Two-Component Bose Mixtures: Mean-Field Theory and Functional Renormalisation Group

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The Wetterich equation

$$\partial_k \Gamma_k[\phi] = \frac{1}{2}\,\mathrm{Tr}\left[\left(\Gamma_k^{(2)}[\phi] + R_k\right)^{-1} \partial_k R_k\right].$$

3D Quantum LPA

LPA with field expansion

$$\Gamma_k = \int d\tau \int d^d x \sum_{i=1}^{2} \phi_i^* \left(\partial_\tau - \frac{\nabla^2}{2m}\right)\phi_i + U_k(\rho_1, \rho_2)$$

Field expansion of U

$$U_k(\rho_1,\rho_2) = \sum_{i=1}^{2} \frac{\lambda_{i,k}}{8}(\rho_i - \kappa_{i,k})^2 + \frac{\lambda_{12,k}}{4}(\rho_1 - \kappa_{1,k})(\rho_2 - \kappa_{2,k}), \qquad \rho_i = |\phi_i|^2 .$$

2D, classical DE(2)

DE(2) with field expansion. Defining $\boldsymbol{\rho_i = |\phi_i|^2}$ and $\mathbf{j}_i = \phi_i^* \nabla \phi_i - \phi_i \nabla \phi_i^*$,

$$\Gamma_k = \int_x d^d x \left[U_k(\rho_1,\rho_2) + \sum_{i=1}^{2}\left(\frac{Z_{i,k}}{2}|\nabla \phi_i|^2 + \frac{Y_{i,k}}{8}(\nabla \rho_i)^2\right) + \frac{Y_{12,k}}{4}\nabla\rho_1 \cdot \nabla \rho_2 - \frac{W_{12,k}}{4}\mathbf{j}_1 \cdot \mathbf{j}_2\right],$$

Field expansion of U

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Questions

- Stability of the phase diagram
- Critical Exponents
- Mass-imbalanced and interaction-imbalanced mixtures
- Miscibility Condition beyond mean-field theory

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- BKT fixed pint
- Critical Exponents
- Super-fluid drag