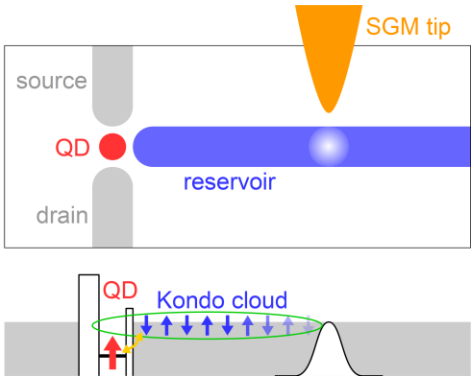
NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2019-2020

Kondo-cloud extension around quantum dots

General scope:
Known for a long time in metals with magnetic impurities, the Kondo effect has shown a revival in the context of semiconductor quantum dots (QD). This many-body effect results from the dynamical screening of an unpaired electron spin by the conduction electrons of the reservoirs. Remarkably, the transmission through this coherent Kondo state is perfect, and all the physical quantities are characterized by a single characteristic scale T_K. According to theory, the conduction electrons involved in this process should form a screening cloud around the localized spin with a characteristic length scale ξ_K. The objective of the project is to demonstrate the existence and to measure the spatial extension of this "Kondo cloud" which is predicted to extend over several microns.

Research project:
The originality of the project is to use scanning gate microscopy (SGM) to vary continuously the size of the electron reservoir hosting the Kondo cloud of the QD. The modulations of the Kondo resonance due to interference in the tip-induced finite-size reservoir will be measured via two weakly-coupled leads. The dependence of these modulations with the reservoir size will provide an experimental determination of the Kondo length. This length will be studied as a function of temperature, parallel magnetic field, and tunnel coupling to the screening reservoir.



Collaboration and networking:
The M2 student will work in the QNES team of the Néel Institute and perform the SGM experiments. The QD devices in GaAs/AlGaAs heterostructures will be fabricated by collaborators at C2N in Paris. The student will also interact with researchers at the CEA-Grenoble for some of the transport measurements, and with a theoretical group at the Néel Institute.

Extension as a PhD:
A PhD grant is available on this project, which is funded by the ANR grant KONEX 2019-2023. The objective of the PhD thesis will be to develop further the above-mentioned experiments, and then to study the Kondo cloud extension in more complex samples containing two distant QDs, coupled to a common reservoir, and sharing the same Kondo cloud. A few SGM experiments at very-low temperature will also be performed with collaborators at IMCN in Belgium to probe the Kondo cloud in the strong coupling regime.

Required skills:
The student should follow a master program in condensed matter physics, quantum physics, or nano-physics, with lectures on quantum transport and advanced quantum mechanics. He/She should be highly motivated by working on a fundamental research topic, and by doing delicate experiments at low temperature.

Starting date: February or March 2020
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