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Experimental Verification of the BCS Theory of Superconductivity by Using Persistent Supercurrents

Abstract: According to the BCS theory of superconductivity, the superfluid density must decrease with increasing temperature; a simple experiment with persistent supercurrents in temperature cycles may confirm (or deny) this BCS prediction.

A simple experiment may confirm (or deny) an important prediction of the BCS theory of superconductivity. Imagine, in a mercury ring (superconductivity below T_c=4.15 K) we establish a persistent supercurrent. Then we organize temperature cycles (T-cycles) in the cryostat, from 3 K to 2.5 K and back. According to the BCS theory of superconductivity [1], the pair density decreases at warming, i.e. a not negligible fraction of pairs annihilates; the same fraction of pairs emerges back at cooling. Annihilated pairs lose their ordered supercurrent momentum on the atom lattice, so the supercurrent must decrease at warming; newly created pairs do not experience any electromotive-force (EMF), since the EMF is no longer available in the ring. Hence, according to the BCS theory, the supercurrent must decrease at every T-cycle and dissipate after a number of T-cycles. If the supercurrent remains stable, then the BCS prediction is wrong and the superconducting electron pairs don't annihilate as predicted in [2].

Notably, exceptional experiments for temperature dependence of persistent supercurrents are unknown. However, every cryostat device produces not negligible temperature fluctuations, so every observation of long-lived stable supercurrents may be considered as the experiment with T-cycles. Thus, one can expect that a direct experiment will confirm: the pair density and related supercurrent are independent of temperature.

Do the pairs really annihilate in the eternal supercurrent? Solving this contradiction we unambiguously confirm or deny the BCS theory.

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[1] Bardeen, John; Cooper, Leon; Schrieffer, J. R. *Theory of Superconductivity*. Physical Review 8(5):1178 (1957).
[2] Stanislav Dolgopolov, *Formation of Cooper Pairs as a Consequence of Exchange Interaction*, arXiv:1501.14978 (2015).