KFM 1: Tutorial: Functional Ferroics (joint session KFM/TUT)

Chair: Dr. Jan Schultheiß (Augsburg University / NTNU Trondheim)

Time: Sunday 16:00–18:15 Location: H3

Tutorial KFM 1.1 Sun 16:00 H3

Domains and domain walls in functional ferroics — •Dennis Meier — Department of Materials Science and Engineering, Norwegian University of Science and Technology — Center for Quantum Spintronics, Department of Physics, Norwegian University of Science and Technology, Trondheim, Norway

Ferroic materials with spontaneous magnetic or electric long-range order are a rich source for functional phenomena. Ferromagnets, for example, are used in hard discs and read heads, whereas ferroelectrics find application as capacitors, energy harvesters, and in tunnel junctions. The rich functionality of ferroic materials is closely linked to their domain structures and the responses of the domains to external stimuli.

In this tutorial, I will give an introduction to the fundamentals that underpin the domain formation in ferroics and discuss different microscopy techniques that allow for imaging electric and magnetic domains. Furthermore, we will talk about more exotic systems, such as improper ferroelectrics and multiferroics, where the interplay of coexisting order parameters gives rise to completely new domain and domain wall properties at the nanoscale. Open experimental challenges will be addressed, as well as future application and research opportunities.

Tutorial KFM 1.2 Sun 16:45 H3

Theory and simulations of ferroelectrics and related materials — •Jorge Iniguez — Luxembourg Institute of Science and Technology — University of Luxembourg

In this tutorial I will introduce the theoretical and simulation methods most frequently employed to investigate ferroelectrics and related materials (antiferroelectrics, multiferroics). I will start from the general electronic-structure methods that permit predictive calculations at the atomic scale, and introduce successive simplifications to eventually reach continuum field schemes that give us access to the mesoscale. I will illustrate the specificity and usefulness of the different approaches by presenting, for each of them, one or two classic examples of application. In passing, this will allow me to emphasize the key role that simulation has played in our field, and to touch upon interesting possibilities for application in energy-related problems.

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Tutorial KFM 1.3 Sun 17:30 H3

Atomic scale analysis of ferroic domain walls — •Shelly Conroy — Department of Materials, London Centre of Nanotechnology, Imperial College London, United Kingdom

The dynamic interfaces of ferroic materials known as domain walls bypass the static limitations of traditional nano-device designs. In contrast to hetero-interfaces between different materials, domain walls can be created, moved and removed via an applied stimulus. By combining multiple ferroic properties such as electricity and magnetism, new multi-functional interactive device applications are possible. As these mobile walls can be atomically sharp, it is essential to have physical characterisation at this scale spatially and time-resolved. In this tutorial, I will give an introduction to electron microscopy techniques starting with how to identify domain patterns in the bulk samples, and the most appropriate electron microscopy techniques to use with increasing magnification, leading to pico-meter characterisation. We will discuss some of the most recent advances in electron microscopy characterisation methods for ferroelectrics such as visualising electric charge density at sub-angstrom resolution, and the benefits of coupling polarisation characterisation with electron energy loss spectroscopy band structure analysis. We will then talk about how one can probe multiferroic properties such as magnetic field, strain and phonon modes. As one of the most exciting aspects of ferroic domain walls is their mobility, the various in situ options to investigate their dynamics will be detailed.