KFM 1: Tutorial: Exploring Ferroic Materials: From Modelling to Imaging Techniques (joint session KFM/TUT)

Recent developments in the study of ferroic materials have unveiled exciting features, encompassing phenomena such as skyrmions and multiferroic domain walls. This tutorial seeks to provide a comprehensive overview, spanning from fundamental theoretical concepts to advanced imaging techniques. We will learn how these cutting-edge developments now enable the bridging of length scales from the individual atom to the macroscopic understanding of the ferroic ordering.

Organizer: Felix Büttner (Univ. Augsburg), Jan Schultheiß (Univ. of Canterbury) Session Chairs: John Freeland (Argonne National Lab), Manuel Zahn (Univ. Augsburg)

Time: Sunday 16:00–18:15 Location: H 1028

Tutorial KFM 1.1 Sun 16:00 H 1028

Ferroelectric domains, domain walls, symmetry and thermodynamic models — •Jiri Hlinka — Institute of Physics, Czech Acad. Sci., Prague, Czechia

Properties and applications of the materials with ferroelectric or other kind of ferroic domains separated by domain walls continue to stimulate our desire to image, model and understand these ultimate nanoscale interfaces in more and more details. We aim to present here only the most general theoretical concepts that can be useful in related physics and materials science activities. In this tutorial presentation, also aimed to facilitate the most recent achievements presented at the DPG meeting, we intend to cover the subject mostly from the phenomenological point of view, relying on the symmetry constraints and Ginzburg-Landau theory arguments.

Tutorial KFM 1.2 Sun 16:30 H 1028

Nanoscale ferroelectricity: insights from optical second harmonic generation — •Nives Strkalj — Institute of Physics, Zagreb

Ferroelectric materials are a promising platform for energy-efficient electronic and optical devices. In thin films, relevant for applications, ferroelectricity is highly susceptible to the influence of interfaces through electrostatic and elastic boundary conditions. A large surface-to-volume ratio at the nanoscale thus leads to dramatic changes in polarization direction, magnitude, and domain configuration. However, evaluating ferroelectricity in thin films remains a challenge for conventional techniques because of significant non-ferroelectric contributions. A highly sensitive optical method, second harmonic generation (SHG), can be used to detect polarization in thin films. SHG has thus become an invaluable tool for studying size effects in nanoscale ferroelectrics.

In my talk, I will give an introduction to ferroelectricity, ferroelectric size effects, and approaches to tuning polarization in nanoscale films. I will present insights from SHG into the emergence and evolution of ferroelectricity in thin films. Finally, I will address the use of SHG for tracking polarization during the growth process - in situ - to access transient effects. I will conclude by showing examples of harnessing findings from SHG to engineer desired ferroelectric responses for specific applications.

15 min. break

Tutorial KFM 1.3 Sun 17:15 H 1028

Magnetic imaging with solid-state spin defects — •Vincent Jacques — Laboratoire Charles Coulomb, CNRS and Uni. Montpellier, France

Experimental methods enabling the optical detection of single spins in the solid-state, which were initially developed for quantum information science, open new avenues for the development of highly sensitive quantum sensors. In this context, the electronic spin of a single nitrogen-vacancy (NV) defect in diamond can be used as an atomic-sized magnetometer, providing an unprecedented combination of spatial resolution and magnetic sensitivity, even under ambient conditions. In this talk, I will first introduce the principle of scanning-NV magnetometry and discuss how it can be used as a powerful tool for exploring the physics of ferroic materials. I will then discuss recent efforts in researching alternative material platforms that could expand the range of quantum sensing functionalities offered by diamond, with a focus on hexagonal boron nitride.

Tutorial KFM 1.4 Sun 17:45 H 1028

Exploring Ferroic Materials in 3D using Atom Probe Tomography — •Shelly Conroy — Department of Materials, London Centre for Nanotechnology, Imperial College London, London SW7 2AZ, UK

Ferroic materials can contain complex interfaces such as grain boundaries, dislocations, domain walls, and higher order topologies. Even slight changes in chemical composition can result in drastic changes in functionality such as conductivity and magnetism. As the regions of interest are often only a unit cell thick and can meander throughout the bulk material in 3D it is vital to have a characterisation method that can achieve the required spatial resolution in 3D. Atom probe tomography (APT) provides 3D compositional mapping of materials with sub-nanometre spatial resolution. In this tutorial the basics of APT characterisation will be discussed, including how to make samples, how to process APT data and specific examples of APT analysis of ferroic materials. Additionally correlative electron microscopy techniques will be detailed, and how to combine structural with chemical information from both techniques.