Spin symmetry in semiconductor quantum wires in a plane magnetic field

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ABSTRACT

Different spin-dependent interactions present in semiconductors in conjunction with the ability of controlling the geometry and dimensionality of semiconductor structures allow for a rich spin physics in such materials. The proper combination of these ingredients can lead to the optimal scenario to investigate a given physical effect or to implement new features in order to develop new technological applications.

In this work, we focus on the idea of modifying the properties of the semiconductor structure to control the spin symmetries of the system. We consider the conduction band of a two-dimensional semiconductor quantum well within the effective mass approximation. The wire geometry is defined by a transversal potential '$V(y)$', while the longitudinal dimension 'x' remains translationally invariant. In order to control the spin dynamics through the device we consider the spin-orbit interaction simulated by the different types of spin-orbit coupling present in III-V semiconductor heterostructures (Dresselhaus [1] and Rashba [2]). Finally, we include the effect of an in-plane magnetic field by means of the Zeeman interaction (see, for example [3]).

We found that a certain condition between the spin-orbit interaction and the Zeeman one in a semiconductor quantum wire allows for the possibility of controlling the flow of spin through the system. The proper choice of the intensity and orientation corresponding to an in-plane magnetic field induces a spin symmetry that decouples the spin from the environment, thus, changing substantially the properties relevant for spin transport. This symmetry is due to existence of the spin operator, related to the strengths of the different types of spin-orbit coupling, that commutes with the resulting Hamiltonian.

REFERENCES

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