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Separate re-entrant superconductivity in asymmetric ferromagnet/superconductor/ferromagnet trilayers

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Abstract

The superconducting and magnetic states of asymmetric ferromagnet/superconductor/ferromagnet (F/S/F′) nanostructures have been investigated using the boundary value problem for the Eilenberger function. It has been shown that 0- and π-phase superconducting states of pure thin F/S/F′ trilayers are controlled by the magnitude and sign of electron correlations in the F and F′ layers, as well as by the competition between homogeneous Bardeen-Cooper-Schrieffer (BCS) pairing and inhomogeneous Larkin-Ovchinnikov-Fulde-Ferrell (LOFF) pairing. The LOFF-BCS-LOFF separate re-entrant superconductivity has been predicted for F/S/F′ trilayers. A continuous control of the pair-breaking factor in the Eilenberger function and transition to the state with re-entrant superconductivity is achieved by varying the thickness of the F′ layer. Sine-modulated 2D LOFF states in asymmetric F/S/F′ trilayers are possible not only for parallel, but also for antiparallel orientations of the magnetizations of the F and F′ layers; this fact significantly facilitates the experimental implementation of the predicted phenomena.

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