Spin Dependent Transport in Magnetic p-n Junctions

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Most of the solid state applications which exploit spin degrees of freedom rely on magnetoresistive effects in metals and insulators [1]. Considering semiconductors, on the other hand, offers additional flexibility in manipulating spin dependent properties in a wide range of heterostructures and nanostructures leading to novel spintronic applications [2]. Nonlinear current-voltage characteristics and inhomogeneous doping in semiconductors imply important differences as compared to the spin dependent transport in metallic systems. We focus on specific semiconductor structures based on magnetic p-n junctions [3,4], the magnetic analogues of ordinary p-n junctions. They are characterized by spatially dependent spin splitting of carrier bands–a consequence of doping with magnetic impurities [5] and/or an applied magnetic field. We predict that the injected nonequilibrium spin leads to the spin-voltaic effect [3,6]–a spin analogue of the photo-voltaic effect. By reversing either the sign of the equilibrium magnetization or the direction of injected spin polarization it is possible to switch the direction of charge current in a closed circuit. Properties of the spin-voltaic effect can be used to perform all-electrical measurements of spin relaxation time [6], as well as to design devices with large magnetoresistance [3] and spin-controlled amplification [7].

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