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Names and affiliations of applicants (* indicates experimentalists):
M. Trekels[1,*], C. Petermann[1,*], S. Couet[1,*], E. Menendez[1,*], A. Vantomme[1], M.J. Van Bael[2] and K. Temst[1]
[1] Instituut voor Kern- en Stralingsfysica, KU Leuven, Celestijnenlaan 200D, 3001 Leuven
[2] Laboratorium voor Vaste-Stoffysica en Magnetisme, KU Leuven, Celestijnenlaan 200D, 3001 Leuven

Report:

The proposed experiment aimed at investigating the influence of a superconducting thin film on the magnetic state of superparamagnetic Fe nano-islands. In most studies considering supeconductor/magnet systems, almost all information on the system is gained by investigating the superconducting properties. Due to a difference in energy scales the influence of the superconductor is difficult to observe. Moreover, the regime in which the largest modifications of the magnetic material possibly take place is the regime of ultra thin magnetic films/particles. Due to the large diamagnetic responce of the superconductor it is very difficult to measure any magnetic signal.

Our strategy to investigate the influence of the superconductor on the magnetic material consisted of two main ideas. First, a minimization of the ordering energy of the magnetic material by using a collection of nanometer sized islands of Fe. These islands become superparamagnetic below a certain size, and at higher temperatures the macrospins of the islands become unstable against thermal fluctuations. Lowering the temperatures causes the magnetic moments to become static again, and the temperature at which this is happening can be lowered by decreasing the size of the islands. Secondly, the isotope sensitivity of Nuclear Resonant Scattering (NRS) is fully exploited to be extremely sensitive to the magnetism of the ultra small amount of magnetic material. In such way only the properties of the nano islands are measured and the superconductor will not contribute directly to the signal.

Temperature and field are varied in order to probe the phase boundary of the superconductor and at each point in the diagram a NRS spectrum is measured. The state of the superconductor is crucial to correlate its properties with the magnetic state

of the superparamagnetic nano islands. Moreover, the changes close to the transition of superconductor are important to understand the nature of the interaction between the two materials. In order to monitor the phase boundary, the sample holder of the cryomagnetic system was modified to be able to measure the resistivity of the sample during the measurements. This allowed us to measure the magnetic properties of the islands reliable very close to the phase boundary (at at temperature of 95% of the transition temperature). A selection of spectra at one particular position on the wedge and zero field is shown in figure **1A** together with a theoretical fit.

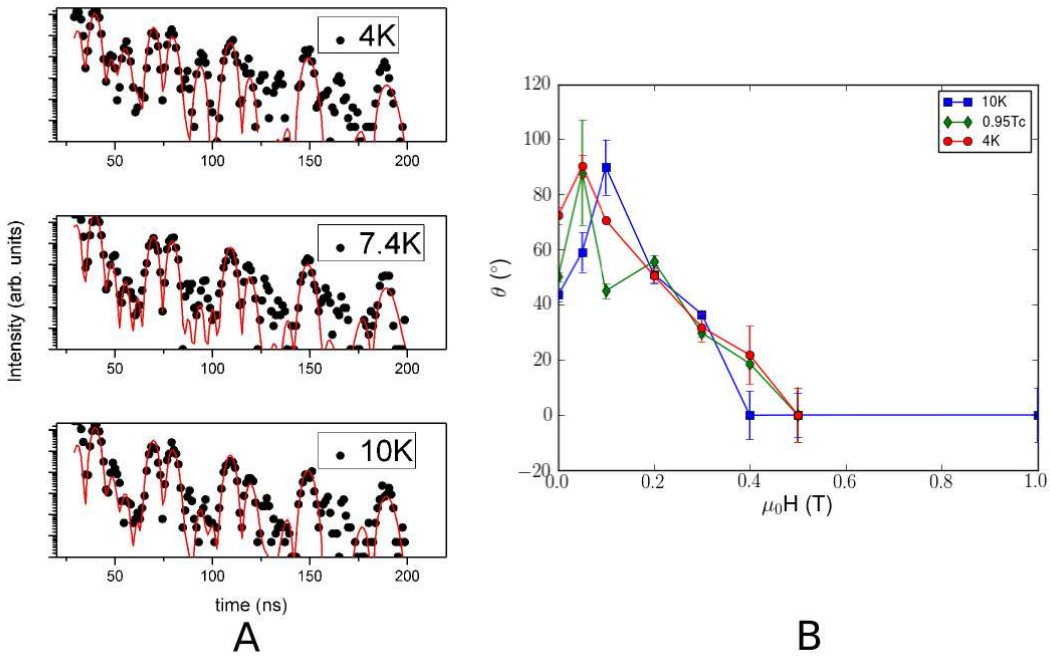

Figure 1: ***A.*** *Selection of NRS spectra at zero field at a particular point on the wedge.* ***B.*** *Out-of-plane angle at this position of the wedge as a function of external field for three temperatures. The external field was applied perpendicular to the sample surface. An angle of zero degrees corresponds to the magnetic moments parallell to the sample normal.*

The spectra could be fitted assuming a zero net magnetization in-plane of the sample. In this case the NRS measurements are only sensitive to the the out-of plane component of the magnetization of the Fe islands. In figure **1B** this component is plotted as a function of the applied external field which was perpendicular to the sample surface. In the low-field regime (below 200 mT), a clear difference in the orientation of the magnetic moments can be observed. This change in orientation seems to be mainly dependent on the state of the superconductor. For example at zero external field, the superconductor forces the moment more in-plane of the sample.

This experiment shows the possibility of measuring the magnetic orientation of nano particles in close contact with a superconducting thin film. In contrary to classical techniques, the NRS signal is not affected by the superconducting material. This allowed the observation of a magnetic reorientation due to superconductivity. Together with theoretical modeling this will lead to more insight in the coupling between these antagonistic phenomena. The data analysis is almost finished and a manuscript will be written to publish the results.