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Allgemeines Physikalisches Kolloquium

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Online-Kolloquium

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Interplay between superconductivity and spin-dependent fields in nanostructures: Superconductivity meets Spintronics

The past decades have witnessed an extraordinary progress in understanding the interplay between superconductivity and magnetism in hybrid devices. Starting in 2001 with the first realisation of ferromagnetic Josephson pi-junctions [1] and the almost simultaneous prediction of triplet superconducting correlations in ferromagnet /superconductor structures [2], superconductivity and ferromagnetism are no longer considered as competing phenomena but rather as sources of new emergent states and effects when combined. More recently the field of superconductivity with spin-dependent fields has been extended to the study of topological superconductivity [3] and non-equilibrium effects [4].

In this talk I review the main aspects of superconductivity in the presence of spin-dependent fields, as exchange field and intrinsic spin-orbit coupling (SOC), from a theoretical perspective. I focus on equilibrium effects in hybrid superconducting systems related to the coupling between the singlet and triplet components of the superconducting condensate [5] and its analogy to the charge and spin coupling in normal systems with strong SOC [6], which exhibit the Spin-Hall and the Edelstein (EE) effects [7].

I discuss the counterpart of these magnetoelectric effects in bulk and 2D superconductors as well as in realistic Josephson junctions, by introducing the quantum kinetic equations describing the superconducting state. As an application I discuss the recent realization of a “phase battery” consisting of a semiconducting nanowire embedded into a superconducting loop [8].

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