

Kondo Effects in Quantum Dots Coupled to Superconducting Leads

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We study Kondo effect in a quantum dot coupled to two superconducting leads, which has recently been realized experimentally [Buitelaar et al., Phys. Rev. Lett. 89, 256 801 (2002)]. We discuss the proximity effect, Josephson current, and zero- π -junction phase transition based on the numerical renormalization group analysis. The system undergoes a phase transition from a π -junction to zero-junction as the superconducting gap decreases. The phase transition occurs when the gap is similar to the Kondo temperature in the normal state. Across the transition point, the Josephson current-phase relation (as well as the sign) changes drastically. The proximity induced pairing potential on the quantum dot also changes its sign.