# TT 4: Matter at Low Temperature: Materials

Time: Monday 9:30–11:15 Location: H 3010

**Invited Talk** TT 4.1 Mon 9:30 H 3010

**Can nuclear spins reveal the nature of tunneling systems in glasses?** — •Andreas Fleischmann — Kirchhoff-Institut für Physik, Universität Heidelberg, INF 227, 69120 Heidelberg

Most properties of amorphous materials at temperatures below 1K are caused by tunneling systems, which are assumed to be groups of atoms or molecules, cooperatively moving between two configurations of comparable energy. However, only little is known about the microscopic nature of these tunneling systems.

During the last years unexpected magnetic field effects were found in the dielectric properties of non-magnetic glasses at very low temperatures. These effects can be attributed to the tunnelling of atoms that carry nuclear quadrupole moments. As the electric quadrupole moments are interacting with the local electric field gradients, the nuclear states are coupled to the tunneling motion, resulting in energy levels and transition matrix elements that strongly depend on the atomic composition and the motion of the tunneling systems.

We present dielectric two-pulse polarization echo measurements on glasses, where the tunneling systems are coherently driven with two short microwave pulses. The observed amplitude of the spontaneous echo is strongly affected by the hyperfine structure that is introduced by the nuclear moments. The quantum beating that modulates the echo decay as well as the strong dependence of the echo amplitude on magnetic fields are found to be unique fingerprints for each glass and can be used to reveal information on the microscopic nature of the tunneling systems in these materials.

TT 4.2 Mon 10:00 H 3010

**Impact of nuclear spins on two-pulse polarization echos in Glycerol.** — •Masoomeh Bazrafshan, Gudrun Fickenscher, Celine Rüdiger, Marek Bartkowiak, Kathrin Reinhold, Andreas Fleischmann, and Christian Enss — Kirchhoff-Institut Für Physik,Universität Heidelberg

A few years ago surprising magnetic field effects were found in the dielectric properties of non-magnetic glasses at very low temperatures. For instance our 2-pulse polarization echo measurements on partially deuterated glycerol show strong magnetic field dependecies. It has since been established that this effect can be attributed to the tunneling motion of groups of molecules that carry nuclear quadrupole moments, between two different configurations of almost equal energy. This magnetic field effect saturates at about 60mT, when the nuclear Zeeman energy becomes larger than the quadrupole splitting. However, detailed studies have shown that one component of these magnetic effects saturates already at about 10 times smaller field. We have shown that the origin of this effect is the interaction of nuclear magnetic dipole moments of the hydrogen atoms in glycerol. Both effects are visible in the magnetic field dependence of the echo amplitude and a quantum beating at zero field which we have studied systematically on a series of glycerol samples with different degrees of deuteration. Numerical calculations were performed and compared to the experimental observations which enables us to probe the microscopic nature of tunneling systems in amorphous glycerol.

TT 4.3 Mon 10:15 H 3010

**Structural phase transition in $CdCr_2O_4$ probed by far-infrared spectroscopy** — •Torsten Rudolf[1], Christian Kant[1], Joachim Deisenhofer[1], Franz Mayr[1], Vladimir Tsurkan[1,2], and Alois Loidl[1] — [1]Experimental Physics V, Center for Electronic Correlations and Magnetism, University of Augsburg, D-86135 Augsburg, Germany — [2]Institute of Applied Physics, Academy of Sciences of Moldova, MD-2028 Chişinău, Republic of Moldova

Strongly frustrated single crystalline $CdCr_2O_4$ [1] was investigated by means of Fourier Transform infrared spectroscopy. The temperature dependence of the far-infrared phonon spectrum was studied from 5 to 300 K. The space group of $CdCr_2O_4$ at room temperature is $Fd\bar{3}m$ and group theory predicts four infrared active phonon modes, which is verified by experiment. The formation of a pyrochlore lattice by the chromium ions leads to a strong geometric frustration in this spinel system, represented by a high frustration parameter $f \approx 9$. It is examined whether below the Néel temperature $T_N$ the magnetic ground state degeneracy is rather lifted by a lattice distortion or by a magnetic exchange induced symmetry breaking. However, due to a strong spin-phonon coupling each single phonon mode shows a splitting below $T_N \approx 8$ K. At 5 K the reflectivity data can be fitted with nine phonons via a generalized oscillator model using four parameters per mode. Dielectric loss data, calculated via the Kramers-Kronig transformation, even uncover a splitting into more than nine phonon modes.

[1] T. Rudolf *et al.*, New J. Phys. **9**, 76 (2007)

TT 4.4 Mon 10:30 H 3010

**Spin-phonon interactions in antiferromagnetic transition metal monoxides** — •Christian Kant, Torsten Rudolf, Franz Mayr, Joachim Deisenhofer, and Alois Loidl — Experimental Physics V, Center for Electronic Correlations and Magnetism, University of Augsburg, D-86135 Augsburg

Spin-phonon coupling in correlated matter gained a lot of attention in contemporary solid state physics. A fact which was triggered by the observation of phonon splittings in several spinel compounds [1]. Since transition metal monoxides like MnO or NiO are paramount examples for correlated electron systems and Mott-Hubbard insulators it seems to be straightforward to reinvestigate these compounds.

We performed temperature dependent measurements on MnO and NiO by means of far-infrared spectroscopy[2]. The obtained phonon spectra were analyzed in detail. Special attention is focused to the phonon splitting accompanying the transition into the magnetically ordered state.

[1] T. Rudolf *et al.*, New J. Phys. **9**, 76 (2007)
[2] T. Rudolf *et al.*, *Preprint* arXiv:0707.0820

TT 4.5 Mon 10:45 H 3010

**$AE$Ca$_4$(CoN$_2$)$_2$, $AE$ = Ca, Ba: $S = 1$ Realization of Shastry-Sutherland Model with Interlayer Interactions** — •Alim Ormeci[1], Joanna Bendyna[1], Peter Höhn[1], Rüdiger Kniep[1], Johannes Richter[2], Walter Schnelle[1], and Helge Rosner[1] — [1]Max-Planck-Institut für Chem. Phys. fester Stoffe, Dresden — [2]Institut für Theoretische Physik, Universität Magdeburg, Magdeburg

Recently the tetragonal alkaline-earth nitridocobaltate compounds $BaCa_4(CoN_2)_2$ and $Ca_5(CoN_2)_2$ were synthesized [1]. The crystal structures of these compounds have in the unit cell two Co layers separated by $c/2 \sim 6.1$ Å. Remarkably each Co layer has the lattice structure of the $Cu^{2+}$ spins known from $SrCu_2(BO_3)_2$. The Co ions in these compounds have two missing $d$ electrons ($s^1d^8$ configuration) so that they form a spin 1 system. Until now, the $S = 1/2$ system, $SrCu_2(BO_3)_2$, has been the only known realization for the Shastry-Sutherland model. The two nitridocobaltates are suggested as the first $S = 1$ realization of this model. Magnetic measurements and first-principles electronic structure calculations (based on the full-potential local orbital, FPLO, method) indicate, however, that the interlayer interactions are non-negligible. Therefore, one has to deal with a modified model of two Shastry-Sutherland layers coupled to one another. Results of first-principles and model Hamiltonian calculations will be compared with experimental data, and the implications will be discussed.

[1] J.K.Bendyna, P.Höhn, R.Kniep, Z. Kristallogr. NCS **222** (2007), CSD no. 409920 and 409921.

TT 4.6 Mon 11:00 H 3010

**Effect of the Magnetic Field on the Coulomb Gap** — •Barbara Sandow[1], Dirk Brossell[1], Olaf Bleibaum[2], and Walter Schirmacher[3] — [1]Institut für Experimentalphysik, Freie Universität Berlin, Germany — [2]Institut für Theoretische Physik, Otto-von-Guericke Universität Magdeburg, Germany — [3]Physik-Department E13, Technische Universität München, Germany

We used break-junction tunnelling spectroscopy to investigate the Coulomb correlation in n-type Germanium. The doping concentration was smaller than the critical concentration for the metal-insulator (Anderson) transition. The tunnelling conductance, which probes the electronic density of states, was found to depend strongly on voltage, temperature and magnetic field.

At low temperatures the differential conductance shows a minimum at zero voltage, as expected for a material with a Coulomb gap near the Fermi energy. Applying a magnetic field up to B = 8 Tesla at T = 0.1 K to 1 K reduces the magnitude of the tunnelling conductance. Furthermore our data on n-type Germanium seem to indicate a strong suppression of the Coulomb gap in large fields. This could be due to the field-induced shrinking of the electron wave functions that strongly reduces the overlap between the localized electron states. Using our theory of break-junction tunnelling in the hopping regime [1] we are able to explain the disappearance of the Coulomb gap in high magnetic fields.

[1] O. Bleibaum, B. Sandow, W. Schirmacher, Phys. Rev. B 70, 045308-1 (2004)