ESF PiShift Workshop

Josephson Junctions: Basic Studies and Novel Applications

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Engineering of Josephson junctions with predetermined properties

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The current status of theoretical understanding of stationary properties of Josephson junctions with ferromagnetic interlayers is briefly reviewed with emphases on physical mechanism leading to formation of π-junctions and structures with peculiar current- phase relationship. The possibility of experimental realization of SFIFS tunnel junctions and SFcFS constrictions are discussed. Potential reliable ferromagnetic materials are suggested. The possibility of engineering of Josephson junctions with predetermined peculiar current-phase relationship based on SFIFS and SFcFS structures are discussed. It is shown that engineered junctions may have a ground state at arbitrary value of phase difference across the junction.

Coherence and nonequilibrium effects in SINIS junctions

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Josephson supercurrent in ballistic double-barrier Josephson junctions can be understood in terms of the interplay between transmission resonances and Andreev Bound States. A universal, coherent regime exists when the transmission resonance width is large as compared to the Andreev states. Then, the supercurrent is linear in transparency. For a more narrow transmission resonance, the electrons and holes dephaze, resulting in a supercurrent that is quadratic in transparency.
In addition to ballistic interlayer transport, also diffusive interlayer transport is modeled. The current-phase relation of double-barrier junctions will be discussed and the question will be addressed whether or not it is possible to realize a SINIS pi-junction.
The nonstationary and nonequilibrium effects in double-barrier junctions can be derived from a Keldysh Green's function approach. One intriguing effect that will be discussed is the existence of a nonzero averaged supercurrent at a finite voltage bias. Furthermore, it will be shown that inelastic scattering in the interlayer of double-barrier junctions does play an important role, in contrast to most other known mesoscopic systems. As an application of the theoretical ideas we will answer the question about the nature of the intrinsic shunt in double-barrier junctions by deriving relevant transport parameters from experiments.