

Stationary Josephson effect as a tool to reveal charge-density-wave gapping in cuprates

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The theory of the stationary Josephson tunnel current I_c is proposed for junctions involving d -wave superconductors partially gapped by biaxial or unidirectional charge density waves (CDWs). Specific calculations were carried out for symmetric and non-symmetric junctions. Allowances were made for the directionality of tunneling. The dependences of I_c on the angle γ between the chosen crystal direction and the normal to the junction plane were found to be significantly influenced by CDWs.

It was shown in particular that the d -wave driven periodicity of $I_c(\gamma)$ in the CDW-free case is transformed into double-period beatings depending on the parameters of the system. The results of calculations testify that the orientation-dependent patterns $I_c(\gamma)$ measured for CDW superconductors allow the CDW configuration (unidirectional versus checkerboard) and the symmetry of superconducting order parameter to be determined. The predicted effects can be used to indirectly reveal CDWs in underdoped cuprates where pseudogaps are observed, which we consider as a consequence of the CDW appearance.

[1] A. M. Gabovich, M. S. Li, H. Szymczak, A. I. Voitenko, *Phys. Rev. B* **87**, 104503 (2013).