ESRF	**Experiment title:** Local magnetism of a thin ferromagnetic Fe layer influenced by the proximity to a superconducting Nb film	**Experiment number**: **HE-3172**
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Report:

The aim of the experiment was to investigate the interaction induced by the proximity effect in layered ferromagnet/superconductor (FM/SC) hybrids. More specifically, the goal was to investigate the effect induced on the ferromagnet once the system is cooled below the superconducting transition temperature T_c. In general, it is very difficult to probe the magnetic field inside a superconductor due to its strong diamagnetic response, and one part of the experiment was dedicated to see if the technique of nuclear resonant scattering, coupled with a ^{57}Fe probe layer approach, could be suitable to probe internal fields in superconductors.

We investigated a simple FM/SC hybrid consisting of a trilayer thin film with the generic structure Nb(50nm)/Fe(d)/Nb(50nm) where the thickness d of the Fe layer was varied from 0.2 to 3 nm. This thickness range covers the ferromagnetic transition which appears at around 1.5 nm in these systems.

The experiment was carried out in a cryomagnet system with a base temperature of 3.2 K. The sample was placed in grazing incidence geometry with the magnetic field perpendicular to its surface. Four electrical contacts were made on the sample to monitor the superconducting transition (drop of resistance to 0 Ω). This allowed us to reconstruct the superconducting phase boundary in-situ and precisely choose the temperatures at which the measurement should be done compared to T_c.

We started the experiment with a sample having a 3 nm thick ^{57}Fe layer. The experimental procedure was to record a nuclear timespectra at 15 K, at 80% of T_c and at 3.2 K. Then the magnetic field was increased and the procedure repeated until the

sample could not enter the superconducting state anymore. Unfortunately, we could not detect any modification of the ^{57}Fe layer's magnetic state when cooling below T_c. In particular, we could not detect the presence or the influence of Cooper pairs within the Fe layer. We believe this is due to a too strong magnetic stability.

The second part of the experiment was carried out on the thin Fe layer of 0.6nm. This layer was not in a ferromagnetic state so that it did not disturb the superconductor and only act as a probe of the local magnetic field. The same procedure as above mentionned was carried out.

Carefull analysis of the recorded time spectra allowed us to model the Fe layer as a paramagnetic medium with spin rotating in the sample plane at high frequency. In this case, the techniques proves to be very sensitive to a modification of the out-of-plane angle of the ^{57}Fe probe layer (< 0.05°), which in turns allow to evaluate the magnetization of the film. In this case, we observe that the magnetization in the center of the superconducting layer and below T_c deviates from the 15K data only for small magnetic fields. We believe this new experiment on a simple FM/SC systems is an example of what can be done with this technique to study more complex systems where no methods is presently available to probe the internal magnetization. These results will be subject of an article which is going to be submitted to the Applied Physics Letters journal very soon.

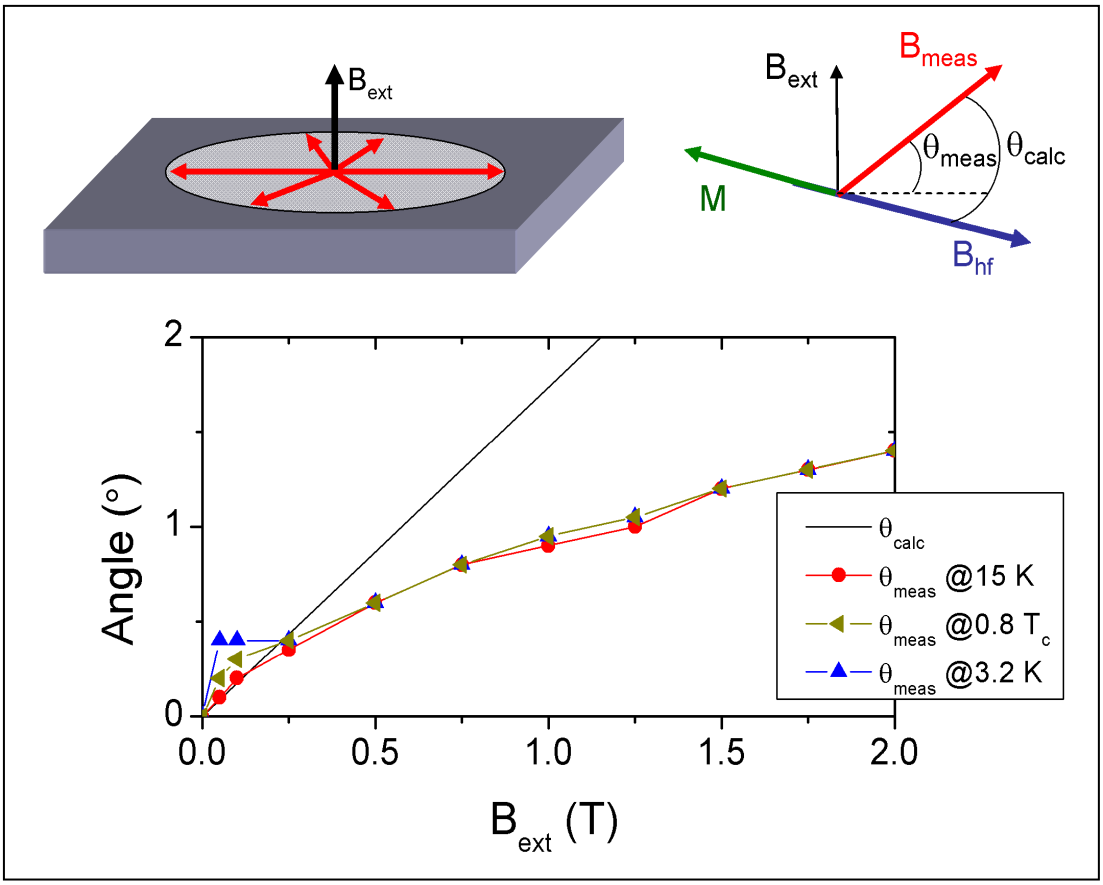

Figure 1: Model used to describe the evolution of the measured field angle as a function of the externally applied external field. The lower graph show the evolution of the measured angle below and above Tc. Signficant deviation appear only in low field.