NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2020-2021

Understanding the multiferroic properties of the spinel $GeFe_2O_4$

General Scope: *"Multiferroic"* refers to a remarkable class of solid materials where both magnetic [*i.e.* (anti)ferromagnetism] and electric [*i.e.* (anti)ferroelectricity] orders coexist. Such coexistence can induce a coupling between the spin and charge degrees of freedom, that is called the magnetoelectric coupling, a key feature for future information technologies. The quest for novel multiferroic materials exhibiting spectacular magnetoelectric coupling is one of the most exciting challenges in the field and drives a considerable amount of research. We are interesting in the study of the multiferroic properties of one particular system: the spinel $GeFe_2O_4$ (Fig. 1**a**). We recently measured strong magnetoelectric coupling and ferroelectricity in this system (Fig. 1**b**). These preliminary results are just the tip of the iceberg and promising additional properties are expected.

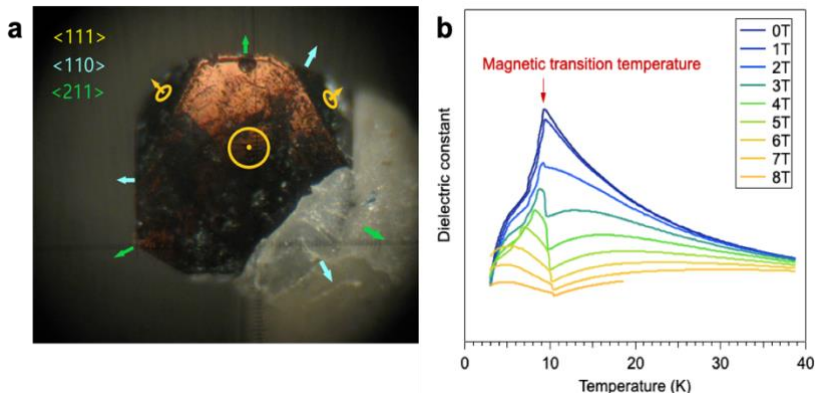

*Figure: **a**, Picture of the $GeFe_2O_4$ single-crystal. The main crystallographic axes are indicated. **b**, Magneto-electric coupling in $GeFe_2O_4$, observed through the temperature and magnetic field dependences of the dielectric constant.*

Research topic and facilities available: The purpose of this internship will be to explore, in details, the multiferroic properties of $GeFe_2O_4$. The main goal is to understand the microscopic mechanisms behind this property through two complementary approaches:

- *Experimental approach*: magnetization and electrical measurements under magnetic field and at low temperatures will be performed at the laboratory to complete the data set we already have. These measurements will be supplemented by diffraction at the laboratory and at large-scale facilities when necessary (synchrotron/neutron sources).
- *Theoretical approach*: symmetry analysis and/or numerical calculations will be also performed to identify the microscopic mechanisms.

Possible collaboration and networking: This work may involve collaboration with researchers of the Néel Institute with possible interactions with EU-founded large scale facilities (ILL and ESRF).

Possible extension as a PhD: *Yes* - This internship could be extended into a PhD if funding for a PhD thesis is obtained via a research project grant or Ph.D. contract awarded by the Physics Graduate School of University Grenoble Alpes.

Required skills: The student should have a background in condensed matter physics with a strong interest for experimental physics addressing fundamental questions.

Starting date: February or March 2021.

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