Temporal Coherence of a Pair-Condensed Fermi Gas

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A condensate of pairs in an isolated, homogeneous, unpolarised, finite-size spin 1/2 Fermi gas at low nonzero temperature T undergoes with time a phase change with a random component due to coupling to the gas thermal phonons. With the quantum second Josephson relation relating the derivative of the condensate phase operator to the phonon occupation numbers, and linearised kinetic equations giving the evolution of occupation number fluctuations, we shall explain how to access the behaviour of the phase change variance at times much longer than the phonon collision time. The case of a convex phonon branch is similar to the Bose gas case: the leading collisional processes are the Beliaev-Landau 3-phonons processes, and the variance is the sum of a ballistic term and of a delayed diffusive term, whose analytical expressions are given in the thermodynamic limit. The concave case is more exotic. It is analysed at time scales $\ll T^{-9}$, allowing one to restrict to 2 phonons $\to$ 2 phonons small-angle Landau-Khalatnikov processes. The total number of phonons is conserved, and the phonon means occupation numbers at equilibrium can exhibit a negative chemical potential, assumed isotropic. The phase change variance is then the sum of a ballistic term, of a diffusive term, of exotic subsubleading terms and of a constant term. The analytic expression of some of the corresponding coefficients is obtained, as well as the diverging leading behaviour of the other ones when the phonon chemical potential tends to 0. When this chemical potential is 0, the variance sub-ballistic part becomes superdiffusive, with an exponent 5/3 and an exactly-known coefficient. For a nonzero infinitesimal phonon chemical potential, a law is found, interpolating between superdiffusive and diffusive phase spreading. Also, new results are obtained on the phonon Landau-Khalatnikov damping rate, in particular at negative phonon chemical potential [1,2].

References

[1] Y Castin, Compt. Rend. Phys. **20**, 540 (2019)

[2] Y Castin, https://hal.archives-ouvertes.fr/hal-01849311]