Dynamical Mean-Field Equations for Strongly Interacting Fermi Gas in a Trap

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We derive the time evolution equations at zero temperature for the wavefunctions of the molecular bosons and the fermion pairs in a trapped Fermi gas near a wide Feshbach resonance. The derivation of the equations is based on the variational principle and the BCS-like ansatz state:

$$| \Phi \rangle = \mathcal{N} \int \phi(r) \psi_\uparrow(r) \psi_\downarrow(r') \rho(r,r') \psi_\downarrow(r') d^3r d^3r' \langle \rho |,$$

In deriving the equations, we have assumed that the external trapping potential and the wavefunction of the molecular bosons are spatially slow-varying on the length scale of the size of the fermionic atom pairs, which should be valid over a wide range on the BEC side of resonance, including the resonance point. In the bosonic region ($\mu \leq 0$, where $\mu$ is the chemical potential), the equations will reduce to one that resembles a Gross-Pitaevskii (GP) equation. We solve the stationary ground state of the system at different detunings near the crossover region and self-consistently checked our assumptions. The time evolution equations provide macroscopic description for the wavefunctions of the molecular bosons and of the fermion pairs near the interesting BCS-BEC crossover region. In future studies, these equations can be used to analyze the interesting physics of vortices or the excitation spectrum in the Fermi condensate.

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