

DF 4: Multiferroics, Phase Transitions & Relaxors

Time: Monday 10:00–12:40

Location: WIL B321

Invited Talk DF 4.1 Mon 10:00 WIL B321
Magnetoelectric effects and excitations in multiferroic manganites — ●ANDREI PIMENOV — Experimentelle Physik 4, Universität Würzburg, Am Hubland, 97074 Würzburg, Germany

Multiferroics are materials simultaneously showing ferromagnetic and ferroelectric order. Two order parameters are coupled in these materials, which leads to such unusual effects like magnetic switching of electric polarization and dielectric constant. As can be expected already from the first principles, changes in the static properties of multiferroics must be accompanied by dynamic effects like characteristic magnetoelectric excitations. Indeed, such excitations could be recently observed in the spectra and were called electromagnons. Contrary to the conventional magnons, the electromagnons are excited by the electric component of the electromagnetic wave and contribute to the static dielectric permittivity. The suppression of electromagnons in external magnetic fields provides a natural explanation for the magnetoelectric effects in broad frequency range between dc and terahertz.

5 min. break

DF 4.2 Mon 10:40 WIL B321
Multiglassy systems based on incipient ferroelectrics — ●VLADIMIR SHVARTSMAN¹, PAVEL BORISOV¹, SUBHANKAR BEDANTA¹, ALEKSANDER TKACH², PAULA VILARINHO², and WOLFGANG KLEEMANN¹ — ¹Angewandte Physik, Universität Duisburg-Essen, Lotharstr. 1, 47048 Duisburg, Germany — ²Department of Ceramics and Glass Engineering, CICECO, University of Aveiro, 3810-193, Aveiro, Portugal

In recent years there has been growing scientific interest in materials exhibiting the magnetoelectric (ME) effect. Research has mainly been focused on multiferroic materials, where two or more ferroically ordered states exist simultaneously. We show that the class of ME materials may be extended to those, where two glassy states of different nature occur simultaneously. This can be realized in incipient ferroelectrics like SrTiO₃ or KTaO₃ moderately doped with a paramagnetic cation, e.g. with Mn²⁺ [1]. The transitions into glassy states manifest themselves by anomalies in the temperature dependencies of the dielectric and magnetic susceptibilities as well as by a particular memory effects ("hole burning"). The ME effects were directly measured using a modified SQUID susceptometer. Although the amount of magnetically active ions is relatively small, a strong higher order ME coupling via both the "paramagnetoelectric" EH² and the "magneto-capacitive" E²H² effects is observed.

[1] V.V. Shvartsman, S. Bedanta, P. Borisov, W. Kleemann, A. Tkach, P.M. Vilarinho, Phys. Rev. Lett. 101 (2008) 165704.

DF 4.3 Mon 11:00 WIL B321
Dimensional crossover and absence of quantum criticality in SrTi¹⁶O_{1-x}¹⁸O_x — ●ANNETTE BUSSMANN-HOLDER¹ and ALAN R. BISHOP² — ¹Max-Planck-Institut für Festkörperforschung, Heisenbergstr. 1, D-70569 Stuttgart — ²Los Alamos National Laboratory, Theoretical Division, Los Alamos NM887545, USA

The isotope-induced ferroelectricity observed in SrTi¹⁸O₃ (STO18) enables a systematic study of the crossover between quantum paraelectricity and ferroelectricity as a function of x in SrTi¹⁶O_{1-x}¹⁸O_x (STO16_{1-x}STO18_x). We predict that all ferroelectric compounds have a finite transition temperature T_c and show a dimensionality crossover from d=3 to d=4 at sufficiently low temperature. A discontinuity in behavior takes place around x=0.35, where quantum fluctuations suppress the transition. No evidence is found for a quantum critical point in the phase diagram. The high temperature structural transition shows a substantial isotope dependence which is, however, less striking than for the ferroelectric transition.

DF 4.4 Mon 11:20 WIL B321
Effect of Ru doping on the structure and properties of PbZn_{1/3}Nb_{2/3}O₃-PbTiO₃ near the morphotropic phase boundary — TORBEN SCHOLZ¹, ●BORIANA MIHAILOVA², GEROLD A. SCHNEIDER¹, NILS PAGELS³, JÜRGEN HECK³, MARIN GOSPODINOV⁴, and ULRICH BISMAYER² — ¹Institute of Advanced Ceramics, Hamburg University of Technology — ²Institute of Mineralogy and Petrology, University of Hamburg — ³Institute of Inorganic and Applied Chem-

istry, University of Hamburg — ⁴Institute of Solid State Physics, Bulgarian Academy of Sciences

The search for novel multifunctional materials has spotted Pb-based perovskite-type solid solutions of relaxor and normal ferroelectrics because of their huge electromechanical coupling and strong photoelastic effects near the morphotropic phase boundary. We studied the local atomic structure, domain pattern and properties of pure and Ru-doped 0.9PbZn_{1/3}Nb_{2/3}O₃-0.1PbTiO₃ single crystals by applying atomic and piezoresponse force microscopy (AFM/PFM), dielectric measurements, X-ray diffraction analysis, Raman scattering and electron paramagnetic resonance. AFM/PFM images reveal the existence of tetragonal and non-tetragonal ferroelectric domains in 0.9PZN-0.1PT. The dielectric and elastoelectric loops show that Ru doping, Ru/(Ti+Zn+Nb) = 0.002, leads to significant ferroelectric hardening due to the immobilization of domain walls. Besides, the addition of Ru decreases the ferroelectric domain size, reduces the polar fraction distributed in the pseudo cubic matrix and changes the unit cell parameters of the overall tetragonal structure.

DF 4.5 Mon 11:40 WIL B321
Ferroelectric Domains Nucleation and Growth in BaTiO₃ — ●STEFANO LEONI¹, MAREK PASCIAK², and SALAH EDDINE BOULFELFEL¹ — ¹Max-Planck-Institut CPFS, Dresden, Germany — ²Institute of Low Temperature, PAS, Wroclaw, Polen

Ferroelectric materials are broadly employed as capacitors and memory materials. However, even for the classical compound BaTiO₃ (BTO), the microscopic nature of the cubic paraelectric (PE) and of the ferroelectric (FE) phases and phase transformations (from cubic to tetragonal, orthorhombic and rhombohedral phases on lowering temperature) is still unclear. However, a deep understanding of the phenomenon of ferroelectricity is of top priority for further material properties control. We perform molecular dynamics simulations based on advanced schemes on the PE to FE phase transition in BTO. We elucidate ferroelectric domain nucleation and growth in detail, stressing the role of anti-ferroelectric coupling in FE domains, and show how a rescaling of critical lengths is accompanying the transition and is responsible for the ferroelectric response of the material. A full picture of domain formation with and without an external field is presented.

DF 4.6 Mon 12:00 WIL B321
Pressure-induced local structural changes in PSN, PSN:Ba and PSN:Bi — ●ANNA-MARIA WELSCH¹, BORIANA MIHAILOVA¹, MARIN GOSPODINOV², RAINER STOSCH³, BERND GUETTLER³, and ULRICH BISMAYER¹ — ¹Universität Hamburg — ²Bulgarian Academy of Sciences — ³PTB Braunschweig

Relaxors represent a special class of ferroelectrics which are attractive for a number of technological applications due to their unusual dielectric properties, intimately related to the presence of polar nanodomains within paraelectric matrix. Majority of relaxors are of Pb-based perovskite-type structure with general formula being ABO₃, which enables substitutional disorder in both A- and B-sites. Different types of cations on A- and B- positions and their degree of order have a direct influence on the formation and behaviour of polar nanodomains. In the recent years pressure came forth as a very powerful experimental approach in investigating the origin and true mechanism of relaxor behaviour, both still elusive to this day in spite of years of extensive research. Pressure acts directly on the inter-atomic level and combined with variations in the chemical composition influence the nano-domain structure and desired relaxor properties.

Here we present our results on the structure of pure, Ba- and Bi-containing PbSc_{0.5}Nb_{0.5}O₃. The pressure-induced structural changes of differently A-site doped compounds were studied by Raman spectroscopy. Our results indicate that pressure induces structural changes, favouring a certain type of ferroic distortion, with varying degree relative to the type and stereochemical nature of the A-site cations.

DF 4.7 Mon 12:20 WIL B321
Niobate (PSN) and A-site Doped PSN at High Pressures — ●BERND MAIER¹, CARSTEN PAULMANN¹, ROSS ANGEL², JENS ENGEL³, MARTIN GOSPODINOV⁴, BORIANA MIHAILOVA¹, and ULRICH BISMAYER¹ — ¹Mineralogisch-Petrographisches Institut, Universität Hamburg —

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High-pressure single crystal X-ray diffraction studies at room temperature on the relaxor ferroelectric lead scandium niobate (PSN) as well as Ba- and Bi-doped PSN are presented. A change in the volume compressibility, broadening of diffraction peaks, suppression of diffuse scattering, and the appearance of (hkl)-reflections ($h, k, l = 2n+1$) using the $Fm\bar{3}m$ -cell shows that PSN undergoes a phase transition near

2 GPa which is consistent with the results of M. Somayazulu [1]. For A-site doped PSN, the phase transition occurs at around 3.5 GPa. The transition for Bi-doped PSN is better pronounced than that for Ba-doped PSN. The suppression of the diffuse scattering at pressures above the phase transition is associated with a decoupling of A- and B-site cations in the existing polar nanoregions which leads to an enhancement of the ferroic distortion in the PbO-system. The decoupling also allows the B-site cations to shift back from their off-center positions which leads to the appearance of the reflections in the (hkl)-layers ($l = 2n+1$).

[1] Somayazulu, M. et al., APS Meeting Abstracts (2008)