

Enhancing Spin Diffusion in GaAs Quantum Wells: The Role of Electron Density and Channel Width

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Abstract

This study examines how spin diffusion in two-dimensional electron gases (2DEGs), hosted in GaAs quantum wells, is affected by electron density and lateral confinement. Using time-resolved magneto-optical Kerr effect microscopy, we explore how varying the Hall-bar channel width and applying back-gate voltages influence spin dynamics. We find that the spin diffusion coefficient increases significantly—up to 150%—in narrower channels and at lower electron densities.

A theoretical model attributes this to the spin diffusion being inhomogeneous, with enhanced diffusion near the channel edges where electron density and electron-electron scattering are reduced. These edge effects become more pronounced in narrower channels, which have a larger proportion of low-density regions. The study emphasizes the importance of controlling both geometry and carrier density to optimize spin transport. These findings offer valuable insights for designing more efficient spintronic devices that rely on precise spin manipulation and coherence.