LONG LIFETIME OF EXCHANGE-DOMINATED SPIN WAVES IN ULTRA-THIN COBALT FILMS

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The miniaturization of magnon-based devices into the nanometer range requires the utilization of exchange-dominated spin waves with wave-length in the nm-range. Only those spin waves possess sufficiently large group velocities for a fast transport of the spin information. High group velocities are realized in particular by spin waves in ultra-thin cobalt-films. These spin waves were studied extensively in the last years using inelastic scattering of low-energy electrons [1,2]. However, because of limitations in the energy resolution the experimental data base was confined to wave vectors between about 3nm^{-1} and the boundary of the surface Brillouin zone. In that range, the lifetime of spin waves is extremely short (<100fs) [3]. Correspondingly, the mean free path of a spin wave packet (defined as the product of group velocity and lifetime) is only of the order of 1nm. For that reason the acoustic spin wave modes of 3d-metals were not considered as possible candidates for spin wave based devices.

Recent improvements in the technology of electron energy loss spectrometers now enable the studies of spin waves of wave-vectors down to 1.5nm^{-1} with an energy resolution down to 2meV [4,5]. In this presentation we report on high resolution data of those spin waves in ultra-thin fcc cobalt layers deposited on Cu(100) surfaces. The results are compared to a theory of spin excitations which takes into account the itinerant character of the electrons. For eight atom layer (8ML) films with a small density of surface steps and wave vectors $q<2\text{nm}^{-1}$ we find lifetimes of several picoseconds, in agreement with our theory. However, those long lifetimes are observed only for well-annealed films with a small density of surface steps.

Ongoing studies on films with regular step arrays obtained by deposition on Cu(1123) and Cu(1113) substrates show that the step-induced damping is particularly severe when steps cross the path of spin waves.

Keywords: Spin waves; Cobalt films, Electron spectroscopy

References

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