TUT 1: Tutorial on Multiferroics and Magnetoelectrics

Time: Sunday 16:00–18:30 Location: HSZ 401

Tutorial TUT 1.1 Sun 16:00 HSZ 401

Magnetic and ferroelectric materials — •Wolfgang Kleemann — Angewandte Physik, Universität Duisburg-Essen, Lotharstr.1, 47048 Duisburg, Germany

In this introductory lecture, pertinent examples, mechanisms and basic theories of magnetic and ferroelectric phase transitions will be presented. We discuss the respective ordered states, the domain structures and some functional properties of relevant materials. Owing to their close vicinity to multiferroic and magneto-electric materials, oxidic systems will be brought into focus.

5 min. break

Tutorial TUT 1.2 Sun 16:50 HSZ 401

Magnetoelectric coupling in multiferroics: Recent developments — •Manfred Fiebig — HISKP, Universität Bonn, Bonn, Germany

Currently, an enormous interest in multiferroics – compounds uniting two or more forms of primary ferroic ordering in one phase – is observed. Aside from technological aspects the interplay of different forms of (anti-) ferroic ordering is a rich source for exploring the fundamental science of phase control. Magnetic ferroelectrics may constitute the most interesting type of multiferroics because they may exhibit an unusually strong, so-called magnetoelectric (ME), coupling of magnetic and electric properties which is useful for controlling magnetic order with electric fields and vice versa. In my talk I will discuss the intricate relation between multiferroicity, ME behavior, and symmetry in ME single-phase multiferroics with particular emphasis on recent developments. For example, simultaneous breaking of time- and space-inversion symmetry by magnetic spirals leads to a new type of “induced” ME multiferroic observed, e.g., in orthorhombic $RMnO_3$, pyroxenes, or $MnWO_4$. This has to be distinguished from multiferroicity in the popular compound $BiFeO_3$ which also forms spin-spirals, but independent of the ferroelectric order. On the other hand, space-time asymmetry can also lead to ferrotoroidicity (a spontaneous order of magnetic vortices) as an entirely different form of ferroic ordering observed, e.g., in $LiCoPO_4$.

5 min. break

Tutorial TUT 1.3 Sun 17:40 HSZ 401

Multiphase multiferroics — •Kathrin Dörr — IFW Dresden, Postfach 270116, 01171 Dresden, Germany

This tutorial addresses multiferroic materials and devices comprising two or more ferroic (ferroelectric or magnetic) phases. Single-phase multiferroics are rare and typically work at low temperatures. A combination of appropriate phases can provide multiferroicity and large magnetoelectric coupling also at ambient temperatures, and early applications have been realized.

One crucial issue is how the different ferroic phases must be coupled in order to achieve a large ”composite”magnetoelectric effect, i. e. the desirable electric control of magnetic order (or magnetic control of dielectric order). The coupling mechanisms by (i) elastic strain and (ii) charge at the interface between the phases will be discussed. Examples for these cases are a piezoelectric-magnetostrictive layered ”sandwich”structure and a field-effect transistor with ferroelectric gate and magnetic channel, respectively. The various designs of the composite materials will be followed through history, ending with self-organized and artificially patterned thin film nanostructures. Finally, the most promising approaches known today will be introduced. These include multiferroic sensors for magnetic ac fields, spin-polarized tunnel junctions with multiferroic barrier and the electrically controlled magnetic exchange bias effect from a $BiFeO_3$ layer.