High-fidelity optical quantum gates based on type-II double quantum dots in a nanowire

We propose an optical gating scheme for quantum computing based on crystal-phase type II double quantum dots in an InP nanowire. The qubit is encoded on the electron spin and the gate operations are performed using stimulated Raman adiabatic passage (STIRAP), using the orbital degree of freedom in double quantum dots to form an auxiliary ground state. Successful STIRAP gating processes require an efficient coupling of both qubit ground states of the double quantum dot to the gating auxiliary ground state, and we demonstrate that this can be achieved using a charged exciton state. Crucially, by using type II dots, the hole is localized between the two spatially separated electrons in the charged exciton complex, thereby efficiently coupling the electron ground-state orbitals. By taking advantage of the high-fidelity state transfer by means of STIRAP in type II double quantum dots, we propose a protocol for coherently manipulating the spin-orbital quantum state of confined electrons in a quantum dot chain of an InP nanowire. We subsequently exploit the protocol to realize single- and two-qubit gates with fidelity above 0.99.