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Effect of the nuclear hyperfine field, and the Dzyaloshinskii–Moriya term on the (swap) α quantum gate

Roberto J Guerrero and **F Rojas**
[1]Universidad Autónoma de Baja California, México
[2]Universidad Nacional Autónoma de México, México

We consider a system of two coupled electronic spins where the Dzyloshinski–Moriya (DM) term is present, imbedded in the magnetic field caused by the surrounding nuclei. In order to describe the statistical effect of the nuclei (Hiperfine field, HF), we consider the system to be under the quasi-static approximation (QSA). The HF will have important consequences on the operation of the $(SWAP)^{1/2}$ gate, utilized in the construction of the CNOT gate. Recently, it has been proposed that a more general two qubit quantum gate, $(SWAP)^{\alpha}$, could be used in place of the CNOT for two qubit gates. It was demonstrated also that $(SWAP)^{\alpha}$ is universal, and equally efficient, in the number of gates used, as the CNOT gate. In this work, we study the effect of the hiperfine field and spin-orbit interactions in the $(SWAP)^{\alpha}$ gate operation. By selecting the area of the exchange J over a period of time, we try to produce the required gate operation; we have calculated dynamical properties of the probability of the two spin states, one spin polarization, entanglement (concurrence) and gate fidelity. We demonstrate that the gate fidelity will never reach a maximum value of 1 due to the DM term. It was found that this error is proportional to the square value of the DM term by the net value of the concurrence. Results are presented for the $(SWAP)^{\alpha}$ gates, with α = ½, ¼ and 1, where we have calculated for each α the adequate area width of J for which the correct quantum gate is performed, and the pulse correction need it to perform a correct operation with a non-cero DM element. For each gate the hyperfine field strength has been modified an evaluated.

rjgm76@uabc.edu.mx

Review of energization and loss processes of electrons from Van Allen radiation belts

Sapna Shekhar
Dartmouth College, USA

Earth's magnetic field is highly dynamic and leads to several interesting processes in the magnetosphere. The energetic charged particles, gyrate, bounce and drift about these magnetic field lines, they can also get energized to relativistic energies through resonating with waves leading to pitch angle scattering and eventual loss into the atmosphere. The BARREL (Balloon Array for Radiation Belt Relativistic Electron Losses) mission was launched first in 2009 to study the electron losses in the atmosphere. Each balloon carries a NaI scintillator to measure the Bremsstrahlung X-rays produced by precipitating relativistic electrons as they collide with neutrals in Earth's atmosphere, and a DC magnetometer. Here we discuss some findings from the mission and the role of wave particle interaction in the observations.

Sapna.Shekhar.GR@dartmouth.edu

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