NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2024-2025

Investigation of magnetization processes in R-M intermetallic compounds

General scope : Magnetic materials are of outmost importance in modern life, they are at the heart of motors, generators, actuators and detectors. The research for improved performance is driven by the need to reduce energy consumption and provide optimise material for each applications. The best materials to date for electric vehicles, windmill or greenhouse magnetic refrigerant are all containing rare-earth elements (R) which have been considered as critical material by the European community as well as the USA. The need for such elements reflects their importance for new technologies as well as the risk of using such elements mostly supplied by China. The R-M phases based on rare-earth (R) and transition metals (M) are fascinating materials from both applied and fundamental viewpoints. 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. 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 : Here we focus our attention on the so called hard magnetic materials aiming to improve their physical properties in particular the magnetic ones. In order to master these complex materials, a good knowledge of the crystal structure is necessary as well as understanding the relationships between structure and physical properties. Among the properties to be improve, we can cite magnetization as well as remanence but also the ordering temperature. In addition the magnetic anisotropy has to be optimised in order to get the largest coercivity field and avoid demagnetisation of the material. Several magnetization measurements will be performed versus composition, temperature and magnetic field in order to determine the best compound and optimize it's properties. The magnetization curves will be analysed in the light of existing models. A special attention will be devoted to the study of magnetization reversal in hard magnetic materials exhibiting promising magnetic properties for permanent magnet applications. The measurements will be carried out from cryogenic temperatures, room temperature, up to the Curie temperature. The origin of the coercivity and the underlying mechanism involved will be analysed in details. This internship is essentially experimental and will include preparation of samples, measurements of their physical properties (structural, electric and magnetic) and analysis of the observed behavior on the basis of knowledge of the material at the atomic, electronic and particles scales. This will be done in close interaction with the researchers using equipment already available.

Ongoing collaborations : Different international collaborations are already established in particular with different research lab in France and abroad, Czech collaborators specialists of magnetic measurements at high pressure, Germany for high magnetic fields. This will be an added value to the project.

This internship is aimed to be followed by a Ph. Thesis involving large scale facilities Synchrotron...

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

Starting period foreseen : February or march 2025

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