CONTRATOS PREDOCTORALES 2021 SEVERO OCHOA

PROJECT TITLE / JOB POSITION TITLE:

Chiral and frustrated magnetoelectric oxides with spin-orbit coupling investigated by neutron and x-ray beams

RESEARCH PROJECT / RESEARCH GROUP DESCRIPTION:
(2.000 characters – including spaces)

Frustration, or the inability to satisfy all interactions, leads to fascinating phenomena and properties (spin liquids, chiral spin orders and skyrmions, quantum magnets, magnetoresistance, etc.). The discovery of new classes of frustrated materials in which the charge, orbital, magnetic or elastic orders and the (ferro-)electric properties are strongly coupled (improper multiferroics) is attracting very much interest because of the possibility to manipulate magnetism by electric fields and vice-versa [1,2]. The CMEOS group investigates and develops strongly correlated materials of interest in fundamental Condensed Matter research and for Information Technologies [3].
This PhD project is focused on the preparation and characterization of novel magnetoelectric frustrated materials, in structures favoring competing charge/orbital/spin orders with enough spin-orbit coupling. The starting point will be frustrated spin-induced multiferroics [2] with chiral spin structures (that break spatial and time inversion symmetries) [4]. A new mechanism of the type “order by disorder” can stabilize chiral magnetic orders at RT [5]. The spin-orbit coupling favours non-collinear and chiral magnetic structures (including skyrmions), considered a very effective way of producing strong magnetoelectric coupling. Selected 3d and 4d compounds presenting topological or exchange frustration and strong Fe-O-Fe magnetic exchange interactions can help to extend the magnetoelectric properties above RT. Studying these materials in single crystal form is very convenient to characterize their anisotropic static and dynamical properties in reaction to external stimuli. Non-collinear chiral and spiral orders can be detected with the help of neutron and magnetic x-ray scattering [6,7]. A key component of the PhD project will be neutron and X-ray scattering experiments at european facilities to uncover magnetic, charge and structural correlations and confront theory.

JOB POSITION DESCRIPTION:
(2.000 characters – including spaces)
Include all the relevant information about the position, role, responsibilities and skills required within the project/group

This PhD project is focused on the fabrication and advanced characterization of multiferroic and magnetoelectric frustrated oxides, with strong correlations between their internal orders. The origin of the concurrent ferroic orders in improper multiferroics is no longer the traditional mechanisms but coupled phase transitions breaking spatial and time reversal

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symmetries. Selected 3d and 4d compounds presenting geometric, magnetic or electronic frustration, in structures favoring competing charge/orbital/spin orders, will be prepared in our lab in different forms, including the growth of single crystals using modern Optical Floating Zone equipment. Besides using the conventional laboratory techniques for structural, magnetic and physical properties characterization, the proposed project requires atomic level structural, magnetic and electronic structure information that will be obtained from neutron scattering experiments and synchrotron techniques in Large European Facilities (including ALBA). Such experiments are a key component of the project, and will be performed as a function of temperature, pressure and under external electrical and magnetic fields. Crystallographic and symmetry-based computational tools will be applied to the description and understanding of the phase transitions and physical mechanisms.

References: **[1]** S. Dong et al., Advances in Physics 64:5-6, 519 (2015). **[2]** T Arima et al., J. Phys. Soc. Jpn. 80 (2011) 052001. **[3]** http://departments.icmab.es/cmeos. **[4]** Y. Tokura et al, Rep. Prog. Phys. 77, 076501 (2014). **[5]** Shang et al., Science Adv. 4, eaau6386 (2018). A. Scaramucci et al., Phys. Rev. Res. 2, 1 (2020). **[6]** R. D. Johnson and Paolo G. Radaelli, Annu. Rev. Mater. Res. 2014. 44:269–298. **[7]** X. Zhang et al, Acta Mater. 206, 116608 (2021).

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RELATED LINKS TO THE POSITION (optional)
URL: https://www.ill.eu
Tittle link: Institut Laue-Langevin (ILL, Grenoble))

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