# *In-Situ* Characterization of SPION Solutions by Means of 1s2p RIXS-MCD

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Magnetic properties of superparamagnetic iron oxide nanoparticles (SPION) in solutions are routinely determined using volume magnetometry. Quantitative analysis of such measurements is often questioned by uncertainty in their size, concentration and chemical composition. In this talk we will discuss the possibility of application of 1s2p RIXS-MCD [1,2] (magnetic circular dichroism in resonant inelastic x-ray scattering) for in-situ characterization of magnetic properties of SPION solutions (Figure 1).

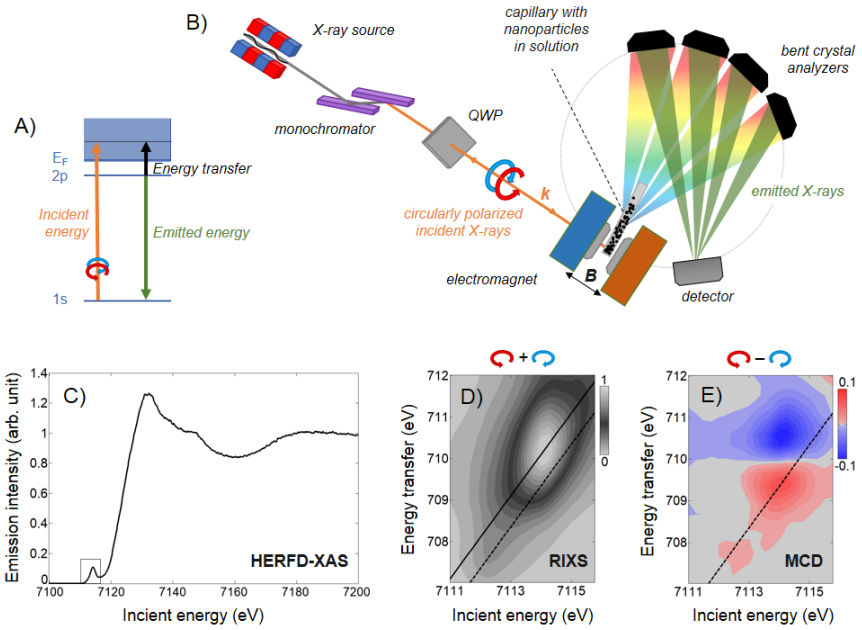


Figure 1: Principle of 1s2p RIXS-MCD on SPION solutions. (A) Definition of transitions involved, namely 1s→3d excitation and 2p→1s emission, and the energy transfer scale. (B) Sketch of the experimental setup. (C) Typical 1s2p HERFD-XAS (high energy resolution fluorescence detected x-ray absorption spectrum) of spinel iron oxide probed at varying incident energy and constant emission energy corresponding to the maximum of $Ka_1$ fluorescence line. (D) RIXS plane, two dimensional map of emission intensity probed in the incident energy range marked in (C) and emission energy (transfer) spanning Ka1 resonance. (E) RIXS-MCD plane being the difference of RIXS probed with opposite helicity of incident x rays. Solid and dashed lines in (D) and (E) correspond to HERFD scans probed at emission energy corresponding to maximum of 1s2p RIXS and MCD features within Fe K pre-edge.

Details of the experimental procedure and results of the preliminary measurements performed on dispersions of pristine, zinc and cobalt doped spinel iron oxide nanoparticles will be presented. The feasibility of probing site selectively magnetic properties of 3d ions simultaneously with their site distribution in spinel ferrite lattice will be discussed. Finally, the solution-free magnetization profiles of SPION derived from the field dependence of RIXS-MCD intensity will be compared to volume magnetometry data. In this way the distribution function of magnetic diameters of SPION can be estimated without the uncertainty related to diamagnetic contribution of the solvent.

**References**

[1] - M. Sikora, A. Juhin, T.-C. Weng, P. Sainctavit, C. Detlefs, F. de Groot, and P. Glatzel, Phys. Rev. Lett. 105, 037202 (2010).

[2] - A. Juhin, P. Sainctavit, K. Ollefs, M. Sikora, A. Filipponi, P. Glatzel, F. Wilhelm, and A. Rogalev, J. Phys.: Condens. Matter 28, 505202 (2016).