ESRF	**Experiment title:** Temperature dependence of the magnetic spin structure in exchange coupled thin films	**Experiment number:** SI-846
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Report:
The influence of the temperature on exchange coupled thin magnetic films separated by a non magnetic layer was studied. There is a temperature dependence on the interlayer exchange coupling and on the high uniaxial anisotropy of the $L1_0$-Phase of $Fe_{45}Pt_{55}$. Both physical effects can be analysed via the spin structure of the magnetic layer system [2]. Figure [1] illustrates the layersystem Fe(100Å)/Pd(wedge:8-16.5Å)/$Fe_{45}Pt_{55}$(300Å) which was used in this experiment.

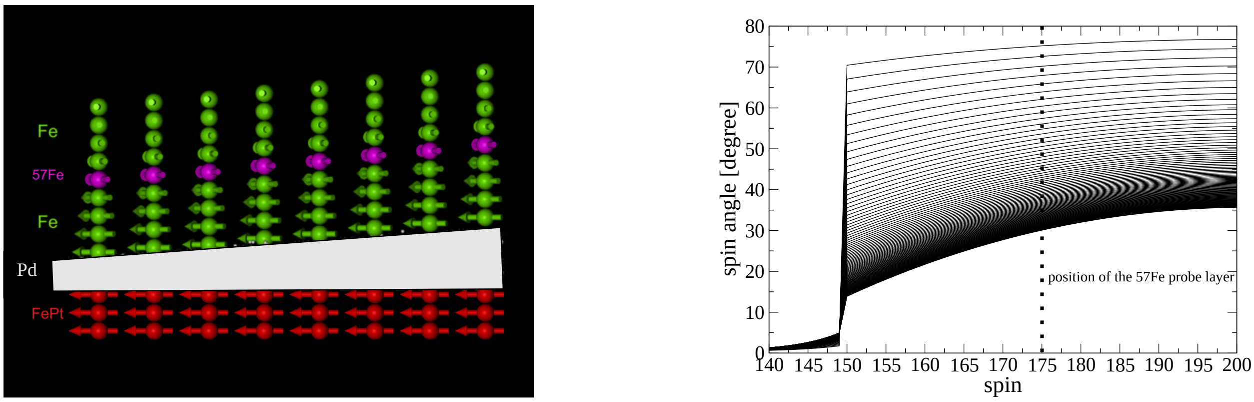

figure 1: Left part: Direction of the discrete magnetisations in a magnetic layer system (Fe/ wedge of Pd/ FePt) caused by an external field perpendicularly (in-plane) to the magnetisation of the hardmagnetic FePt layer depending on the distance of the hartmagnetic FePt. Right part: calculated direction of the "spins" for different interlayer coupling constants of Pd (varied from 0.3 - 5 mJ/m^2 with a stepsize of 0.05 mJ/m^2) using eq. (1).

For the theoretical description of this system it is advantageous to devide the magnetic layers into separate discrete magnetisations [1]:

$$E = -\sum_{i=1}^{N-1} \frac{A_{i,i+1}}{d^2} \cos(\theta_i - \theta_{i+1}) - \sum_{i=1}^{N} K_i \cos^2(\theta_i) - \sum_{i=1}^{N} H M_i \cos(\theta_i - \theta_H) \qquad (1)$$

The total magnetic energy of the layer system can be calculated taking into account the external magnetic field H, the saturation magnetisation M_h (M_s), the anisotropy constant K_h (K_s) and the intralayer exchange constant A_h (A_s) of the hardmagnetic (h) and softmagnetic (s) layer. Each of the discrete magnetisations is aligned with the angle θ_i relative to the hardmagnetic $Fe_{45}Pt_{55}$ layer and separeted by d =2 Å. The ^{57}Fe probe layer is defined by the angle θ_{175} and the interlayer coupling constant with $A_{149,150}$.
Using nuclear resonant scattering [2] (countrate: $\approx$ 300 Hz) the result of our experiments are the alignments of the ^{57}Fe probe layer, for different thicknesses of the Pd-wedge layer and different constant external fields. Thus, using eq. (1) and parameters given in Refs. [1,2], we are able to calculate the magnitude of the interlayer coupling constant depending on the thickness of the interlayer and the temperature (see fig. 2). The change in the anisotropy constant is neglected in these calculations.

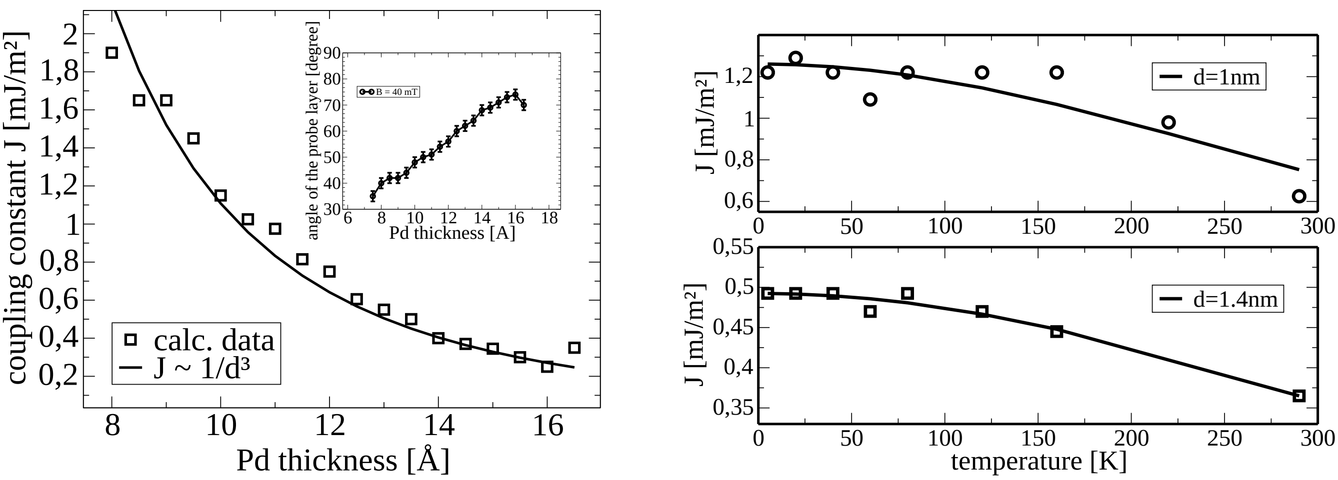

figure 2: Left part: calculated coupling constants resulting from the experimentally acquired "spin" direction (inside) of the ^{57}Fe probe layer (4 K). Right part: temperature dependence of the coupling constant for two different Pd thicknisses. The line is a fit with $A(T) = [T/T_0]/[\sinh(T/T_0)]$.

The influence of the temperature dependence on the anisotropy constant as well as the influence of a biquadratic component [3] on the coupling constant are currently subject of further theoretical and experimentel investigations.

References

[1] E. Fullerton et al.,Phys. Rev. B 58, 12193 (1998).
[2] R. Röhlsberger et al., Phys. Rev. Lett. 89, 237201 (2002).
[3] T. Klein et al., in preparation.