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Landau-Zener tunneling and magnetic control of spin qubit in a quantum wire: Dynamic matrix approach

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We study the quantum tunneling of a two-level multi-crossing system in an accelerating one-dimensional optical parabolic potential manifested in a 3D heterostructure magnetic quantum wire. By direct integration using the Dynamic matrix approach (DMA), we establish the time and magnetic field dependencies of the generalized ana-lytic expressions of the survival and transition probabilities, respectively in the presence and in the absence of a harmonic confinement potential. The system causes a modulation of the transition frequency which differs from the one observed in the Landau-Zener (LZ) theory that appear when such magnetic inhogeneity occurs. It is shown that in the absence of a curved confinement and for exceedingly low and extremely high frequencies of the mag-netic field, the phase difference of the two wave packets acquired between subsequent crossings allows us to probe Landau-Zener-St¨uckelberg (LZS) interferometry effects. Otherwise, in the presence of a curved confinement and for low values of the LZ parameter, the system readily exhibits more multi-crossings in the tunneling probabilities. The probe qubit spectrum obtained from this approach can be used to characterize the qubit evolution in the sample while the DMA is used for the modeling of dynamic spins in order to satisfy an optimum control quality with high accuracy.

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