Exact non-adiabatic holonomic spin-orbit qubit manipulation

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We will present exact solutions for an electron in a quantum wire with time dependent spin-orbit interaction and driven by external time-dependent potential [1,2]. The corresponding geometric Anandan phase or in the adiabatic limit the Wilczek-Zee phase will be given analytically.

Next the result will be generalized and an exact solution will be presented for the time-dependent wavefunction of a Kramers doublet which propagates around a quantum ring with tuneable Rashba spin-orbit interaction [3]. By propagating in segments it will be shown that Kramers-doublet qubits may be defined for which transformations on the Bloch sphere may be performed for an integral number of revolutions around the ring. Prospects and challenges for possible realizations will be discussed for which rings based on InAs quantum wires are promising candidates [4].

Various types of potential noise in gates controlling non-adiabatic holonomic transformations of spin-qubits will be presented. It will be shown how exact results can be derived for deviations of spin rotation angle and fidelity of the qubit transformation. It will be demonstrated how the drivings can be tuned to optimise the final fidelity of the transformation and to minimise the variances of the qubit transformation [5].

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