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Experimentelle Physik 2

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Persistent spin grids in laterally confined 2D electron gas

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In a 2D electron gas, spin-orbit interaction causes propagating electron spins to precess around an effective magnetic field that depends on the propagation direction. In the diffusive regime, electrons can follow various paths, each inducing a different spin rotation; averaging over these paths results in spin relaxation. The relaxation can be suppressed by fine-tuning the spin-orbit parameters to make spin rotation path-independent, leading to the emergence of long-lived periodic spin patterns, known as persistent spin helices.

Here, we introduce a new strategy to achieve 2D spin transport with suppressed spin relaxation for arbitrary values of spin-orbit parameters. We consider spin diffusion in a 2D electron gas confined within a grid of narrow channels. We show that the lifetime of certain spin distributions in such grids greatly exceeds that in an unconfined 2D electron gas and diverges as the channel width approaches zero. Such persistent spin grids arise when the electron spin orientation remains invariant after diffusion around the grid plaquette. We establish a topological $\mathbb{Z}_2$ classification for persistent spin grids and speculate that the setup could be used to simulate non-Abelian lattice gauge theories.

A.V. Poshakinskiy, arXiv:2502.06745 (2025)