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Spin qubits in semiconductor and graphene quantum dots

Quantum dots formed both in semiconductor and carbon-based structures have been under intense experimental and theoretical investigation as a potential host material for spin qubits. The first part of this talk will cover recent challenges for semiconductor-based spin qubits, mainly originating from the hyperfine coupling to a large number of nuclear spins. We present a new theoretical model for nuclear-spin preparation in a two-electron double-dot system, as well as coherent manipulation of a singlet-triplet T+ qubit, based on Landau-Zener-Stückelberg transitions. The second part of the talk will be on graphene which has recently emerged as an interesting alternative material for spin qubits, due to the low concentration of nuclear spins and relatively weak spin-orbit coupling. We discuss the formation of quantum dots in extended graphene, being a non-trivial problem due to the absence of a band gap and the effect of Klein tunneling. Further issues such as the role of the valley degeneracy, hyperfine interactions with 13C nuclear spins, as well as spin-orbit induced spin relaxation for spin qubits in graphene will be discussed.

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