Ultrafast spin dynamics in Gd/Fe and its signature in the electronic structure

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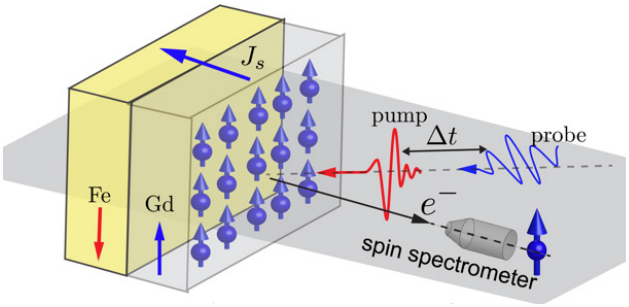
Understanding ultrafast spin dynamics is not only a complex and fascinating challenge in fundamental physics, but carries the potential for magnetic recording based on all-optical switching (AOS) of the magnetic order [1]. AOS triggered by a single fs laser pulse was first observed in the ferrimagnetic alloy FeCoGd and more recently in Pt/Co/Gd stacks [2]. The key to AOS is exchange of angular momentum between the oppositely aligned magnetic moments of the transition metal and rare earth sublattices [3]. Spin transport and exchange scattering are discussed as microscopic processes responsible for spin dynamics and all-optical switching. However, it remains debated to what extent ultrafast magnetization dynamics generates spin currents and *vice versa*. We will briefly highlight a few examples of the signature of spin dynamics in the electronic structure studying Fe and Gd single layers [4].



In the main part of this talk we present microscopic insights to spin-transport-driven ultrafast magnetization dynamics in a Gd/Fe bilayer. In a recent experiment, we used time- and spin-resolved photoemission spectroscopy to study an antiferromagnetically coupled Gd/Fe bilayer, a prototype system for all-optical switching. Spin transport leads to an ultrafast drop of the spin polarization at the Gd surface demonstrating angular-momentum transfer over several nanometers. Thereby Fe acts as spin filter, absorbing spin majority but reflecting spin minority electrons. Spin transport from Gd to Fe was corroborated by an ultrafast increase of the Fe spin polarization in a reversed Fe/Gd bilayer. In contrast, for a pure Gd film spin transport into the tungsten substrate can be neglected as spin polarization stays constant. This significant difference is corroborated by the electron temperature. In the bilayer, hot electrons are efficiently removed from the Gd layer before they can heat the phonon system while in pure Gd/W(110) electron and phonon subsystems equilibrate at an elevated temperature after 1.5 ps.

Our results suggest that ultrafast spin transport drives the magnetization dynamics in Gd/Fe and reveal microscopic insights into ultrafast spin dynamics [5].

References:

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