Probing the Kondo cloud in a quantum dot : finite-size effects and barrier symmetry

Diego Fossion[1]
B. Brun-Barrière[2], V. Champain[2], U. Genser[3], D. Mailly[3], X. Jehl[2], S. De Franceschi[2], L. Janssen[2], H. Sellier[1]

[1] Univ. Grenoble Alpes, CNRS, Institut Néel, 25 avenue des Martyrs, 38000 Grenoble, France
[2] Univ. Grenoble Alpes, CEA, Grenoble INP, IRIG-Pheliqs, Grenoble, France
[3] CNRS, C2N, 10 Boulevard Thomas Gobert, 91120 Palaiseau, France

diego.fossion@uclouvain.be

The Kondo effect is a many-body effect, initially observed in metals containing magnetic impurities. The localized spin of the impurity is gradually screened by the spin of the conduction electrons, forming, at temperatures below the Kondo temperature T_K, a many-body singlet. This phenomenon is also observed in quantum dots [1,2], with an odd number of electrons, leading to the presence of a localized spin that mimics that of a single magnetic impurity. Theory predicts that the many-body singlet is not limited to the quantum dot but extends over a characteristic length ξ_K [3], forming a so-called Kondo cloud of correlated electrons.

In this work, we investigate a GaAs/AlGaAs quantum dot in the Kondo regime using RF reflectometry (Figure 1). The Kondo cloud is probed by embedding the dot next to an electronic Fabry-Pérot cavity of comparable length to affect the Kondo temperature by finite-size effect. We demonstrate how the cavity allows for modulating the Kondo temperature via density-of-state modulations at the Fermi level [4,5]. We also study the effect of symmetry of the coupling to the reservoirs on the amplitude of the modulations, as well as on the subtle relationship between the Kondo temperature and the Kondo conductance (Figure 2). These results provide insight into the properties of the strongly-correlated electron cloud that forms around degenerate localized states via the Kondo screening mechanism.

References

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Figures

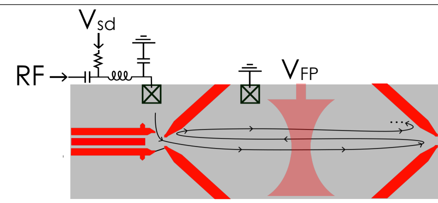

Figure 1: Schematic of a quantum dot coupled to a Fabry-Pérot cavity in a 2DEG. A middle gate (V_{FP}) tunes the interference pattern by locally modifying the electron wavelength without depleting the 2DEG, instead of varying the cavity size.

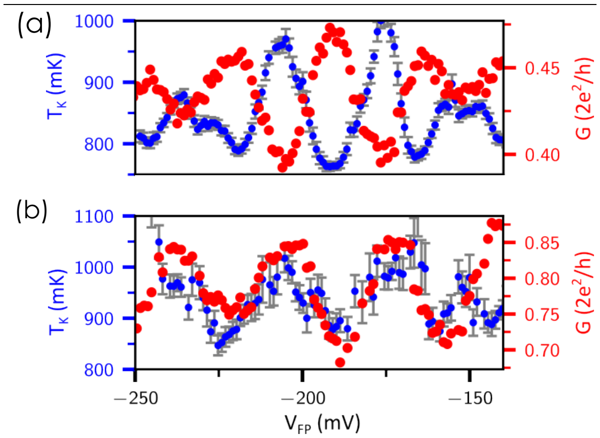

Figure 2: Oscillations of the Kondo temperature (T_K) and conductance in a quantum dot coupled to a Fabry-Pérot cavity. (a) In the regime where the dot is strongly coupled to the cavity, the resonance condition tuned via V_{FP} induces conductance oscillations (red) and oscillations of T_K (blue) due to density-of-states modulations at the Fermi level. In this case, the conductance and T_K oscillations are out of phase. (b) In the regime where the dot is weakly coupled to the cavity, the conductance (red) and T_K (blue) oscillations are in phase.