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Holonomic Quantum Computation with Electron Spins in Quantum Dots[1] MASSOUD BORHANI, SUNY at Buffalo, VITALY GOLOVACH, LMU Munich, DANIEL LOSS, University of Basel — With the help of the spin-orbit interaction, we propose a scheme to perform holonomic single qubit gates on the electron spin confined to a quantum dot. The manipulation is done in the absence (or presence) of an applied magnetic field. By adiabatic changing the position of the confinement potential, one can rotate the spin state of the electron around the Bloch sphere in semiconductor heterostructures. The dynamics of the system is equivalent to employing an effective non-Abelian gauge potential whose structure depends on the type of the spin-orbit interaction. As an example, we find an analytic expression for the electron spin dynamics when the dot is moved around a circular path (with radius R) on the two dimensional electron gas (2DEG), and show that all single qubit gates can be realized by tuning the radius and orientation of the circular paths. Moreover, using the Heisenberg exchange interaction, we demonstrate how one can generate two-qubit gates by bringing two quantum dots near each other, yielding a scalable scheme to perform quantum computing on arbitrary N qubits. This proposal shows a way of realizing holonomic quantum computers in solid-state systems.

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