How to directly measure Kondo cloud's length

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The Kondo effect in a quantum dot has been intensively studied over the last decade. Tunability of a quantum dot has enabled to clarify the various aspects of the Kondo effects. Although the Kondo effect is well known, its spatial features still remain to be addressed. The Kondo singlet between the impurity spin and a conduction electron is formed over an extended conduction electron region, called the screening cloud. The size of Kondo screening cloud is $\xi_K = \hbar v_F / T_K$, where T_K is the Kondo temperature and v_F is the Fermi velocity. There have been several proposals for ways to detect the cloud, but no one has experimentally deteted it yet.

We theoretically propose how to directly detect the size ξ_K of the Kondo cloud, based on the intution that a change of conduction electrons inside the Kondo cloud will affect the Kondo effect [1]. We consider a quantum dot at $x = 0$ coupled to two semi-infinite wires with tunneling amplitude t_{WD} (Figure 1). Gate voltages V_g are applied to the wires beyond distance L from the dot (in $|x| > L$). We find that when $L \gg \xi_K$, V_g negligibly affects the cloud. However, when $L \ll \xi_K$, the Kondo temperature T_K is sensitive to V_g. By measuring the conductance or T_K with varing L or t_{WD}, one can detect the crossover and hence ξ_K. We analyze the system using the poor man scaling, the numerical renormalization group study, and the Fermi liquid theory.

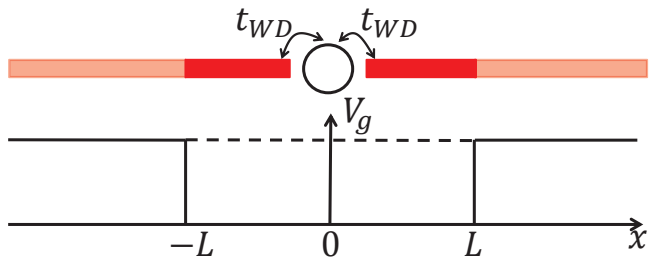

Figure 1: A quantum dot couples to quantum wires along $\hat{x}$ axis, with electron tunneling amplitude t_{WD}. Gate voltage V_g is applied over distance L from the dot (in $|x| > L$). The Kondo effect becomes sensitive to V_g, as L decreases below the cloud size.

[1] Jinhong Park, S.-S. B. Lee, Yuval Oreg, and H.-S. Sim, arXiv:1210.6138.