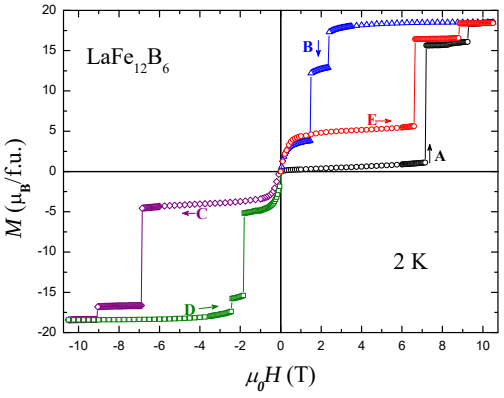
NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2023-2024

Investigation of magnetization processes in R-M intermetallic compounds

General scope : The R-M phases based on rare-earth (R) and transition metals (M) are fascinating materials from both applied and fundamental viewpoints. Indeed, R-M have led to the first modern magnets like Sm-Co ($SmCo_5$ and Sm_2Co_{17} type) and latter to the high performance Nd-Fe-B magnets. Other examples are the (Dy,Tb)Fe_2 type Terfenol ® alloys which are by far the best magnetostrictive materials to date and are widely used in sensors and actuators leading to many applications (Sonar). Other R-M alloys have also contributed to the development of various techniques such as magneto-optic recording on thin films (Gd-Co). Some compounds are now also considered for new applications such as spintronic devices (Gd-Co), magnetic refrigeration using magnetocaloric materials (LaFeSi, RCo_2..). The R-M compounds are however complex materials and need fundamental studies to master their magnetic properties and optimize their performances. Indeed, they are combining two types of magnetism, the localized magnetic moment originating from the inner 4f electronic shells of the R element with the delocalized magnetic moments carried by the itinerant 3d electrons of the M transition metals. Depending upon the atomic concentration one can thus play with different origin of the magnetization. From a fundamental point of view, the R-M compounds are ideal systems to probe solid state magnetism since they are presenting a wide range of unusual magnetic behaviour.

Research to be carried out : Among the interesting magnetization process that attracted our attention, we can cite magnetization reversal in hard magnetic materials exhibiting promising magnetic properties for permanent magnet applications. We also recently discovered the occurence of ultrasharp magnetization behaviour in $LaFe_{12}B_6$ see Figure. This manifest itself by unexpected giant metamagnetic transitions consisting of a succession of extremely sharp magnetization steps separated by plateaus. This behavior has been found at low temperature in $LaFe_{12}B_6$. This unprecedent behaviour for a purely 3d itinerant electron system needs to be further investigated since it presents many remarkable properties. For instance, under certain combinations of the external parameters (temperature and magnetic field), the time dependence of the magnetization displays an unusual step-like feature. However, the origin and the underlying mechanism involved in such unusual magnetization process have to be clarified. The internship will include synthesis of polycrystalline samples, measurements of their physical properties (structural, electric and magnetic) and analysis of the observed behavior. This will be done in close interaction with the researchers using equipments already available.



Ongoing collaborations : In the frame of this research work, different collaborations are already established in particular with the Institute Laue Langevin, Czech collaborators specialists of magnetic measurements at high pressure and Brazilian colleagues. This will be an added value to the project.

This internship is aimed to be followed by a Ph. Thesis

Formation / skills : Master 2 in Solid State Physics or Nanophysics or Engineer in Materials sciences Interest for experiments and wish to broaden its knowledge in fundamental and applied sciences.

Starting period foreseen : February or march 2024

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