ICCUB

EXCELENCIA MARÍA DE MAEZTU

Institut de Ciències del Cosmos
UNIVERSITAT DE BARCELONA

Functional renormalization for Bose-Bose mixtures

Felipe Isaule
fisaule@icc.ub.edu
Institute of Cosmos Sciences
Universitat de Barcelona

F. Isaule, I. Morera, A. Polls and B. Juliá-Díaz, arXiv:2011.00487 (2020)

Exploring Quantum Many-Body Physics with Ultracold Atoms and Molecules

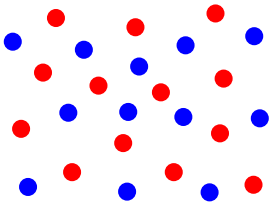
December 14, 2020

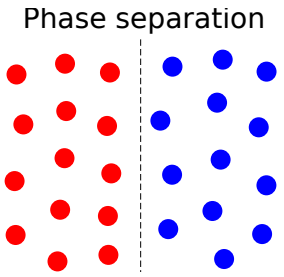
Bose-Bose Mixtures

- Gases with two species of bosons have attracted significant attention in recent years
- Interplay between the two components leads to rich physics:
  - Superfluid drag
  - Phase separation (repulsive inter-species interaction)
  - Self-bound droplets (attractive inter-species interaction)

    D. Petrov, PRL **115**, 155302 (2015)
- Bose-Bose mixtures have been achieved experimentally with cold-atom gases

  T.-L. Ho and V. B. Shenoy, PRL **77**, 3276 (1996)
- They have been studied with a variety of theoretical approaches

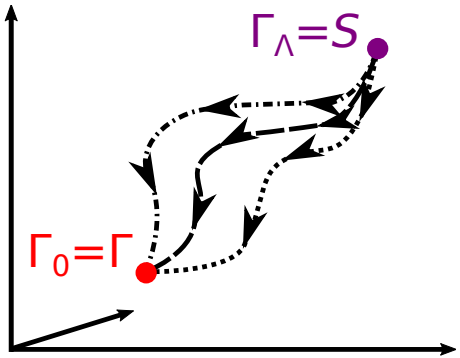




Functional renormalization group (FRG)

- Non-perturbative technique within field theory where the effective action Γ is obtained by means of a RG equation.
- Quantum and thermal fluctuations are gradually incorporated.
- FRG is used in a variety of fields. Particularly useful to study strongly-correlated systems, universality and criticality.

N. Dupuis *et al.*, arXiv:2006.04853 (2020).



- It has successfully described cold quantum gases in different configurations: One-component Bose gases, Fermi gases (BCS-BEC crossover), optical lattices.
- We study balanced and repulsive Bose-Bose mixtures at zero temperature.

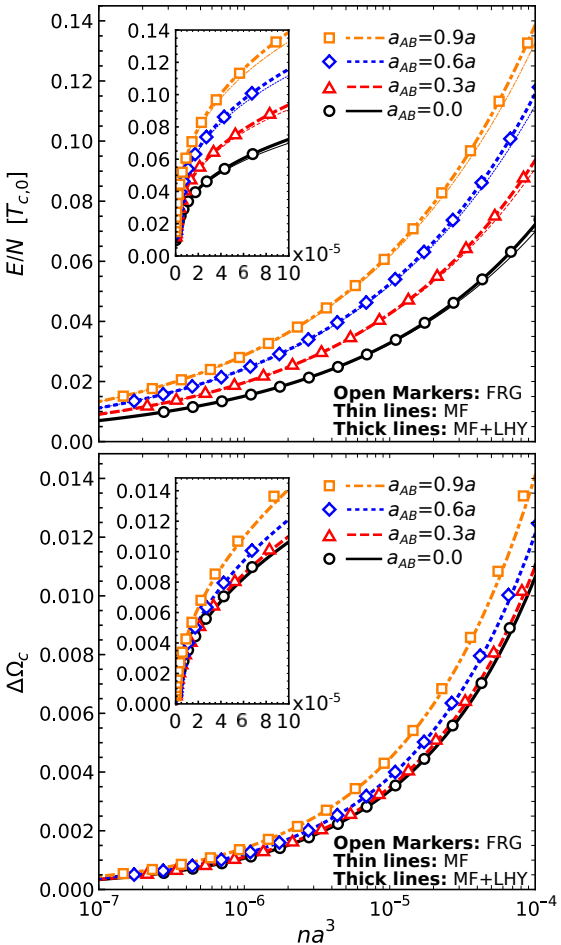
$$\Gamma = \int_x \left[\psi_a^\dagger \left(S\,\partial_\tau - \frac{Z}{2m}\nabla^2 - V\,\partial_\tau^2 \right) \psi_a - \frac{\lambda_{ab}}{2}(\rho_a - \rho_0)(\rho_b - \rho_0) \right], \qquad \rho_a = \psi_a^\dagger \psi_a, \qquad a, b = A, B$$

$\langle \rho_a \rangle = \rho_0$: Condensate density

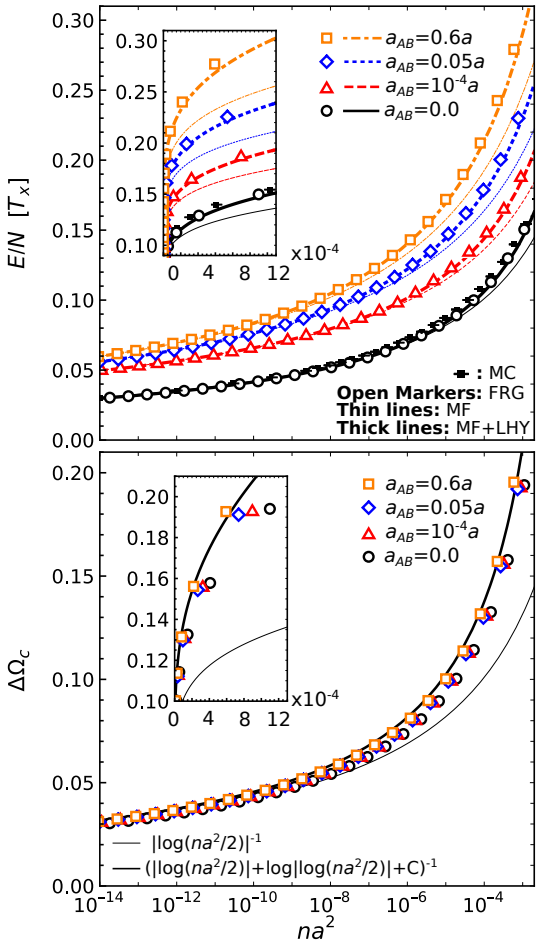
Inputs: μ, a, a_{AB}

Results

d=3



d=2



Conclusions and future work

- We have studied repulsive and balanced Bose-Bose mixtures with the FRG
- Macroscopic results compare favorably with other approaches
- Future work:
  - Attractive Bose-Bose mixtures: liquid phase, dimerization, strongly-interacting regime, effect of three- and more-body correlations
  - Bose-Fermi mixtures
  - Bose polaron