Entanglement in a spin-valley graphene system.

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Abstract

Characterizing whether a complex quantum system is entangled or separable is an important subject since it helps to determine the type of involved correlations: quantum or classical, which is of great interest for quantum computation and quantum information fields. We investigate a two-electron double quantum dot with both spin and valley degrees of freedom in graphene. These degrees of freedom can be considered as a potential four qubit register. In particular, we focus on the dynamics of correlations between the subsystems of the model. The two quantum dots are coupled by the spin/valley-preserving hopping. The effective Hamiltonian contains Heisenberg-exchange terms (spin-spin, spin-valley and valley-valley) [1]:

$$\hat{H}=\frac{J(t)}{8}[(\vec{s}_1\vec{s}_2)(\vec{\tau}_1\vec{\tau}_2)+\vec{s}_1\vec{s}_2+\vec{\tau}_1\vec{\tau}_2-3],$$

where $J(t)$ is a pulse-like exchange coupling used to control the quantum dynamics of the system, $J(t;\lambda)=J_0\,\mathrm{sech}^2(2\lambda(t-t_0))$.

We evaluate the evolution of quantum discord and concurrence [2,3] in the half-swap quantum gate on spin and valley qubits. The half-swap gate generates entangled states by superposition between the initial state and its corresponding π-rotated state. It is possible to generate a circuit for producing the CNOT quantum gate using half-swap gate. We show some of the obtained results in Figure [2], where we describe the eigenstates of the system as $\Psi=|\, s_1 s_2 v_1 v_2 \rangle$, being the values for spins s_1, s_2 and valley states v_1, v_2 denoted by '1' or '0'.

References

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Figures

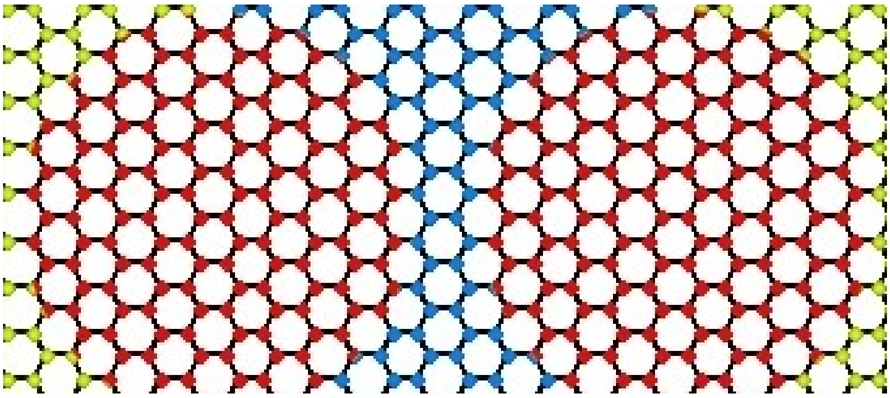

Fig. 1. Schematic view of a double quantum dot in graphene.

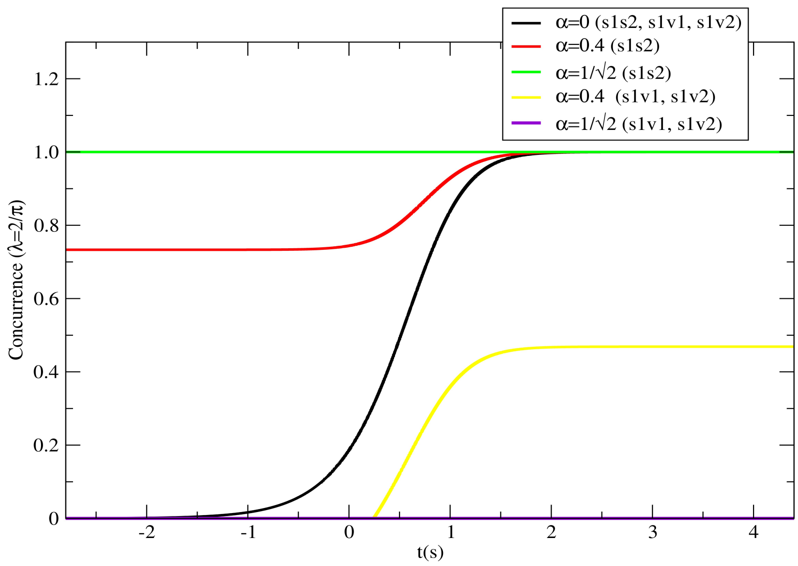

Fig. 2. Concurrence versus time for a pulse *J(t)* with J_0=1 and $\lambda=2/\pi$, being the initial condition $\psi_0=\alpha|0101>+\sqrt{1-\alpha^2}|1001>$.

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