Enhanced Kondo effect in two-dimensional helical electrons

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The effect of spin-orbit (SO) interactions in an electron system in the presence of a magnetic impurity in the Kondo regime has remained controversial for more than forty years [1]. Much of the difficulty in approaching the problem becomes evident when considering the Anderson Hamiltonian: the presence of SO interaction breaks the SU(2) spin symmetry considered essential for the Kondo effect. Recent works have addressed the issue with conflicting results: while some predict no essential change in the Kondo physics [2], there are indications that an exponential increase of the Kondo temperature could be achieved [3]. We address the question by analyzing the Kondo limit of an Anderson Hamiltonian for a 2DEG with Rashba SO interactions and a local spin ½ magnetic impurity. By means of an energy-dependent Schrieffer-Wolff transformation we obtain the effective Hamiltonian in the Kondo regime. As SO interactions inherently mix orbital and spin angular momenta, they preclude the use of spin as a good quantum number, which affects the resulting Kondo state. This is captured by the appearance of a Dzyaloshinsky-Moriya (DM) term in the Kondo Hamiltonian, which imparts a non-collinear magnetic interaction on the ground state.

In this paper, we present a study of this problem with numerical renormalization group (NRG) methods, revealing that the strength of the SO interactions determine two well defined regimes for Kondo physics. In agreement with previous studies, we find only minor changes in the Kondo temperature scale when the Rashba coupling is increased at *fixed Fermi energy*. However, for *fixed band filling*, increasing the SO coupling can move the Fermi energy near a Van Hove singularity in the effective density of states, leading to an exponential enhancement of the Kondo temperature. In this *helical* regime (where only one branch of the dispersion is accessible near the Fermi energy), static spin correlations confirm that the impurity couples to conduction channels of nonzero orbital angular momentum and convey an intrinsic spiral structure to the relative spin alignment of the reservoir electrons and the magnetic moment of the impurity.

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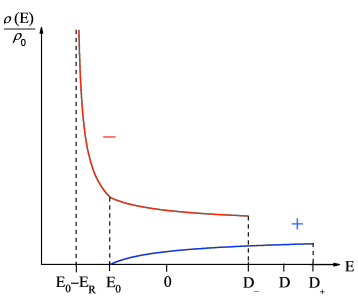

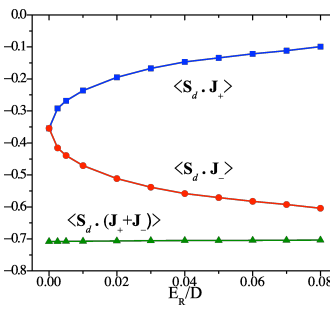

Fig. 1. Left panel: DOS for 2DEG in the presence of Rashba SOI. Red and blue curves indicate different chirality value (− or +). Notice Van Hove singularity of − channel near bottom of band at E_0-E_R. Right panel: Spin correlation amplitude per channel in Kondo in chiral regime.