


Internship proposal 2009-2010

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Neutron Scattering studies of magnetic excitations in photomagnetic materials

Scientific project: This research subject deals with fundamental properties of new nano-magnetic materials (molecular magnetic clusters, magnetic nanoparticles) displaying new functional properties like photo-commutation or controlled magnetization at the molecular level (data storage). These “switchable” molecular solids are promising materials for high-density optical memory devices, especially since synthesis and deposition techniques now allow thin-film organisation or the size and shape control at the nanoscale of magnetic particles.

Molecular materials with so-called “spin transition” properties are capable to drastically change their magnetic state (from a non-magnetic state to a ferromagnetic or antiferromagnetic state) upon temperature variation or under light radiation. This transition is induced by an electronic state conversion of the magnetic atoms. For example, in MoCu_6 ($S=0$), the charge transfer from Cu^{2+} ($S=1/2$) to Mo^{4+} ($S=0$), who turns into Mo^{5+} ($S=1/2$), is driven by visible light irradiation that leads to an $S=3$ magnetic state of the molecule. This electronic transfer changes the magnetic state but also leads to the appearance of an exchange interaction or coupling between the Mo and Cu spins. In other materials, like Prussian blue analogues (CoFe for instance), diamagnetic pairs are converted into ferromagnetic pairs through light excitations. These states are generally “metastable” and can be reversed with temperature; however some of them are photo-commutable up to room temperature.

In this context, the objective of the training will be to understand how exchange interactions between neighbouring spins emerge during the spin-transition process. To do so, we wish to use Inelastic Neutron Scattering (INS), a spectroscopic technique which is well-adapted to magnetism. INS is a powerful technique to probe spin energy levels in a large energy range (typically 0.1–100 meV) which permits a clear determination of the spin quantum states in a molecule. The charge transfer phenomenon can then be studied through the analysis of the exchange interactions and of the magneto-crystalline anisotropy generated by the electronic state change of the magnetic ions.

Techniques in use: Magnetic characterisation (SQUID, VSM at Saclay); Elastic and Inelastic Neutron Scattering (Saclay, Grenoble), cryogenics (1.5K), magnetic fields, laser optics.

Applicant skills: Some solid knowledge in condensed matter physics, a strong taste for experimental physics and a substantial autonomy in both experimental and theoretical work are required. Good knowledge in English is compulsory; some basic knowledge in French will be an asset.

Granted internship: yes (300 – 800 €/ month depending on curriculum)
C'nano IdF laboratory (France only): yes
Possibility for a thesis: yes (type of grant: CFR (CEA grant) upon curriculum)