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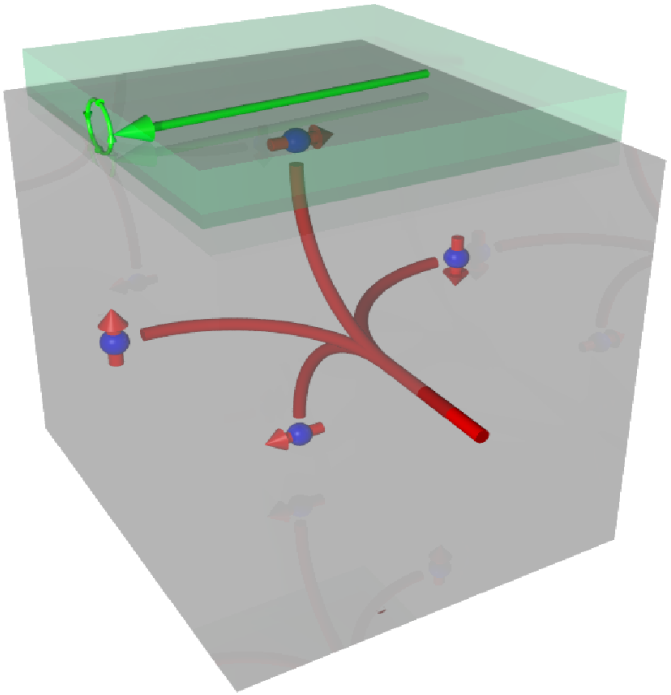
Spin Hall Effect in Metallic Multilayers

G. Woltersdorf, Physics, Martin-Luther-University Halle

The discovery of the spin pumping effect and the Spin Hall Effect (SHE) has stimulated the research on dynamics in metallic magnetic nanostructures. Here a comprehensive study of the SHE in metallic multilayers will be presented. We study the direct as well as the inverse SHE. In the case of the direct SHE a dc charge current is applied in the plane of a ferromagnet/normal metal layer stack and the SHE creates a spin polarization at the surface of the normal metal leading to the injection of a spin current into the ferromagnet [1,2].
This spin current is absorbed in the ferromagnet and causes a spin transfer torque. Using time and spatially resolved Kerr microscopy we measure the transferred spin momentum and compute the spin Hall angle. In a second set of experiments using identical samples pure spin currents are injected by the spin pumping effect from the ferromagnet
into the normal metal [3]. The spin current injected by spin pumping has a large ac component transverse to the static magnetization direction and a very small dc component parallel to the magnetization direction. The inverse SHE converts these spin current into charge current [4,5]. The corresponding inverse SHE voltages induced by spin pumping at ferromagnetic resonance (FMR) are measured in permalloy/platinum and permalloy/ gold multilayers in various excitation geometries and as a function of frequency in order to separate the contributions of anisotropic magnetoresistance and SHE. In addition, we present experimental evidence for the ac component of inverse SHE voltages generated by spin pumping [6,7].



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