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Voltage dependence properties of ballistic spin currents and spin transfer torques in magnetic tunnel junctions

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Interest in spintronics [1] has been strongly accentuated by the discovery of current induced magnetization switching caused by spin transfer torque (STT) [2]. Among the most favorable candidate systems for the realization of STT-based spintronic devices are epitaxial magnetic tunnel junctions (MTJ) [3]. Here we present a systematic study of voltage-induced STT in MTJs and provide an insight into the nature of its voltage behavior by investigating the properties of ballistic spin currents [4,5]. We demonstrate that the band filling has a dramatic impact on voltage dependence properties of both STT components, tunnel magnetoresistance (TMR) as well as on equilibrium interlayer exchange coupling [5]. Both in-plane (Slonczewski) and perpendicular-to-the-plane (field-like) STT components demonstrate a wide range of nontrivial behavior as a function of applied voltage [4,5]. The explanation is given in terms of the spin and charge current dependence on the interplay between evanescent states in the insulator and the Fermi surfaces of the ferromagnetic electrodes comprising the MTJ [5]. In particular we show that in ballistic regime the field-like torque is an even parity function of applied voltage while the parallel torque may exhibit a wide range of behavior [4,5]. Recent experiments [6] are in agreement with these predictions. Calculations are based on the non-equilibrium Green functions technique.

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