the density jumps from the gas to the liquid phase. Furthermore, in 3D, the line of first-order transition terminates at a tricritical point and in 2D a relevant role in the gas-liquid transition is played by the quantum scale anomaly. The experimental relevance of these findings is also discussed.

References:

1) Phase separation in binary Bose mixtures at finite temperature, G. Spada, L. Parisi, G. Pascual, N. G. Parker, T. P. Billam, S. Pilati, J. Boronat and S. Giorgini, SciPost Phys. 15, 171 (2023).
2) Attractive solution of binary Bose mixtures: liquid-vapour coexistence and critical point, G. Spada, S. Pilati and S. Giorgini, Phys. Rev. Lett. 131, 173404 (2023).
3) Quantum droplets in two-dimensional Bose mixtures at finite temperature, G. Spada, S. Pilati and S. Giorgini, preprint, arXiv:2405.09368.

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