Modelling transport properties of a transverse magnetic focusing system with spin-orbit coupling

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Spintronics, where spin is manipulated instead of charge to transfer and store information, is a promising field that can deliver energy efficient devices. Spatially separating electrons of different spins and efficiently generating spin currents are crucial steps towards building practical spintronics devices. Transverse magnetic focusing (TMF) is a potential technique to accomplish both those tasks. In a two-dimensional material where there is significant Rashba spin-orbit interaction, electrons of different spins will traverse different paths in the presence of an external magnetic field (Fig. 1). Experiments have demonstrated the viability of this technique by measuring conductance spectra that indicate the separation of spin-up and spin-down electrons. However, there are physical effects that are still not well understood. We utilise a finite difference method and the non-equilibrium Green's function (NEGF) formalism to calculate transport properties of TMF devices using the software KWANT. [1] By doing so, we analyse the effects of varying conditions such as spin-orbit coupling, magnetic field, device geometry, and disorder strength. [2]

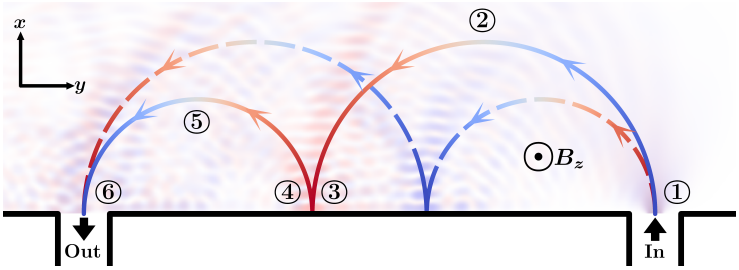

Figure 1: Schematic of a typical transverse magnetic focusing device. Injected are focused and collected by applying an out-of-plane magnetic field B_z. Spin–up (red) and spin–down (blue) electrons have different trajectories due to the Rashba spin–orbit interaction. A plot of calculated spin-projected probability density is underlaid, showing agreement with the classical trajectories, but demonstrates quantum effects such as interference and dispersion. [2]

[1] C. W. Groth, M. Wimmer, A. R. Akhmerov, and X. Waintal, *New J. Phys.* **16**, 063065 (2014).

[2] Y. K. Lee, J. S. Smith, J. H. Cole, *Nanoscale Res. Lett.* **17**, 31 (2022).