Spin qubits in graphene and carbon nanotubes

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We show how to form spin qubits in carbon-based materials like graphene and single-wall carbon nanotubes. For the former system, we discuss a new type of long-distance coupling for solid-state spin qubits that is possible because of the narrow-gap and highly electron-hole-symmetric spectrum in graphene nanoribbons. For the latter system, we analyze spin relaxation due to spin-orbit interaction (SOI) and electron-phonon coupling. It turns out that the interplay of SOI in combination with the one-dimensional nature of nanotubes results in a complex behavior with an extremely wide range of relaxation rates. Most remarkably, at zero magnetic field, the spin-orbit interaction induces a zero-field splitting in the energy spectrum. We show that this opens the door for an all-electrical control of spin in nanotube quantum dots.