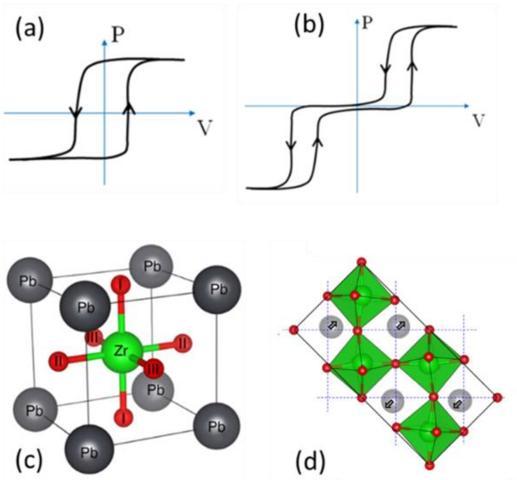
Unité Mixte de Physique CNRS/Thales – Université Paris-Saclay – 1 avenue Fresnel – 91767 Palaiseau- France

MASTER THESIS PROPOSAL (M2) 2016-2017

Exploring antiferroelectricity in epitaxial thin films

Ferroelectricity is a property of certain materials that have a spontaneous electric polarization that can be reversed by the application of an external electric field (cf. Fig. 1a). The polarization is the sum of the individual electric dipoles in each unit cell of a material, and in a ferroelectric these dipoles align parallel to one another. The term "ferroelectricity" was coined in analogy to ferromagnetism, in which a material exhibits a permanent magnetic moment. Just as another class of magnetic materials is constituted by antiferromagnets in which individual magnetic moments typically order in two antiparallel ferromagnetic sublattices, some compounds are *antiferroelectric*, i.e. adjacent electric dipoles order in opposite (antiparallel) directions. As a result, the spontaneous polarization is zero in the absence of external electric field. The application of an electric field induces a transition to a ferroelectric state and the polarization cycle shows off-centered double loops (as shown in Fig. 1b)



From Tagantsev et al. Nature Commun. 4, 2229 (2013)

While ferromagnets, ferroelectrics and antiferromagnets have been intensely investigated for several decades, the research on antiferroelectrics is still in its infancy. In thin films, the field is practically virgin, many questions remain unanswered and device opportunities await to be explored.

This internship will aim at the exploration of the physics of antiferroelectric materials in thin films. Two types of compounds (both from the perovskite family) will be selected: $PbZrO_3$ (the prototype antiferroelectric compound, sketched in Fig. 1c; Fig. 1d shows the antiparallel motion of Pb ions, responsible for the antiferroelectric character) and rare-earth-doped $BiFeO_3$. They will be grown as epitaxial thin films by pulsed laser deposition (PLD). After optimizing the growth of both types of compounds, their structural properties will be characterized by X-ray diffraction and their electrical response by polarization measurements and, at the nanoscale, by piezoresponse force microscopy. The influence of strain and film thickness on the properties will be addressed.

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Techniques in use: Thin film growth by pulsed laser deposition, X-ray diffraction, atomic force microscopy, piezoresponse force microscopy, polarization measurements.

Applicant skills: Affinity for experimental work, good knowledge of condensed matter physics and crystallography, good organization skills, capacity to work in a group.

Allowance: >400 €/month **Possibility to extend by a PhD thesis:** Yes