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Presentation Title

Recovery of quantum spin information in spin-orbit coupled systems

Abstract

In order to manipulate the spins by electric means, which is one of the main goals in spintronics, the relativistic spin-orbit interaction (SOI) is indispensable. However, on the other hand, SOI violates the conservation law of the spins, leading to the spin relaxation. In semiconductors, the relaxation time is typically less than 1nsec, and it has been believed that the spin information is lost beyond this spin lifetime.

However, we will show that this is not the case, and the original spin information is kept and survives the elastic scattering even in the presence of SOI. The central idea is the new conservation law associated with the geometrical nature of the SOI, i.e., it is related to the parallel transport of the wavefunctions. Based on this principle, we can define the “twisted spin”, which is conserved for the time-dependent SOI even in the presence of the disorder elastic scatterings. Furthermore, it is an adiabatic invariant, i.e., it remains constant for infinitely slow change of the SOI.

These properties lead to the prediction of “spin-orbit echo”, where the spin is recovered by the adiabatic switch-off of the SOI even after the spin relaxation finishes completely. We also provide the numerical confirmation of this prediction and the proposal for the experimental test in n-type semiconductors.