Asymptotic behaviour of tunnelling magnetoresistance with doping in Fe/MgO/Fe/InAs junctions

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Enhancement of the tunnelling magnetoresistance (TMR) by electron filtering in an Fe/MgO/Fe/GaAs(001) junction arises from a momentum-space collimation of the tunnelling electrons that is directly controlled by the carrier density of GaAs [1].

We consider Fe/MgO/Fe/InAs junctions within the Landauer formalism. The presence of the semiconductor imposes a well-defined kinematic restriction on the in-plane momenta contributing to transport, which we derive using wavefunction matching and complex-band tunnelling through MgO. This leads to a simple asymptotic TMR scaling in which the MgO barrier thickness and the semiconductor doping enter separately: the TMR grows linearly with the number of MgO layers while being suppressed with increasing InAs carrier density.

The resulting description is relevant for theoretical modelling and for informing the design of experiments and devices in which semiconductor doping is used to tune tunnelling magnetoresistance.

References:

[1] Strong Enhancement of the Tunnelling Magnetoresistance by Electron Filtering in an Fe/MgO/Fe/GaAs(001) Junction