Experimental mapping of the quantum phase diagram for the two-impurity Kondo effect

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Abstract

Quantum phase transitions are governed by competing interaction parameters in the Hamiltonian of a physical system. They are of fundamental conceptual interest but nontrivial to realize experimentally. The two-impurity Kondo effect provides an appealing system to verify theoretical predictions of an interesting and nontrivial quantum phase transition. In a conduction electron Fermi sea containing dilute magnetic moments, the local magnetic moments can be screened by the spins of conduction electrons, leading to a Kondo-screened ground state at zero temperature. The local magnetic moments can also interact with each other, leading to a RKKY-coupled ground state. Theory predicts that a quantum critical point separates these two ground states and evolves into a quantum critical regime at finite temperatures. We demonstrate that the experimental mapping of the quantum phase diagram for the two-impurity Kondo effect is possible by using an Al/AlOx/M tunnel junction system with a selected transition metal M. In our design, a few M atoms situating at the AlOx/M interface act as local magnetic moments and cause the exotic Kondo effect with an induced magnetic quantum phase transition.

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