Influence of proximity effect with Umklapp processes on the Josephson current in the SFS nanostructure

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We consider the Josephson effect in symmetric superconductor-ferromagnetic-superconductor (SFS) system. The Josephson current is calculated as a function of the ferromagnetic layer thickness d_f. The Fulde-Ferrell-Larkin-Ovchinnikov (FFLO) pairs in the F layer have a nonzero wave vector, and the transformation the BCS pairs to the FFLO pairs (and vice versa) at passing through SF (FS) borders may be proceeded through the Umklapp processes[1]. To estimate the influence of proximity effect we use the expansion of superconductor energy in the powers of an order parameter (near the critical temperature T_c). We take into account the dependence of the critical temperature T_c from the phase difference φ between the order parameter in the left and right S side of the SFS contact, respectively, i.e. $T_c = T_c(\varphi) = T_{c\varphi}$. The result expression for critical current incorporates a term proportional to $T_{c0} - T_{c\pi}$ which gives the main contribution near T_c. Our results are compared with known data for the $NbCu_{0.47}Ni_{0.53}Nb$ nanostructures[2] where the critical Josephson current oscillations due to transitions between 0 and π phase state were observed. A good agreement is obtained by taking into account the Umklapp processes.

[1]Yu. A. Izyumov, Yu. N. Proshin, and M. G. Khusainov, Physics/Uspekhi **45**, 109 (2002).
[2]V.V. Ryazanov et al., Rev. Low Temp. Phys. **136**, 385 (2004).