Electron spin relaxation in quantum dots: effect of the 3D shape

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Quantum confinement has a profound influence on the orbital motion of electrons, which is then felt by the spin degree of freedom through spin-orbit interaction (SOI). This has been exploited in two-dimensional electron gases to achieve unprecedented control on the electron spin, opening venue for new spin physics and spin-based applications. In the last decade, much of this knowledge has been transferred to the study of SOI effects in quasi-two-dimensional (electrostatic or self-assembled) quantum dots (QDs), enabling full control over individual spins.[1]

Yet, recent experiments have started addressing the spin dynamics of colloidal QDs, where the fully three-dimensional quantum confinement can be tailored to form a variety of shapes.[2, 3, 4] Structural anisotropies are known to have important consequences on spin-orbit coupling. Therefore, proper modeling of the 3D nature of SOI becomes essential to understand the properties and the possibilities of these systems.

In this presentation, we explore how the 3D confinement geometry affects the electron spin relaxation between Zeeman sublevels of zinc-blende QDs. As compared to the well-established case of quasi-2D systems, the additional (vertical) degree of freedom brings about a qualitatively different behavior. This allows us to generalize the role of the interaction between quantum confinement and SOI in the spin dynamics. In particular, we show that the conduction band Dresselhaus spin-orbit interaction is suppressed in spherical nanocrystals.[5] The suppression of the Dresselhaus term implies that spherical nanocrystals with wide gaps are essentially left with Rashba spin-orbit interaction alone, which is an ideal scenario for external control of spin degrees of freedom.

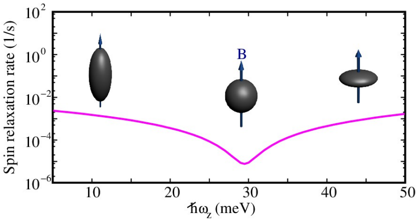

Figure: Electron spin relaxation rate in QDs with varying aspect ratio.
Note the suppression for spherical QDs.

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