

T_CSUH Special Seminar

Texas Center for Superconductivity at the University of Houston

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12:00 Noon – 1:00 p.m.

Supercurrents Through a Ferromagnet, Josephson π - Junctions as Superconducting Phase Inverters

Abstract

It was predicted by Larkin and Ovchinnikov and by Fulde and Ferrel that superconducting pairing can occur when the electron momenta at the Fermi energy are different for the two electron spin directions, for instance as the result of an exchange field in magnetic superconductors. The resulting 'LOFF'-state is qualitatively different from the zero-momentum state: it is spatially inhomogeneous and the order parameter contains nodes where the phase changes by π . The LOFF state was never observed in bulk material, but we present experimental evidence that it can be induced in a weak ferromagnet (F) sandwiched between two superconductors (S). Such an SFS junction can yield a phase shift of π between the superconducting banks. The phase change of the superconducting order parameter in the ferromagnet arises as a response of the Cooper pair, which consists of two electrons of opposite spin and momentum, to the energy difference between two spin directions in the ferromagnet. This shift manifests itself in reentrant superconducting behavior of the critical supercurrent temperature dependence, $I_c(T)$, of the Josephson SFS junction as well as in half-period shift of $I_c(H)$ -dependence of a triangular SFS junction array at point of a transition of the junctions from a "0-" to a " π "- state. The π -state offers fundamentally new ways for studying the coexistence of superconductivity and magnetism and may also be important for superconducting electronics, in particular in quantum computing: several schemes for the realization of the necessary qubits (quantum two level systems) rely on the use of phase shifts of π in a superconducting network.

Bio

Prof. Valery V. Ryazanov is Head of the Laboratory for Superconductivity in the Institute of Solid State Physics of the Russian Academy of Sciences (ISSPRAS) in Chernogolovka. Since 1975, he has investigated experimentally in ISSPRAS different Josephson structures based on the low-temperature and high-temperature superconductors. His Ph.D. and "Doctor of Sciences" theses were related to the study of the novel thermoelectric and nonequilibrium phenomena in multilayered superconducting systems. Recently a new type of Josephson junction, π -junction, was discovered in a superconductor-ferromagnet-superconductor system. He is currently working on the development of superconducting mesoscopic circuits to obtain macroscopic quantum two-level systems for quantum computing.

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