Theory of Proximity Effect in Superconductors and Superfluids

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We discuss theory for the boundary problem in proximity contacts. A good starting point for studying the boundary effects is the Ginzburg-Landau (GL) equation. The GL theory is, however, valid only near the critical temperature. Theories applicable to low temperatures have been reported in the framework of the quasiclassical Green's function. Recently, a spin-triplet superconductor/dirty normal metal junction has attracted much attention. In this system, some unusual properties due to zero-energy bound states were predicted on the basis of the quasiclassical theory [1]. Analogous system can be provided by superfluid ^{3}He partially filled with aerogel. In early quasiclassical theories, which are concerned with dirty s-wave superconductor contacts, Kuprianov and Lukichev (KL) [2] derived the boundary condition for the Usadel equation. The KL boundary condition has been widely used in the studies of the proximity effect. However, this boundary condition is valid only for a low-transmission interface. This was first pointed out by Lambert et al. who proposed a more general boundary condition. Their derivation, however, rely on an idealized model in which the mean free paths and the Fermi momenta on the both side of interface are the same. The boundary condition for the Usadel equation in real proximity system has not yet been established. We discuss the boundary problem in the dirty s-wave superconductors in some detail.

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