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Quantum criticality in hybrid nanostructures

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I will present our recent results on quantum critical behavior in hybrid nanoscale systems, such as quantum dots and molecules, coupled to normal and superconducting electrodes. In such systems, the ground state is conditioned by the competition between the Kondo screening and superconducting proximity effect, giving rise to rich phase diagrams. For single quantum dots, the phase transition occurs between the BCS and Kondo phases, accompanied by a characteristic behavior of the correlation cloud [1]. On the other hand, double quantum dot systems turn out to be convenient platforms for the realization of the so-called Andreev molecules, characterized by competing singlet, doublet and triplet phases [2]. Furthermore, quadruple quantum dots enable the exploration of the Nagaoka ferromagnetism and, when attached to superconducting contacts, allow for studies of the interplay between ferromagnetism and proximity effect [3]. In addition to the static properties of the considered systems, we also shed light on the dynamical behavior, in particular, exploring the dynamical quantum phase transitions, i.e. phase transitions which emerge in time evolution following an abrupt change of the system parameters [4]. Our considerations are performed using the state-of-the-art numerical renormalization group methods, which allow for accurate non-perturbative examinations of correlation effects in the considered hybrid systems. Our results provide thus an important insight into the physics of hybrid nanostructures, relevant among others for the implementation of quantum bits and Kitaev chains based on quantum dots.

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