

MANY-BODY CONTRIBUTIONS TO SPIN RELAXATION IN SEMICONDUCTORS

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ABSTRACT

Spintronics has the potential to play a significant role in future electronic devices. The success of the field hinges on our ability to maintain and propagate spin signals over various length scales and periods of time. Common to all devices designed to carry spin signals is a need to hold the spin orientation of constituent particles, individually or in bulk. Spin relaxation is a measure of how long particle spins remain polarized while subjected to both spin-dependent and spin-independent interactions.

An effect typically driven by the spin-orbit interaction in semiconductors, spin relaxation describes the rate at which spin polarized particles return to an equilibrium spin distribution. This is generally in competition with the goals of spintronic devices which generate out-of-equilibrium spin populations to represent signals. By studying the various mechanisms of spin relaxation in different systems, we learn which materials are appropriate for specific applications and get hints about how to minimize signal loss.

This report focuses largely on Dyakonov-Perel spin relaxation of carriers in III-V semiconductors. Of the spin relaxation mechanisms in III-V semiconductors, Dyakonov-Perel often dominates or is at least a primary contributor. We study the mechanism in detail for both non-magnetic and dilute magnetic semiconductors, deriving analytic expressions that include contributions from many-body interactions. The results shed light on the validity of commonly made approximations in calculating spin relaxation for various systems. More importantly, we show how spin relaxation can affect other physical observables, such as spin diffusion. By investigating this spin relaxation mechanism in a dilute magnetic semiconductor, we include the effects of spin-dependent interactions. These interactions result in some peculiarities of spin relaxation for carriers undergoing a ferromagnetic transition.