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FİZİK BÖLÜMÜ SEMİNERİ

Effects of spin current pumped by ferromagnetic resonance: Spin torque of spin current and spin diode application

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Spins can be pumped alternatively into a normal (N) metal at the interface of a preccessing ferromagnet (F) without a need of a charge current. In an F/N/F trilayer the two F's can be coupled dynamically through spin currents even if the N layer is thick enough to suppress any static interactions. If two F's precess at the same time both of the F's interfaces inject opposing spin currents into N layer and therefore extra damping on the ferromagnetic resonance (FMR) linewidth will cancel out.

We asked ourselves what if the opposing spin currents do not cancel and how is this possible. It is therefore possible if two F's resonate antiparallel without any long range static interaction between them. A Co/Ag/Co/Gd multilayer can satisfy the antiparallel alignment of two Co layers below the compensation temperature (Tcomp) of antiferromagnetically coupled Co/Gd bilayer. Two resonances are found at room temperature (RT) corresponding to the Co and Co/Gd where the resonance absorption of Co/Gd is at lower fields due to the antiferromagnetic exchange coupling. We observe the cancellation of pumped spin currents above Tcomp where the absorption peak for the Co/Gd vanish approximately 50 K below RT. However FMR linewidth of live Co in the multilayer did not increase above the value of temperature dependent linewidth of bare Co below Tcomp. Somehow the system feels the presence of Gd (or Co/Gd) in the system even though its resonance is absent in the spectra.

We then set out to find the effect of this hidden spin current which reduces the FMR linewidth substantially. We prepared a Co/Ag/Gd trilayer where Co and Gd are thought to couple dynamically below the Curie temperature (TC) of Gd when it is ferromagnetic. We intend to find the spin torque of spin current pumped from the Co interface at the FMR absorption of Co. We knew that the bare Gd's FMR absorption would be absent below its TC and only its electron paramagnetic resonance (EPR) spectra may be visible above its TC at room temperature. We observe that the resonance absorption of Co reduces substantionally almost down to its intrinsic value at room temperature where Gd is not ferromagnetic at all. Linewidth increases as the temperature decreases when Gd turns magnetic however the value of linewidth is still lower than that of the bare Co in the absence of the Gd absorption. Can Co couple dynamically to nonmagnetic Gd even over another nonmagnetic Ag layer?

The next question I plan to address is: what if there is a nonreciprocal spin current and is this possible? The goal is to successfully control the flow of spin current in one direction over the other. The observable effect of such a nonreciprocal spin current (spin diode) is differential damping of magnetic resonance over a large temperature interval. If successful, I would have a control over the magnetic damping mechanism. I will show experimental data on the spin diode effect for a polycrystalline SmCo/Co/Fe trilayer when the polarization direction of half metallic Co is pinned by hard SmCo magnet.

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