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Quantum impurity simulator operating in the fractional quantum Hall regime

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It is well-known that a single-electron transistor (SET) device provides a perfect playground for simulating various quantum impurity models, a class of systems defined by the finite number of local degrees of freedom coupled to one or few bath continua. This is due to the Coulomb blockade phenomenon that is the origin of the charge quantization in the quantum dot (QD). Recently, the charge implementation of the multi-channel Kondo model has been achieved in breakthrough series of experiments [1, 2]. The device in [1,2] has been designed in a hybrid metal-semiconductor SET formed in a two-dimensional electron gas, where the QD is connected to few reservoirs via nearly open single-mode quantum point contacts (QPC). In contrast with the original spin-1/2 impurity problem, where Kondo effect is attributed with the spin degree of freedom, the quantum pseudo-spin in the charge Kondo implementation is represented by two degenerate macroscopic charge states of the QD [3,4]. Together with the high tunability of the one-dimensional (1D) conducting channels entering the QD, this provides access to the study of the multi-channel Kondo physics.

In this talk, I will discuss how electron-electron interactions in 1D conducting channels in the presented above device affect the Kondo physics. To cover effects of interaction, I utilize the Luttinger-liquid model. In real experiment [1,2], effects of Luttinger-liquid may be observed if the hybrid metal-semiconductor SET device will operate in the fractional quantum Hall regime with filling factor $\nu = 1/m$, where m is odd integer. In case of two-terminal SET, when the problem is mapped onto the 2-channel charge Kondo model, I predict that the power of leading temperature correction to the conductance is determined by the fractional filling factor. In case of the multi-terminal setup, the SET device can be treated as the simulator of the Luttinger-liquid with an impurity, whose effective interaction parameter is determined by the filling factor ν and number of open ballistic channels. I will discuss the conductance scaling in the weak and strong tunnel regimes in order to characterize the low temperature transport behavior of the multi-channel charge Kondo circuits.

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