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Conduction electrons and the Landau-Lifshitz-Gilbert equation[1]

SHUFENG ZHANG, University of Arizona

In conducting ferromagnets, spin-polarized transport properties are strongly correlated with static and dynamic magnetic properties. These correlations have led to a number of interesting phenomena such as giant magnetoresistance, spin transfer torques, spin pumping, non-uniform and non-local magnetization damping, and electric voltage induced by domain wall motion. In this talk, we discuss the roles of non-equilibrium conduction electrons on the magnetization dynamics by taking into account both spin-orbit interactions and exchange interactions between conduction electrons and magnetization vectors. For a non-uniform time-dependent magnetization vector, the exchange interaction generates spin-dependent electric and magnetic potentials which can be viewed as new forms of spin-orbit coupling. By explicitly calculating the non-equilibrium spin density and spin current, we relate the magnetization damping to the angular momentum carried away by the conduction electrons. We numerically evaluate the contribution of the conduction electrons to the magnetization damping for several different domain walls. Finally, we discuss a possible realization of the Aharonov-Bohm effect in magnetic ring structures with controlled domain walls. Work was done in collaboration with Steven S. Zhang.

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