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Spin transistor action via tunable Landau-Zener transitions in magnetic semiconductor quantum wells[1]

DIETER WEISS, Institute of Experimental and Applied Physics, University of Regensburg, D-93040 Regensburg, Germany

Spin-transistors, employing spin-orbit interaction like Datta-Das prototypes [1], principally suffer from low signal levels due to limitations in spin injection efficiency, fast spin relaxation and dephasing processes. Here we present an alternative concept to implement spin transistor action where efficiency is improved by keeping spin transport adiabatic [2]. To this end a helical stray field B, generated by ferromagnetic Dysprosium stripes, is superimposed upon a two-dimensional electron system in (Cd,Mn)Te, containing Mn ions with spin 5/2. Due to the giant spin splitting, occurring at low temperatures and small B in (Cd,Mn)Te quantum wells, the B-helix translates into a spin-helix and the electron spins follow adiabatically the imposed spin texture. Within this approach the transmission of spin-polarized electrons between two contacts is regulated by changing the degree of adiabaticity, i.e. an electron's ability to follow the spin helix. This is done by means of a small applied homogeneous magnetic field while the degree of adiabaticity is monitored by the channel resistance. Our scheme allows spin information to propagate efficiently over typical device distances and provides an alternative route to realize spintronics applications. We note that our concept is not restricted to a particular choice of materials, temperature, methods of spin injection, manipulation as well as detection.

Work done in cooperation with Christian Betthausen, Institute of Experimental and Applied Physics, University of Regensburg, D-93040 Regensburg, Germany; Tobias Dollinger, Henri Saarikosi, Institute of Theoretical Physics, University of Regensburg, D-93040 Regensburg, Germany; Valeri Kolkovsky, Grzegorz Karczewski, Tomasz Wojtowicz, Institute of Physics, Polish Academy of Sciences, PL-02668 Warsaw, Poland; and Klaus Richter, Institute of Theoretical Physics, University of Regensburg.

[1] H. C. Koo et al., Control of spin precession in a spin-injected field effect transistor. Science 325, 1515 (2009).
[2] C. Betthausen et al., Spin-Transistor Action via Tunable Landau-Zener Transitions. Science 337, 324 (2012).

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