

Internship proposal 2011-2012

Laboratory : SOLEIL and IMPMC

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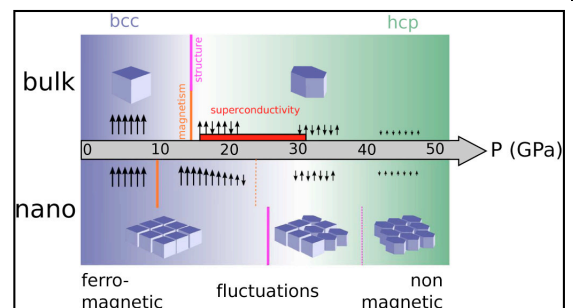
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Unveiling the mysterious magnetic state of superconducting Iron under pressure

Scientific project: Iron is a well-known material since antiquity for its unique magnetic properties. Recently, research has focused on its high-pressure phase of wide interest from metallurgy to geophysics. Under pressure, Fe undergoes a transition from bcc to hcp crystalline structure at 12 GPa with an apparent loss of ferromagnetism. However a different picture has emerged in several theoretical works that is compatible with a zero net magnetisation but showing anti-ferromagnetic fluctuations or spin density wave. Such a state has not been observed yet, but the recent discovery of superconductivity in Fe at very low temperature ($T_c = 2$ K) under pressure (Shimizu *et al.*, *Nature* (London) **412**, 316 (2001) suggests a pairing interaction with exchange of magnetic fluctuations, and thus the proximity of a magnetic phase. But do these magnetic fluctuations exist? In a recent work, we have highlighted the existence of a small magnetic moment on iron at high pressure in the hcp phase where ferromagnetic ordering is already lost (A. Monza *et al.* *Phys. Rev. Lett.* **106**, 247201 (2011), see figure), using X-ray emission spectroscopy. This result however was obtained at ambient temperature well above the superconducting transition. In this project we would like to extend for the first time the measurement of the magnetic signal down to 2 K, where superconductivity takes place, in a region of the PT phase diagram where the enigmatic magnetic state is expected. The measurements will be carried out at the new inelastic x-ray scattering beamline GALAXIES at SOLEIL. We will use crystal analysers fabricated at IMPMC, in collaboration with A. Shukla, specifically for the Fe K_β emission line, and a new high pressure – low temperature cryostat realised in collaboration between IMPMC and F. Baudalet (ODE beamline at SOLEIL) who also participates to this project. The project will give the exciting opportunity to realize new measurements and take part to the commissioning of a new beamline and high-pressure system.



Techniques in use : X-ray emission spectroscopy, high pressure cells for cryogenic studies.

Applicant skills : motivation, curiosity, knowledge of solid state physics and spectroscopy, interest for instrumentation.

Granted internship : yes (~ 400 €/month)

C'nano IdF laboratory (France only) : yes

Possibility for a thesis : yes (type of grant : SOLEIL and UPMC)