Superfluidity of a spin-imbalanced Fermi gas in a three-dimensional optical lattice

M. Fortes[a], R. Mendoza[b], and M.A. Solís[a]

[a]Instituto de Física, Universidad Nacional Autónoma de México, México
[b]Posgrado en Ciencias Físicas, Universidad Nacional Autónoma de México, México

We study fermion pairing in a population-imbalanced mixture of ^{6}Li atomic gas loaded in a three-dimensional lattice at very low temperatures. Using the number equation for each population, the gap equation and the equation for the Helmholtz free energy, we determine the gap, chemical potentials and pair-momentum as functions of polarization. These parameters define the stability regions for a Fulde-Ferrell-Larkin-Ovchinnikov phase; a phase separation region where BCS and normal phases coexist; a Sarma phase when the pair-momentum vanishes, and the transition to the normal phase when the gap disappears. The collective-mode energies are then calculated using a Bethe-Salpeter approach in the general random phase approximation assuming that the system is well described by the single-band Hubbard model. A novel result is that fermionic atomic gas shows a superfluidity behavior revealed by rotonlike minima in the asymmetric collective-mode energy spectrum.

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