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Anomalous Josephson effect in $d_{x^2-y^2}/F/I/F/d_{xy}$ junctions

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We study a quasi two-dimensional Josephson junction of d-wave superconductors through two ferromagnetic layers in between. Ferromagnets are separated by isolator barrier. In the frame of Bogoliubov –de Gennes formalism we solve scattering problem to find current-phase relations in the case of $d_{x^2-y^2}$/ferromagnetic barrier/d_{xy}-wave superconductor junctions. We find that current-phase relation is anomalous, $I(\varphi = 0)$ 0, with $I(\varphi) = -I(-\varphi + \pi)$, and has 2π periodicity. Also the net Josephson current can be separated in two series which are proportional to $\sin\ (2n\varphi)$, and $\cos\ ((2n-1)\varphi)$, for n 1. These two components of Josephson current exhibit phase transition from coegsistence of 0 and π states to $\pi/2$ state of junction and vice versa with increasing of ferromagnetic layer thickness but for different values of thicknesses. We observed nonmonotonous temperature dependence of critical current through this junction with finite interface transparency between ferromagnets. This result gave a possibility of junction phase transition with changing a temperature. Influence of cos part of Josephson current is significant on higher temperatures.

References:

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