MUON SPIN RELAXATION STUDY OF THE INTRA- AND INTER-PARTICLE SPIN CORRELATIONS IN FE(CU) PARTICLES IN A AG MATRIX

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The technological applications and the understanding of size-dependent properties have prompted an enormous research effort on systems comprising magnetic fine-particles distributed in a supporting matrix [1]. This arrangement gives rise to magnetic behaviors such as spin-glass, cluster spin-glass, superparamagnetic, exchange bias, among others [2]. In these, the nature of the matrix and the size of the inhomogeneities are the main factors governing the magnetic properties. While *ideal* spin-glass and superparamagnetic behaviors are well-known, there exists some confusion when dealing with nanostructures with a significant concentration of magnetic particles. In this case, collective phenomena originated by the magnetic interactions among the magnetic particles are evident. For this, it is important to get a *direct* evidence of the *relaxation* of the spins in the particle. We report here the results and analysis of one of the first experiments using muon spin relaxation (μSR) on a magnetic fine-particle system.

In μSR spectroscopy, a spin-polarized muon is implanted in a sample. Depending on the internal magnetic local field, the spin experiences a precession followed by a decay process emitting a positron. μSR measurements were performed at the GPS spectrometer (5 K<T<200 K) on the pM3 beamline at the Paul Scherrer Institute (Villigen, Switzerland). For these experiments a fair (grams) amount of sample is needed. A $Fe_{13}Cu_{10}Ag_{77}$ alloy has been synthesized by mechanical alloying for 70 h under Ar atmosphere. Composition and structural characteristics have been checked by EDAX, scanning transmission electron microscopy (STEM), *multipattern Rietveld* refinement of X-ray and neutron powder diffraction (XRD and ND), and small angle neutron diffraction (SANS). These reveal the existence of Fe(Cu) (around 4.6 nm in diameter) magnetic nanoparticles embedded in a nanogranular diamagnetic Ag matrix. Special care was needed for the achievement of to high-contrast Rutherford scattering STEM images. We have performed a thinning of a single grain (100-200 μm) to a thickness of ~ 40 nm by Focused Ion Beam Milling.

Results of μSR show a single signal from the sample at all temperatures. The signal displays a rapid depolarization with a minor diamagnetic signal. The muon depolarization can be described by a Dynamical Lorentzian Kubo-Toyabe [3]. This is in agreement with a correlated spin particle behavior. The intra-particle interactions are also probed by the temperature decrease of the static width (W) reflecting the reduction of effective nanoparticle moment due to spin fluctuations within the nanoparticle.

References:

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