SFB-Kolloquium

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Ort: PHY 9.2.01

Zeit: Dienstag, 22. Oktober 2019, 14.15 Uhr

Thema: Topological Superconductivity in Phase-Controlled Josephson Junctions

Abstract
The search for Majorana bound states has been one of the most intense topics of research in condensed matter physics during the past decade. Recent experimental progress in proximity-inducing superconductivity in two-dimensional systems points to possible alternatives to setups based on one-dimensional wires. Among these proposals, those based on phase-controlled Josephson junctions with strong spin-orbit coupling (SOC) offer an attractive alternative [1]. A key advantage of this proposal is the tunable superconducting phase difference, which serves as an additional knob to control the topological transition and offers the prospect of avoiding experimentally difficult fine-tuning like the one required in wires.

Here, we first discuss the conditions for the formation of a topological superconducting phase hosting Majorana bound states in phase-controlled Josephson junctions. We elucidate how Josephson junctions with an arbitrary combination of SOC can host Majorana bound states for a wide range of parameters as long as an appropriately oriented in-plane magnetic field is applied [2]. Moreover, we study the topological phase diagram and the optimal conditions to observe Majorana bound states. Finally, we discuss recent experiments that point to the observation of a topological phase transition in a Josephson junction made of a HgTe quantum well well coupled to thin-film aluminium [3].