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PhD position

CROSS-COUPLING EFFECTS IN SPINEL FERRITES:
A VERSATILE MODEL FOR MANIPULATING MULTIFERROICITY

Keywords: Multiferroics, magnetoelectric, neutron and resonant X-ray scattering.

Context and objectives: The coupling between **spin-charge-lattice-orbital** degrees of freedom is at the origin of intriguing phenomena in strongly correlated systems. One famous example is the conventional superconductivity, successfully explained by the BCS theory, where the coupling between electron (charge) and phonon (lattice) is at the origin of the formation of the Cooper pairs [1]. More generally, the interplay between degrees of freedom induces a staggering variety of exotic phenomena. The aim of fundamental research focused on cross-coupling effects is to apprehend the mechanism behind the coupling in order to control and enhance the phenomenon for technological applications. This PhD project will focus on **multiferroics** in which the coupling between degrees of freedom is at the origin of their remarkable properties.

The term "multiferroics" refers to an original class of solid materials where both the magnetic [*i.e.* (anti)ferromagnetism] and the electric [*i.e.* (anti)ferroelectricity] orders coexist and are strongly intertwined (**Figure 1a**). In multiferroics, the cross-coupling effect, the so-called magnetoelectric (ME) coupling (*i.e.* between spin and charge degrees of freedom) is a playground for many applications. It can lead to the control of the polarization **P** (magnetization **M**) by applying a magnetic **H** (electric **E**) field. The discovery of multiferroics exhibiting strong ME coupling has attracted considerable interests in the past decades, motivated both by their fundamental outcomes and for their potential applications in novel electronics based on both spin and charge [2].

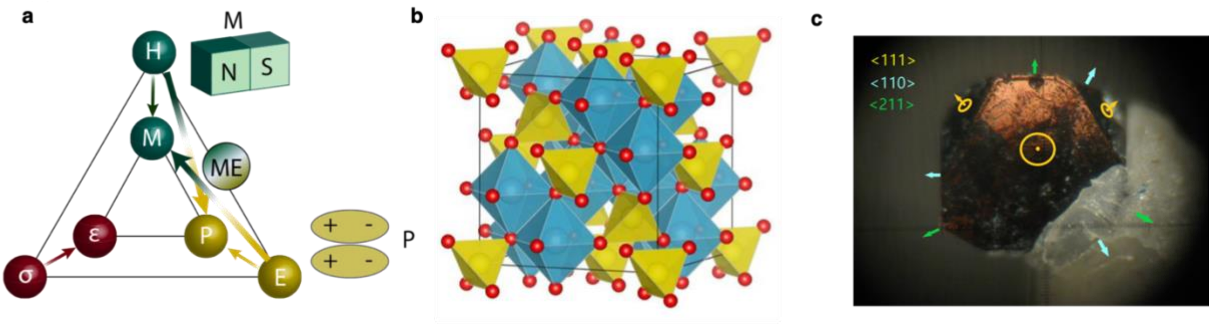

*Figure 1: **a** - The ferroic orders and their interplay in multiferroics. The polarization **P**, magnetization **M**, and strain **ε** is usually controlled by applying an electric field **E**, magnetic field **H**, and stress **σ** respectively. In magnetoelectric (ME) multiferroics, the cross-coupling effect induces a control of **P** (**M**) by applying a **H** (**E**) field. Adapted from Ref. [3]. **b** - Schematic representation of the spinel structure. **c** - Picture of the $GeFe_2O_4$ single-crystal. The main crystallographic axes are indicated.*

In this stimulating context, this PhD thesis will explore two aspects of the multiferroicity: the **magnetic frustration** and the **charge ordering**, through the study of one particular family of compounds: the spinel ferrite (**Figure 1b**). More specifically, this PhD will aim at characterizing and understanding in details the properties of two members of this family: the magnetic frustrated spinel ferrite $GeFe_2O_4$ (**Figure 1c**) [4] and the mixed-3d-ion spinel ferrite $NiFe_2O_4$ [5]. The implementation of this project is driven by the wish to:

- **Objective 1:** explore new promising multiferroic candidates,
- **Objective 2:** identify the ME effects (static ?, dynamic ?)
- **Objective 3:** clarify the microscopic mechanisms at the origin of these properties.

Methods: This PhD project will combine macroscopic characterizations at the laboratory and two cutting-edge techniques on large-scale facilities: **neutron scattering** and **resonant X-rays.** These two techniques will constitute a powerful approach to reveal the coupling between magnetic and charge degrees of freedom in these systems. The PhD student will conduct the experiments and analyze the data under the supervision of experts in the field and communicate the results to the scientific community (publications and conferences). This project involves researchers from the MRS and MagSup teams of the Institut Néel as well as the SIMaP laboratory. This collaboration will provide a rich interdisciplinary research environment for the PhD student who will be placed on a strategic position for a flourishing career development at the crossroad between the synchrotron and neutron communities.

Profile and skills required: The candidate should have a master degree or equivalent in condensed matter physics with a strong interest for experimental physics addressing fundamental questions. She/He should be well organized and meticulous, motivated by large-scale facilities experiments and interested in both performing the experiments and analyzing the data. Experience on coding will be appreciated. The candidate should also have a good level in English (for writing publications and participate to international conferences).

Practical aspects: The PhD thesis will start on the **01/10/21** at the **Institut Néel**, Université Grenoble Alpes (UGA) and Centre National de la Recherche Scientifique (CNRS).

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The candidates should send their CV, cover letter, copy of the highest diploma with their grades, and recommendation letters at:

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Deadline for submitting an application 07/07/2021

References:

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