New hybrid excitation in strongly correlated materials: the electromagnon.

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An interesting domain of research in condensed matter involves the coexistence of multiple ordered phase in some material. If taken independently, these phases are often very well understood from a theoretical point of view (such as ferroelectricity, magnetism, charge density waves etc…). However, their coexistence opens a new field of investigation since the presence of different order parameters may become more than just the sum of the two components: a coupling arises.

This is the case of multiferroics materials such as $RMnO_3$ and RMn_2O_5, where ferroelectricity coexists with magnetism. The understanding of their mutual coupling progresses gradually (at least from a static point of view): a complex magnetism is generally required and originates from a geometrical magnetic frustration. Two main microscopic mechanisms may apply, according to this complex ordering, and both engender new functionalities such as magneto-electric coupling. From a practical perspective, this coupling notably enables altering the magnetic order with an electric field and the ferroelectricity with a magnetic field.

From a dynamical point of view, however, a lot remains to be discovered. A major issue is a new kind of elementary excitation called electromagnon. Despite the absence of consensus, it is often described as a hybrid mode, partly phonon (activated through electric dipole measures), partly magnon (through magnetic dipole activation). However, the very nature of such a mode is yet to be unveiled, and so is its theoretical description.

In this internship (and PhD) proposal, we aim to reveal key experimental characteristics of this mysterious hybrid mode in the RMn_2O_5 family of magneto-electric multiferroics. Using Raman scattering, infrared spectroscopy, dielectric constant measurements and inelastic neutron scattering, we intend to provide a large and as exhaustive as possible picture of this electromagnon to bring crucial information leading to a theoretical description. This work will involve work both in the laboratory and in national facilities (LLB and ILL neutron centers and synchrotrons) and will benefit from well-established collaborations with experts in each of these experimental techniques and with theorists.

Latest publications of our team on this topic:
- G. Yahia, F. Damay, S. Chattopadyay, V. Balédent et al. Physical Review B 97, 085128 (2018)
- S. Chattopadhyay, S. Petit, E. Ressouche, S. Raymond, V. Balédent et al. Nature Scientific Reports (2017)
- W. Peng, V. Balédent, et al. PRB 96, 054418 (2017)
- G. Yahia, F. Damay, S. Chattopadhyay, V. Balédent et al. PRB 95, 184112 (2017)
- S. Chattopadhyay, V. Balédent et al. PRB 93, 104406 (2016)
- V. Balédent et al. Physical Review Letters 114, 117601 (2015)
- S. Chattopadhyay, V. Balédent Physica B 460, 214 (2015)
- S. Petit, V. Balédent et al. PRB 87 140301 (2013)