MAP-fis Essay Proposal, 2014-2015

(*please write in English*)

Supervisor

Name: Joaquim Agostinho Gomes Moreira e Teresa Tranchete

e-mail: jamoreir@fc.up.pt

Title

Interacting elementary excitations and electromagnon driven optical properties in magnetoelectric La-doped $BiFeO_3$

Area

(*Materials, Optics, Condensed Theory, High Energy Theory,....*);

Condensed Matter Physics

Summary of Proposal

This PhD project is aimed at studying the driving forces at the basis of magnetoelectricity in $Bi_{1-x}La_xFeO_3$, with x = 0 to 0.5.

This system is known as one of the most representative examples of room temperature magnetoelectrics [1-5]. Although promising, the reported magnetic and polar are not reproducible by different authors, and the reason remains still unknown [1-7]. Time dependent isothermal structural transitions have been suggested in literature for the parent compound $BiFeO_3$ and, more recently, thermal-cycles have proved the change between different structures, whose energy is similar. Moreover, near the 30% La composition, a morphotropic phase boundary is suggested [8].

Before addressing a systematic study of the physical properties of the La-doped BiFeO3, we need to ascertain how the structure depends on the processing route, time and thermal cycles. Crystal structure, lattice dynamics, polar and magnetic properties of $Bi_{1-x}La_xFeO_3$, x near 0.3, will be studied both as a function of processing route, namely annealing temperature and cooling rate, sample time (since prepared) and thermal cycles.

The interplay between elementary excitations, including spin-waves, phonons and electromagnons, will be addressed through a characterization of the dielectric, polar and magnetic properties as a function of external parameters. Furthermore, the magnitude of the magnetoelectric coupling will be ascertained in quasi-static and dynamic conditions. Since both phase symmetry and sequence are matter of discussion, X-ray diffraction experiments will be performed as a function of temperature and x. As the coupling between optical phonons, magnons and the emergence of electromagnons are

in this framework of huge relevance, a study of their spectral response will be carried out as a function of external parameters, using Raman and terahertz time-domain spectroscopy [9].

After mastering the magnetoelectric coupling of the system, its room temperature magnetoelectric capability will be used to fabricate optical devices, an optical insulator and a tunable non-reciprocal light absorption system, by exploring electric/magnetic field control of both directional dichroism and terahertz-radiation polarization rotatory power [10-13].

References

(*to allow students first look at topic*)

1	J. M. Teresa, Science 286, 507 (1999)
2	A. Simoes et al, Mater. Chem. Phys. 116, 2-3 (2009)
3	T. Carvalho, PhD Thesis, UTAD (2013)
4	Dmitriy A. Rusakov et al, Chem. Mat. 23, 285 (2011)
5	S. Zhang et al, Appl. Phys. Lett. 88, 16 (2006)
6	I. Troyanchuk et al, Phys. Rev. B 83, 054109 (2011)
7	T. T. Carvalho et al, J. Alloy. Comp. 554, 97 (2013)
8	J. J. Lee et al, J. Mater. Chem. 22, 1667 (2012)
9	A. Pimenov et al, Nature Physics 2, 97-100 (2006)
10	Brown et al, J. Appl. Phys. 34, 1233 (1963)
11	D. Szaller et al, Phys. Rev. B 87, 014421 (2013)
12	Takahashi et al, Nature Physics 8, 121–125 (2012)
13	S. Bordacs et al, Nature Phyics 8, 734 (2012)