Tuesday, 27.08.2019, Room G 95

Time	ID	KOND I: Magnetism Chair: Verena Ney, JKU Linz
14:00	101	**Spin fluctuation induced Weyl semimetal state in the paramagnetic phase of $EuCd_2As_2$** *Junzhang Ma [1], Ming Shi [1], Joël Mesot [2], Simin Nie [3], Youguo Shi [4], Tian Qian [4], Hong Ding [4]* *[1] Paul Scherrer Institute, [2] ETH Zürich, [3] Stanford University,* *[4] Institute of Physics, Chinese Academy of Sciences* Weyl fermions can arise in Weyl semimetals (WSMs) in which the energy bands are usually nondegenerate, resulting from inversion or time-reversal symmetry breaking. Nevertheless, experimental evidence for magnetic WSMs is scarce. Here, using photoemission spectroscopy, we observe the degeneracy of Bloch bands already lifted in the paramagnetic phase of $EuCd_2As_2$. We attribute this effect to the itinerant electrons experiencing quasi-static and quasi-long-range ferromagnetic fluctuations. Moreover, the spin-nondegenerate band structure harbors a pair of ideal Weyl nodes near the E_f. Hence, we show that long-range magnetic order and the spontaneous breaking of time-reversal symmetry are not an essential requirement for WSM states in centrosymmetric systems, and that WSM states can emerge in a wider range of condensed-matter systems than previously thought.
14:15	102	**Spin wave modes in Permalloy micro stripes using time-resolved scanning transmission X-ray microscopy** *Andreas Ney [1], Santa Pile [1], Thomas Feggeler [2], Taddäus Schaffers [1], Katharina Ollefs [2], Verena Ney [1], Ralf Meckenstock [2], Kilian Lenz [3], Ryzard Narkovicz [3], Jürgen Lindner [3], Hendrik Ohldag [4]* *[1] Johannes Kepler Univ Linz, [2] Univ Duisburg-Essen,* *[3] Helmholtz Center Dresden Rossendorf, [4] Stanford Synchrotron Radiation Source* Micro-resonators fabricated by optical lithography can be combined with scanning transmission x-ray microscope (STXM) and a time-resolved detection scheme to measure magnetic excitations in ferromagnetic resonance (FMR) with ultimate spatio-temporal resolution of nominally 35 nm and a snapshot detection down to 17.4 ps [1]. Two perpendicular Permalloy micro-stripes were fabricated using e-beam lithography and pre-characterized using conventional FMR. The dynamic magnetic contrast measured by STXM-FMR enable to directly observe both uniform FMR modes as well as inhomogeneous spin-wave modes which exhibit a remarkably good agreement with respective micro-magnetic simulations. Moreover the properties of the spin-waves can be modified via the mutual positioning of the two Py stripes. [1] T. Schaffers et al., Rev. Sci. Instrum. 88, 093703 (2017)
14:30	103	**Spin-orbitronics of wurtzite semiconductors** *Margherita Matzer, Rajdeep Ahikari, Alberta Bonanni, Johannes Kepler University, Linz* Spin pumping is an efficient mechanism for the inception of spin current and for its conversion into charge current in non-magnetic metals or semiconductors via spin Hall effects. The generation of spin current in bilayers Py/*n*-GaN:Si is here reported. In *n*-GaN:Si and for a layer thickness greater than the spin diffusion length - a condition not met in previous studies on e.g. *n*-ZnO - a spin Hall angle $\theta_{SH} = 3.03 \times 10^{-3}$ is found, exceeding by one order of magnitude those of other relevant semiconductors, and pointing at wurtzite nitride compounds as efficient spin current generators.

14:45 **104**

Combining high-resolution Atomic Force Microscopy with Scanning Tunneling Microscopy induced light emission on single molecules

Katharina Kaiser, Leo Gross, Fabian Schulz, IBM Research Zurich

The field of STM induced light emission (STM-LE), especially on single molecules, has grown rapidly in the past 25 years [2] with astounding spatial as well as energetic resolution [3]. Yet, combining structural and optical information on single molecules remains challenging.
We present first results of a combined AFM and STM-LE setup on single vanadyl-phthalocyanine (VOPc) molecules. This setup so far allows for structure determination with atomic resolution by AFM with CO functionalized tips [5] and the possibility to perform controlled atom manipulation conjunct with the investigation of opto-electronic properties by STM-LE.

[2] X. Qiu et al. (2003). Science, 299(5606), 542–547.
[3] B. Doppagne et al. (2017). Phys. Rev. Lett., 118(12), 127401.
[5] Gross et al. (2009). Science, 325(5944), 1110–1114.

15:00 **105**

Reduced Density Matrix Functional Theory for Superconductors

Carlos L. Benavides-Riveros, Jonathan Schmidt, Miguel A. L. Marques
Martin-Luther-Universität Halle-Wittenberg

In this talk I present a new ab-initio theory for superconducting systems with non-local external potentials based on the one-particle reduced density matrix $\rho(r,r')$ and the anomalous density $\chi(r,r')$. All the equilibrium properties of the system are determined uniquely by these two quantities. By replacing the local electronic density with the non-local one-particle reduced density matrix, our theory is able to solve difficulties which arise in DFT for superconductors. I sketch the proof of the existence of a non-interacting Kohn-Sham system that is able to reproduce ρ and χ of the interacting system at finite temperature. On the basis of the Kohn-Sham system, one obtains a set of Bogoliubov-de Gennes-like single particle equations.

15:15 **106**

Multiple Coulomb Phase in the Fluoride Pyrochlore $CsNiCrF_6$

Tom Fennell [1], Mark Harris [2], Stuart Calder [3] Martin Ruminy, Martin Boehm [4], Paul Steffens [4], Marie-Hélène Lemée-Cailleau [4]; Oksana Zaharko [1]. Antonio Cervellino [1], Steven Bramwell [5]
[1] Laboratory for Neutron Scattering & Imaging, Paul Scherrer Institut
[2] University of Edinburgh, [3] Oak Ridge National Laboratory
[4] Institut Laue Langevin, [5] University College London

Coulomb phases can be constructed for degrees of freedom that obey an ice rule on the pyrochlore lattice. Using diffuse and single crystal neutron and powder x-ray scattering, we identify a structural Coulomb phase (charge ice) formed by the Ni^{2+} and Cr^{3+} cations in $CsNiCrF_6$. The cations form a configurational structural ice and dictate local distortions of the $(Ni/Cr)F_6$ octahedra, which inherit Coulomb phase correlations. The resulting exchange disorder can be mapped to a fully-packed loop model. Despite this disorder, diffuse and inelastic magnetic neutron scattering show that the spins also form a Coulomb phase, whose correlations and dynamics have much in common with those of the canonical pyrochlore Heisenberg antiferromagnet.

T. Fennell et al., Nat. Phys. 19, 60 (2019)

15:30 **107**

Spatially resolved thermoelectric effects in semiconductor-metal heterostructures

Nadine Gächter [1,2], Fabian Könemann [1], Masiar Sistani [3], Maximilian Georg Bartmann [3], Philipp Staudinger [1], Alois Lugstein [3], Bernd Gotsmann [1]
[1] IBM Rüschlikon, [2] EPFL, [3] TU Wien

Semiconductor-Metal heterostructures act as energy filters for charge transport with promising applications in thermoelectric energy conversion. Using a scanning thermal microscope technique we measure the temperature distribution of operando Al-Ge-Al nanowire devices integrated in a back-gated field effect transistor. The Ge segments are contacted with self-aligned quasi one-dimensional crystalline Al leads of 20 nm diameter. The high spatial resolution of our temperature map allows for the extraction of parameters governing the thermoelectric processes at the energy barrier, which are hardly extractable using other techniques. We extract Peltier coefficient, thermal conductivity and interface resistance to the substrate.

15:45	**108**	**Progressive lifting of the ground-state degeneracy of the long-range kagome Ising antiferromagnet** *Jeanne Colbois [1], Andrew Smerald [2], Frédéric Mila [1]* *[1] Institut de Physique, Ecole Polytechnique Fédérale de Lausanne* *[2] Max Planck Institute for Solid State Research* The frustrated nearest-neighbour antiferromagnetic Ising model on the kagome lattice exhibits a macroscopic ground state degeneracy. We implement an MCMC algorithm to study the degeneracy lifting leading to the ground state of the dipolar model, focusing on models with up to fourth neighbour interactions. The ground state of the J1-J2-J3 model exhibits five different phases as a function of the ratio J3/J2, four of which still have a non-zero residual entropy. We investigate how tensor networks can help to better understand these phases. Surprisingly, in the model with dipolar couplings truncated at fourth neighbours, we find states lower in energy than the ground states of the dipolar J1-J2-J3 model and the full dipolar model: further neighbours must play a role.
16:00	**109**	**Spin Hamiltonian and Dimensional Reduction in (Ba,Sr)$CuSi_2O_6$** *Stephan Allenspach [1], Pascal Puphal [2], Jakob Lass [3], Gregory Tucker [4], Christof Niedermayer [3], Ekaterina Pomjakushina [2], Christian Rüegg [1]* *[1] Neutrons and Muons Research Division, PSI. [2] Solid State Chemistry Group, PSI* *[3] Laboratory for Neutron Scattering and Imaging, PSI, [4] Rutherford Appleton Laboratory* The quantum magnet $BaCuSi_2O_6$, consisting of stacked spin dimer bilayers, undergoes an anomalous dimensional reduction from 3D to 2D close to the quantum critical point [1]. Mechanisms for this dimensional reduction were proposed based on inter-bilayer frustration resulting from an antiferromagnetic intra-bilayer exchange. Ab initio calculations propose a ferromagnetic intra-bilayer exchange rendering such a frustration impossible [2]. We have performed neutron spectroscopy on $BaCuSi_2O_6$ and $Ba_{0.9}Sr_{0.1}CuSi_2O_6$. Our results suggest ferromagnetic intra-bilayer exchanges with at least three different dimer types in $BaCuSi_2O_6$ and only one dimer type in $Ba_{0.9}Sr_{0.1}CuSi_2O_2$. We conclude that the existence of different dimer types in $BaCuSi_2O_6$ might lead to the observed 2D behavior. [1] C. E. Sebastian et al., Nature 441, 617 (2006). [2] V. V. Mazurenko et al., PRL 112, 107202 (2014).
16:15	~~**110**~~	*cancelled*
16:30		***Coffee Break***
19:30		***Public Lecture***

Time	ID	**KOND II: Low-dimensional systems** *Chair: Oleg V. Yazyev, EPFL*
17:00	**111**	**Spin-Orbital Excitations in Ca_2RuO_4 revealed by Resonant Inelastic X-Ray Scattering** *Lakshmi Das [1], Johan Chang [1], Mario Cuoco, Masafumi Horio [1], Fiona Forte, Veronica Granata, Oleh Ivashko [1], Marcus Dantz [2], Daniel McNally [2], Yi Tseng [2], Frank Schindler [1], Henrik Rønnow [3], W. Wan, Jonathan Pellicciari [2], Paul Olade-Velasco [2], N. Kikugawa, Antonio Vecchione, Claudia G. Fatuzzo [3], Thorsten Schmitt [2], Niels B. Christensen, Rosalba Fittipaldi, Titus Neupert [1]* *[1] Physik Institut, Uni Zürich, [2] Paul Scherrer Institut, [3] EPFL* Here, we have studied the magnetically ordered phase of Ca_2RuO_4 at T = 16 K, using O-K edge Resonant Inelastic X-ray Scattering technique. Four excitations have been identifed- 2 low energy excitations at 80 meV and 400 meV respectively and two high energy excitations at energies 1.3 eV and 2.2 eV. The low energy peaks are interpreted to be arising from composite spin-orbital excitations due to spin orbit coupling and the high energy excitations arise from singlet-triplet excitations at the Ruthenium site set by Hund's coupling. With the light polarisation analysis of the x-ray absorption and the RIXS spectra, we were able to characterise the mott active Ruthenium orbitals involved in the absorption processes.
17:15	**112**	**Disentangling charge and spin excitations and their evolution in the phase diagram of $Bi_2Sr_2CaCu_2O_{8+x}$ superconducting cuprate** *Wenliang Zhang [1] Yi Tseng [1], Eugenio Paris [1], Enrico Giannini [2], Thorsten Schmitt [1]* *[1] Paul Scherrer Institut, [2] EPFL* Whether the magnetic excitations in doped cuprates are described by paramagnons or the continuum of charge and spin excitations of correlated electrons is still controversial. Recent RIXS studies with azimuthal-dependent measurements for polarization analysis demonstrated how charge and spin nature of the low-energy excitations can be resolved, providing thereby a way to study their properties separately. Here we studied the evolution of the charge and spin components of the excitations by azimuthal-dependent RIXS in the phase diagram of $Bi_2Sr_2CaCu_2O_{8+x}$. Possible renormalizations by superconductivity of both kinds of excitations are explored by comparing their changes above and below T_c. Our results help to elucidate the nature of the magnetic excitations in cuprates and their possible correlations to superconductivity.
17:30	**113**	**High-speed domain wall racetracks in a magnetic insulator** *Saül Vélez, Jakob Schaab, Martin S. Wörnle, Marvin Müller, Elzbieta Gradauskaite, Pol Welter, Christian L. Degen, Morgan Trassin, Manfred Fiebig, Pietro Gambardella, ETH Zürich* We investigate the internal structure of the domain walls (DWs) in $Tm_3Fe_5O_{12}$ (TmIG) and TmIG/Pt bilayers and demonstrate their efficient manipulation by spin-orbit torques with velocities of up to 400 m/s and current threshold for DW flow of 5x10^6 A/cm^2. Pt current lines patterned on extended TmIG films allow controlling DW propagation and magnetization switching in selected regions. Scanning nitrogen-vacancy magnetometry reveals that the DWs of thin TmIG films are Néel walls with left-handed chirality, with the DW magnetization rotating towards an intermediate Néel-Bloch configuration upon deposition of Pt. These results indicate the presence of a sizable interfacial Dzyaloshinskii–Moriya interaction in TmIG, which leads to novel possibilities to control the formation of chiral spin textures in centrosymmetric magnetic insulators.
17:45	**114**	**Static and dynamic magnetic coupling in $Co_xZn_{1-x}O$ – Permalloy heterostructures** *Verena Ney, Martin Buchner, Bastian Henne, Julia Lumetzberger, Andreas Ney* *Johannes Kepler Universität Linz* $Co_xZn_{1-x}O$ – Permalloy (Py) heterostructures were investigated with frequency-dependent ferromagnetic resonance (FMR), x-ray magnetic circular dichroism (XMCD) and SQUID magnetometry. At low temperatures $Co_xZn_{1-x}O$ is an uncompensated antiferromagnet showing a narrowly opened hysteresis and a vertical exchange-bias effect [1,2]. By means of SQUID a static interaction is evidenced by increased coercive fields for Py at low temperature in the $Co_xZn_{1-x}O$ – Py system. The

		dynamic interaction is measured by using FMR from 3-12 GHz. We find an increasing frequency dependence of the homogeneous broadening of the FMR linewidth with increasing Co concentration evidencing spin pumping from Py into $Co_xZn_{1-x}O$. [1] V. Ney et al., Phys. Rev. B 94, 224405 (2016). [2] M. Buchner et al., Phys. Rev. B 99, 064409 (2019)
18:00	**115**	**La_2NiMnO_6 thin films grown by off-axis RF magnetron sputtering** *Gabriele de Luca [1], Umar Bashir [1], Claribel Dominguez [2], Cinthia Piamonteze [3], Marta Gibert [1]* *[1] University of Zürich, [2] University of Geneva, [3] Paul Scherrer Institut* La_2NiMnO_6 (LNMO) is an insulating double perovskite oxide with ferromagnetic Curie temperature around 280 K driven by the oxygen-mediated super exchange interaction between long-range ordered Ni^{2+} and Mn^{4+} ions. An insulating ferromagnet would be ideal for novel spintronic devices but only a few attempts of growing ultrathin films have been reported. Here we show that the epitaxial growth of LNMO ultrathin films can be accomplished with off-axis RF magnetron sputtering. Structural characterization illustrates the preparation of films with high crystalline quality and minimal degree of antisite disorder. SQUID magnetometry and synchrotron XMCD indicate that the ferromagnetic character of the film is retained at least down to 2 nm. This is one important step towards the implementation of LNMO films in multilayer geometries.
18:15	**116**	**Tuning the electronic structure of $LaNiO_3$ thin films** *Jasmin Jandke [1], Marco Caputo [1], Muntaser Naamneh [1], Eduardo Bonini Guedes [1,2], Nicholas Plumb [1], Ming Shi [1], Milan Radovic [1]* *[1] Paul Scherrer Institut. [2] EPFL* Since many years, rare earth nickelates attract the researchers interest due to their huge variety of fascinating physical properties which are tunable by the interplay of electron correlations and crystal structure. Further, these systems show dimensionality-driven transitions (e.g. $LaNiO_3$ (LNO) thin films), and strain-induced transitions (e.g. $NdNiO_3$ heterostructures). We investigate the evolution of the electronic structure of LNO thin films in proximity to doped $La_{1-x}S_xMnO_3$ (LSMO) grown on STO and NGO substrates by pulsed laser deposition (PLD). The combined study of angle resolved photoemission spectroscopy (ARPES) and transport measurements demonstrates that the electronic properties of LNO thin films can be tuned via the LSMO buffer layer. The results will be explained in terms of charge transfer mechanism and electron-phonon coupling.
18:30	**117**	**Electron-lattice interaction boost on the verge of metal-insulator transition in oxides** *Vladimir Strocov [1], Marius-Adrian Husanu [1], Lorenzo Vistoli [2], Carla Verdi [3], Anke Sander [2], Vincenzo Garcia [2], Julian Rault [4], Federico Bisti [1], Leonid L. Lev [5], Thorsten Schmitt [1], Feliciano Giustino [3], Andrey Mishchenko [6], Manuel Bibes [2]* *[1] Swiss Light Source, Paul Scherrer Institute, 5232 Villigen PSI* *[2] Unité Mixte de Physique, CNRS, Thales, Université Paris-Saclay, FR-91767 Palaiseau* *[3] Department of Materials, University of Oxford, Parks Road, Oxford OX1 3PH, UK* *[4] Synchrotron SOLEIL, L'Orme des Merisiers Saint-Aubin, BP 48, FR-91192 Gif-sur-Yvette* *[5] National Research Center "Kurchatov Institute", RU-123182 Moscow* *[6] RIKEN Center for Emergent Matter Science (CEMS), 2-1 Hirosawa, Wako, Saitama 351-0198, Japan* Many perovskite transition metal oxides (TMOs) exhibit metal-insulator transitions whose complex physics is not fully understood. We use soft-X-ray ARPES to visualize how the electrons delocalize and couple to bosonic lattice excitations in $CaMnO_3$ upon its doping with Ce. We show the progressive development of a complex Fermi surface where mobile electrons weakly coupled to lattice coexist with much heavier charge carriers formed by strongly coupled polarons. The latter originate from a boost of electron-phonon interaction (EPI) when the populated bandwidth becomes of the order of phonon energy, breaking down the Migdal theorem and invoking high-order terms of EPI. Our results shed light on the complex transport response of Ce-doped $CaMnO_3$ and suggest strategies to engineer TMO-based quantum matter.

18:45	**118**	**Giant Magnetoelectric Response and Cross-Caloric Effect Around a Tetracritical Point in Multiferroic $SrMnO_3$** *Alexander Edström, Claude Ederer, ETH Zürich* $SrMnO_3$ can be strain-engineered to be multiferroic, with coexisting and tuneable magnetic and ferroelectric (FE) order. We recently showed, using first principles calculations, that the ferroic strain-temperature phase diagram of $SrMnO_3$ accommodates a tetracritical point (TCP) with coinciding magnetic and FE ordering temperatures. Here, we construct a Landau theory with parameters determined from first principles DFT and effective Hamiltonian calculations, and demonstrate large magnetoelectric coupling, several orders of magnitude larger than in conventional magnetoelectrics, occurring near the TCP. We study a giant magnetic cross-caloric effect, increasing the electrocaloric effect by 60%, providing an example of a large, useful magnetoelectric coupling effect in an antiferromagnetic multiferroic. This opens new possibilities for promising research directions among caloric effects for solid state cooling.
19:00		***Postersession with Apéro***
20:30		

Thursday, 29.08.2019, Room G 95

Time	ID	**KOND III: Oxides** *Chair: Fabian O. von Rohr, Uni Zürich*
17:00	**121**	**Investigation of topological channels in twisted bilayer graphene** *Peter Rickhaus [1], John Wallbank [2], Sergey Slizovskiy [2], Riccardo Pisoni [1], Hiske Overweg [1], Marius Eich [1], Yongjin Lee [1], Ming-Hao Liu [3], Klaus Ensslin [1], Thomas Ihn [1]* *[1] ETH Zürich, [2] National Graphene Institute, University of Manchester, Manchester, M13 9PL* *[3] Department of Physics, National Cheng Kung University, Tainan 70101, Taiwan* We show electronic transport data on a particular interesting carbon system: Two vertically stacked layers of graphene that are twisted with respect to each other. With the twist angle, the properties change fundamentally. The two layers are decoupled at large and strongly coupled at small angles. It is even possible to achieve superconductivity at a certain twist angle. To probe the system we make use of an electronic Fabry-Pérot interferometer. We probe a network of topological channels at tiny twist angles [1] and the physics of decoupled graphene layers at very large twists. [1] P. Rickhaus, et.al. Nano Lett. 18, 11, 6725 (2018)
17:15	**122**	**Temperature dependent photoemission study of the charge-ordered phases in $IrTe_2$** *Maxime Rumo [1], Christopher William Nicholson [1], Thomas Jaouen [1], Marie-Laure Mottas [1], Geoffroy Kremer [1], Björn Salzmann [1], Aki Pulkkinen [2], Bernardo Barbiellini [2], Fabian von Rohr [3], Phillip Aebi [1], Claude Monney [1]* *[1] Université de Fribourg, [2] LUT Université, [3] University of Zürich* We investigate the electronic structure of $IrTe_2$ to elucidate the origin of its charge-ordered phase transitions. Here, we present an X-ray photoemission spectroscopy study as a function of temperature across the $IrTe_2$ phase transitions. Our surface sensitive measurements reveal new results on the specific nature of the transitions in contradiction with the literature. According to our measurements, the transition at 270 K remains first-order, occurring within only a few Kelvin, while the transition at 180 K is second-order, developing over a range of several tens of Kelvin. In parallel, we perform an angle-resolved photoemission spectroscopy study as a function of temperature, which allows us to confirm the previous deductions.

17:30	**123**	**Van der Waals magnetic materials: growth and characterization** *Dumitru Dumcenco, Enrico Giannini* *Department of Quantum Matter Physics, University of Geneva* Novel properties and exciting perspectives are offered by two-dimensional magnetic materials, like binary MX_2 and ternary MYZ_3 (M is a metal element; X is a halogen; Y = Si, Ge or P; Z is a chalcogen). Various complementary growth techniques are employed to produce these materials in crystalline form, namely the Chemical Vapor Transport and the high temperature solution (flux) growth. Here we summarize the growth techniques and conditions, as well as the recent advances in the crystal growth of magnetic van der Waals materials. The quality of the bulk crystals is proven by structural and chemical investigations and the study of magnetic properties. These materials can be successfully exfoliated and are being applied in atomically thin devices.
17:45	**124**	**ARPES study of few layer black phosphorus crystals** *Florian Margot, Felix Baumberger, Irène Cucchi, Anna Tamai, Simone Lisi,* *Ignacio Gutiérrez-Lezama, Alberto Morpurgo, Université de Genève* The electronic structure of 2D materials undergoes significant changes as their thickness is reduced down to the atomic limit. In few layer black phosphorus (BP) crystals, a promising semiconductor for optoelectronic and electronic applications, the bandgap increases drastically and the effective mass at the valence band and conduction band edges changes significantly. Here, we present the first direct electronic structure measurements on ultrathin BP. As BP is an air sensitive material, this is achieved by encapsulating exfoliated flakes in graphene or hBN. Our results reveal the quantum well states in the valence band and give a mapping of the anisotropic bandstructure of thin BP flakes. In particular, we determine the anisotropic effective mass at the valence band edge.
18:00	**125**	**Three Dimensional Lithography on Silicon Nanowire Arrays -** **An Electrochemical Approach** *Gilles Bourret [1], Fedja Wendisch [1], Michael Saller [1], Alex Eadie [1], Andreas Reyer [1],* *Maurizio Musso [1], Marcel Rey [2], Nicolas Vogel [2], Oliver Diwald [1]* *[1] University of Salzburg, [2] Erlangen-Nürnberg University* We will report on a templated electrochemical technique for patterning arrays of single-crystalline Si nanowires with feature dimensions down to 5 nm. This technique, termed three-dimensional electrochemical axial lithography (3DEAL) [1], allows the design and parallel fabrication of hybrid silicon nanowire arrays decorated with complex metal nanoring architectures in a flexible and modular approach. 3DEAL is based on simple chemical and electrochemical approaches that were developed previously [2] and can produce homogeneous macroscale metal-Si wire arrays. [1] F. J., Wendisch, M. Saller, A. Eadie, A. Reyer, M. Musso, M. Rey, N. Vogel, O. Diwald, G. R. Bourret Nano Letters 2018, 18, 11, 7343-7349 [2] T. Ozel, G. R. Bourret and C. A. Mirkin Nat. Nanotech. 2015, 10, 319–324
18:15	**126**	**Optically active nanowires nucleated** **via a novel focused ion beam implantation method** *Suzanne Lancaster [1], Markus Schinnerl [1], Aaron Maxwell Andrews [1], Masiar Sistani [1],* *Alois Lugstein [1], Werner Schrenk [2], Gottfried Strasser [1,2], Hermann Detz [3]* *[1] Institute of Solid State Electronics, TU Wien, [2] Center for Micro- and Nanostructures, TU Wien,* *[3] Brno University of Technology* We have previously demonstrated a novel approach for the growth of III-V nanowires on Si, using focused ion beam (FIB)-implanted Ga as nucleation points for self-catalysed GaAs nanowire growth. In this work, we have further investigated the possibility of growing optically active nanowires using this technique, via the growth of GaAs nanowires containing single InGaAs quantum wells in the shell. The nanowires show good emission, proving the high material quality of NWs grown via FIB-implantation. By comparison with randomly nucleated NWs, we find some C-doping of the NW core, attributed to the implantation process.

18:30	**127**	**Electrostatically-Defined Quantum Dots in Bilayer Graphene** *Annika Kurzmann [1], Marius Eich [1], Hiske Overweg [1], Peter Rickhaus [1], Riccardo Pisoni [1], Yongjin Lee [1]; Rebekka Garreis, Chuyao Tong [1], Kenji Watanabe [2], Takashi Taniguchi [2], Thomas Ihn [1]; Klaus Ensslin [1]* *[1] ETH Zürich, [2] National Institute for Material Science* Graphene is a promising candidate for nano-electronic devices, due to the expected long spin lifetimes and high carrier mobilities. Improvements in fabrication for graphene nanostructures have leveraged their quality to such an extent, that quantum dots in bilayer graphene are comparable to the best devices in gallium arsenide [1]. We use finite bias spectroscopy to identify the single-particle and many-body ground- and ex- cited states of electrostatically-defined quantum dots in bilayer. The results of our experiments allow us to propose a clear level scheme for two-particle spectra, in which the spin- and valley- entanglement and the exchange interactions play a crucial role [2]. [1] M. Eich, et al., Phys. Rev. X 8, 031023 (2018). [2] A. Kurzmann, et al., arXiv:1904.07185 [cond-mat.mes-hall] (2019).
18:45	**128**	**Imaging Disorder in a Bilayer-Graphene Channel** *Carolin Gold [1], Annika Kurzmann [1], Rebekka Garreis, Chuyao Tong [1], Kenji Watanabe [2], Takashi Taniguchi [2], Klaus Ensslin [1] Thomas Ihn [1]* *[1] ETH Zürich, [2] National Institute for Material Science* Bilayer-Graphene based Nanostructures promise unique opportunities in the field of quantum electronics. However, the endeavor to form quantum electronic building blocks such as Quantum Point Contacts (QPCs) and Quantum Dots (QDs) is significantly hampered by the presence of disorder. To understand the influence of disorder on the formation of QPCs and QDs in Graphene, we employ Scanning Gate Microscopy on a 3 μm-long, splitgate-defined channel on encapsulated bilayer graphene. By scanning the voltage-biased metallic tip of an atomic force microscope over the graphene channel, we perturb the potential landscape of the channel locally. This allows us to infer the local disorder potential within the channel.
19:00		***Transfer to Dinner***
19:30		***Conference Dinner***

Friday, 30.08.2019, Room G 95

Time	ID	KOND IV: Optical phenomena *Chair: Gottfried Strasser, TU Wien*
11:15	**131**	**μ-fluidic sensing with a quantum cascade lab-on-a-chip** *Florian Pilat [1], Benedikt Schwarz [1], Hermann Detz [2], Aaron Maxwell Andrews [1], Bettina Baumgartner [3], Bernhard Lendl [3], Gottfried Strasser [1,4], Borislav Hinkov [1]* *[1] Institute of Solid State Electronics, TU Wien* *[2] CEITEC, Brno University of Technology, CZ-Brno* *[3] Institute of Chemical Technologies and Analytics, TU Wien* *[4] Center for Micro- and Nanostructures, TU Wien* The mid-infrared spectral region is referred to as fingerprint region since molecules have their unique fundamental absorption features there. Addressing this optical regime, quantum cascade technology provides innovative optoelectronic devices to significantly improve integration and performance in chemical sensing. In this work, we present a room-temperature monolithically-integrated quantum cascade laser detector device for on-chip liquid-sensing of μl-samples, with a footprint smaller than a ping-pong ball. A surface plasmon polariton waveguide connecting laser and detector enables high coupling efficiencies and maximizes the interaction volume with the surrounding analyte. Concentration-dependent absorption, rapid-response and long-term-stability measurements are shown in the first proof-of-principle experiments.

11:30	**132**	**Theoretical study of the intra-cavity dynamics behind phase locking of quantum cascade laser frequency combs** *Nikola Opačak [1], Gottfried Strasser [1,2]; Benedikt Schwarz [1]* *[1] Institute of Solid State Electronics, TU Wien, [2] Center for Micro- and Nanostructures, TU Wien* Quantum cascade laser (QCL) has established itself as the main laser source in the mid-infrared portion of the electromagnetic spectrum. Due to a substantial third-order non-linearity in the laser active region, QCLs can work in a self-starting frequency comb regime, making them interesting for spectroscopic applications. A model based on Maxwell-Bloch equations was developed in order to study phase locking dynamics of a free running mid-infrared QCL frequency comb. A thorough study of the impact of the dispersion and optical non-linearities on the cavity mode dynamics was conducted. Recent experimental findings, showing chirped frequency modulated output, were reproduced for the first time, giving important insight into the governing mechanisms responsible for the modal phase-locking.
11:45	**133**	**Dual-comb spectrometer by single Doppler shifted MIR QCL frequency comb** *Mehran Shahmohammadi, Andres Forrer, Pierre Jouy, Mattias Beck, Jérôme Faist, Giacomo Scalari, ETH Zürich, Institute for Quantum Electronics* We present a dual-comb spectrometer consisting of a free running frequency comb quantum cascade laser (QCL) and its Doppler shifted counterpart reflected from a fast scanning mirror. The stable multi-heterodyne signal is centered at 400 kHz and well defined by the linear scanning velocity of the reflector. This dual comb spectrometer features higher stability than the standard dual comb spectrometers, in which the mutual coherence of the two utilized combs limits the acquisition time to typically less than tens of μs. This brings indeed a great simplification compared to dual comb spectrometers, where the phase noise of the combs needs to be either actively suppressed or measured continuously and adaptively adjusted.
12:00	**134**	**Picosecond pulses from mid-infrared quantum cascade lasers** *Johannes Hillbrand [1], Aaron Maxwell Andrews [1], Hermann Detz [1], Harald Schneider [2], Gottfried Strasser [1], Federico Capasso [3], Benedikt Schwarz [1]* *[1] TU Wien, [2] Helmholtz-Zentrum Dresden, [3] Harvard University* Quantum cascade lasers (QCL) are a compact and electrically pumped source of coherent mid- infrared light. Recently, it was discovered that QCLs can operate as frequency combs whose out- put is characterized by suppression of amplitude modulation and strong frequency modulation. However, the generation of short pulses by mode-locking of mid-infrared QCLs remains challeng- ing to date due to their ultrafast gain dynamics. We report on active mode-locking of mid-infrared QCLs resulting in the emission of intense picosecond pulses. We investigate the temporal dynamics of the QCL using both linear and quadratic autocorrelation techniques. Both methods confirm independently that the QCL emits a train of isolated pulses.
12:15	**135**	**Interband and quantum cascade laser frequency combs: From fundamentals towards monolithic spectrometers** *Benedikt Schwarz [1], Johannes Hillbrand [1], Maximilian Beiser [1], Nikola Opačak [1], Aaron Maxwell Andrews [1], Hermann Detz [2], Anne Schade [3], Robert Weih [4], Sven Höfling [3]* *[1] TU Wien, [2] CEITEC, Brno University of Technology, CZ-Brno, [3] Würzburg University, [4] nanoplus Nanosystems and Technologies GmbH,* Frequency combs are ideal candidates to realize miniaturized spectrometers without moving parts. We present an overview of our current research on mid-infrared frequency comb generation using interband and quantum cascade lasers (ICLs and QCLs). Our work ranges from fundamental laser physics to the realization of monolithic devices. We will highlight similarities and differences between these two types of lasers and show how both frequency modulated and pulsed frequency combs can be realized. In the last part, we will discuss why the ICL comb platform is a perfect candidate for the realization of miniaturized and battery driven mid-infrared spectrometers.

12:30	**136**	**Thermoelectrically cooled THz quantum cascade laser operating up to 210 K** *Lorenzo Bosco, Martin Franckié, Giacomo Scalari, Mattias Beck, Jérôme Faist* *ETH Zürich, Institute for Quantum Electronics* THz radiation is subject to a wide range of research and technological efforts, but it is limited by a lack of compact and powerful THz sources. A promising candidate is the quantum cascade laser (QCL), although it currently requires cryogenics since they only operate below 200 K. We present the first THz QCL operating on a thermoelectric cooler, up to a record-high temperature of 210 K. The design achieves high-temperature operation thanks to a systematic optimization by means of a nonequilibrium Green's function model, which also reliably reproduces the experimental results. Thanks to the relatively high peak power measured at 206 K (>1 mW), the laser spectra were acquired with a commercial room-temperature detector, making the whole setup cryogenic free.
12:45	**137**	**Ring Interband Cascade Lasers Running in Continuous Mode Operation** *Hedwig Knötig [1], Borislav Hinkov [1], Robert Weih [2], Sven Höfling [2,3], Werner Schrenk [4], Johannes Koeth [2], Johannes P. Waclawek [5], Bernhard Lendl [5], Gottfried Strasser [1,4]* *[1] Institute of Solid State Electronics, TU Wien, [2] nanoplus Nanosystems and Technologies GmbH* *[3] Physikalisches Institut and Wilhelm Conrad Röntgen-Research Center for Complex Material Systems, University Würzburg* *[4] Center for Micro- and Nanostructures, TU Wien* *[5] Institute of Chemical Technologies and Analytics, TU Wien* We present the first interband cascade lasers fabricated into ring-shaped cavities emitting in continuous wave operation. A second order distributed feedback grating is used for single mode emission and light outcoupling in vertical direction through the GaSb substrate. In addition, the implementation of an epitaxial-side down mounting scheme facilitates improved heat transport from the active region. The devices with a waveguide width of ~5 μm and an outer diameter of 800 μm show light emission at a wavelength of ~4.38 μm. These newly developed devices are employed in a project for trace gas analysis via the principle of photothermal interferometry.
13:00	**138**	**Optoelectronic devices based on non-polar ZnO/ZnMgO quantum wells** *Borislav Hinkov [1], Arnaud Jollivet [2], Hanh T. Hoang [1], Stefano Pirotta [2], Maria Tchernycheva [2], Raffaele Colombelli [2], Maxime Hugues [3], Nolwenn Le Biavan [3], Miguel Montesbajo [4], Adrian Hierro [4], Jean-Michel Chauveau [3], Gottfried Strasser [1,5], Francois H. Julien [2]* *[1] Institute of Solid State Electronics, TU Wien, [2] C2N University Paris-Sud, [3] CNRS-CRHEA,* *[4] ISOM Universidad Politecnica de Madrid, [5] Center for Micro- and Nanostructures, TU Wien* The performance of state-of-the-art GaAs-based THz-QCLs is limited by parasitic LO phonon transitions, preventing above-200 K operation. This can be overcome by using material systems with higher LO-phonon energies like ZnO, for which above-room-temperature operation in THz-QCLs is predicted. Using novel optoelectronic materials like wurzite Zn(Mg)O with no internal fields in the m-plane [10-10] orientation, simplifies the design of any QC structure. After the recent demonstration of intersubband absorption in such m-plane ZnMgO structures, we present the first mid-IR Zn(Mg)O-based QCD with peak responsivity of 0.15 mA/W (77 K) at 3 μm wavelength. The responsivity persists up to 300 K. In addition, we show first photoluminescence measurements from m-plane Zn(Mg)O THz-QCL structures, emitting at ~4.8 THz at liquid-nitrogen temperatures.
13:15	**139**	**n-type Ge/SiGe Quantum Cascade Devices for THz Electroluminescence** *David Stark [1], Luca Persichetti [2], Michele Montanari [2], Chiara Ciano [2], Luciana di Gaspare [2], Monica de Seta [2], Marvin Zöllner [3], Oliver Skibitzki [3], Michele Ortolani [4], Leonetta Baldassarre [4], Michele Virgilio [5], Thomas Grange [6], Stefan Birner [6], Kirsty Rew [7], Douglas Paul [7], Jerome Faist [1], Giacomo Scalari [1]* *[1] ETH Zürich, [2] Università di Roma Tre, [3] IHP-Leibniz-Institut für innovative Mikroelektronik,* *[4] Università di Roma "La Sapienza", [5] Università di Pisa,* *[6] nextnano GmbH, [7] University of Glasgow* Exploiting intersubband transitions in Ge/SiGe quantum cascade devices provides a way to integrate terahertz light emitters into silicon-based technology. To date all electroluminescence demonstrations of Si-based heterostructures have been p-type using hole-hole transitions. In the

		pathway of realizing an n-type Ge/SiGe terahertz quantum cascade laser, we present electroluminescence measurements of quantum cascade structures with top diffraction gratings. The devices for surface emission have been fabricated out of a 4-well quantum cascade laser design with 30 periods. An optical signal was observed with a maximum between 8-9 meV and full width at half maximum of roughly 4 meV.
13:30	**140**	**Superfluorescence from lead halide perovskite quantum dot superlattices** *Michael A. Becker [1], Gabriele Raino [2], Maryna I. Bodnarchuk [3], Rainer F. Mahrt [1], Maksym Kovalenko [2], Thilo Stöferle [1]* *[1] IBM Research - Zurich, [2] ETH Zürich, [3] EMPA* Superfluorescence is a many-body collective coupling phenomenon, where coherence is established through spontaneously triggered correlations of quantum fluctuations from initially fully uncorrelated excited emitters. Here, we investigate densely packed cuboidal arrays of fully inorganic cesium lead halide perovskite quantum dots, known as superlattices and we observe key signatures of superfluorescence: A more than twenty-fold accelerated radiative decay with dynamically red-shifted emission, photon bunching, extension of the first-order coherence time and an intensity-dependent time delay after which the photon burst is emitted. Also, at high excitation density, the superfluorescent decay exhibits a Burnham-Chiao ringing behavior, reflecting the coherent Rabi-type interaction. Rainò, G.; Becker, M. A.; Bodnarchuk, M. I.; Mahrt, R. F.; Kovalenko, M.; Stöferle, T.; Nature, 563, 671-675, (2018)
13:45		***END***

ID	KOND Poster
151	**Time-resolved tunneling between Landau levels in a weakly coupled quantum dot in the integer and fractional quantum Hall regimes** *Marc P. Röösli, Beat Bräm, Szymon Hennel, Lars Brem, Giorgio Nicoli, Benedikt Kratochwil, Annika Kurzmann, Matthias Berl, Christian Reichl, Werner Wegscheider, Thomas Ihn, Klaus Ensslin* *ETH Zürich* We study the electronic transport properties of weakly coupled 1 μm-large quantum dots (QDs) defined in GaAs/AlGaAs-heterostructures in the integer and fractional quantum Hall regime. Between filling factor $2 > \nu > 1$, the Coulomb resonances observed in the current through the QD are modified whenever an electron tunnels between the two Landau levels. Additionally, we employ charge detection and real-time counting techniques to measure tunneling between the Landau levels time-resolvedly. We observe similar behaviour for the first time in the fractional QH regime $\nu < 1$. The presented investigations pave the way for time-resolved measurements of quasiparticle tunneling between fractional QH states predicted to exhibit anyonic statistics.
152	**Characterization of Tannin-Furanic Foams by Raman Spectroscopy** *Maurizio Musso [1], Andreas Reyer [1], Francesco D'Amico [2], Nicola Cefarin [2], Thomas Sepperer [3], Gianluca Tondi [3], Lisa Vaccari [2], Sandro Donato [2], Gilles Bourret [1], Barbara Rossi [2], Giovanni Birarda [2]* *[1] University of Salzburg, Department of Chemistry and Physics of Materials* *[2] Elettra Sincrotrone Trieste* *[3] Salzburg University of Applied Sciences, Department of Forest Products Technology & Timber Construction* Rigid tannin-furanic foams are porous materials synthetized from wood industry products, and have potential applications as new materials for green-building technology, and possibly also for waste water purification. Within the Interreg Italy-Austria ITAT1023 InCIMa project (2017-2019), foam samples synthetized under varying chemical conditions at the Salzburg University of Applied Sciences have been characterized by Raman spectroscopy at the University of Salzburg and at the IUVS beamline of the Elettra synchrotron in Trieste. The additional synergistic complementation with several analytic techniques available at the Elettra synchrotron through the beamlines SISSI (Infrared), SYRMEP (microtomography), and SAXS (small angle X-ray scattering), performed within several CERIC proposals, enables us to more deeply characterize, and in future subsequent steps optimize, these materials.

153	**Optimizing the mechanical performance of 3D-printed wood-fiber-reinforced biocomposites by adjusting the infill orientation** *Maurizio Musso [1], Stefan Kain [2], Josef Valentin Ecker [3], Andreas Haider [3], Alexander Petutschnigg [2]* *[1] University of Salzburg, Department of Chemistry and Physics of Materials* *[2] Salzburg University of Applied Sciences, Department of of Forest Products Technology & Timber Construction* *[3] Kompetenzzentrum Holz GmbH (Wood K Plus), Department of Bio-based Composites and Processes* A detailed characterization of the mechanical performance, such as tensile strength, heat deflection temperature, compressive strength as well as impact strength, of 3D-printed wood-fiber-reinforced biocomposites was carried out as a function of various infill pattern orientations. Two wood filaments differing in terms of wood fiber content were utilized for specimen production, using a commercially available FDM 3D printer. All FDM 3D printed samples were evaluated depending on the infill orientation and on the wood fiber content. It could be proven that all investigated mechanical characteristics of the FDM 3D-printed wood-fiber-reinforced biocomposites are heavily dependent on the wood fiber content and on the infill pattern orientation. This study has been conducted within the international project Interreg Austria-Bavaria AB97 TFP-HyMat.
154	**Finite-element mesh generation and simulation of magnetization dynamics in a three-dimensional artificial spin structure** *Sebastian Gliga, University of Glasgow, Sven Friedel, COMSOL Multiphysics GmbH* Magnetic three-dimensional structures on the nanoscale possess static and dynamic properties not found in their 'flat' counterparts. The recent development of three-dimensional lithography and probing techniques (such as X-ray tomography) has enabled the experimental investigation of such structures. Concurrently, simulations need to be developed to gain detailed understanding of the magnetization dynamics. We have developed a finite-element meshing technique involving Eikonal equations, which has allowed us to produce high-quality efficient meshes for to describe a mesoscopic 'Buckyball' made of hollow beams, exemplifying a complex network with tree-fold junctions. Our micromagnetic simulations based on tetrahedral meshes reveal reversal avalanches mediated by the nucleation and propagation of domain walls during the field-driven magnetization reversal in the cylindrical tubes making up the Buckyball.
155	**Ultra-low electronic temperature measurement in a cryogen-free dilution refrigerator with an ^{4}He immersion cell** *Giorgio Nicolí, Peter Märki, Beat Bräm, Marc Röösli, Szymon Hennel, Andrea Hofmann, Christian Reichl, Werner Wegscheider, Thomas Ihn, Klaus Ensslin, Solid State Physics Laboratory, ETH Zürich* The investigation of quantum phenomena in solid state systems requires the ability to cool down macroscopic samples to low temperature. Lowering the temperature allows said quantum phenomena to develop and emerge in experiments. In semiconducting devices and at millikelvin temperatures, the cool down of an electron gas is increasingly challenging due to vanishing thermal conductivities and the freezing-out of phonons. We measured ultra-low electronic temperatures in a cryogen-free dilution refrigerator with a base temperature below 4 mK, achieved by using low-noise read-out and an innovative ^{4}He immersion cell for improved thermalization of the sample. With this setup we can perform experiments at extremely low electronic temperatures and in high magnetic field on gate-controllable nanostructures.
156	**Weyl Orbits Without an External Magnetic Field** *Tena Dubcek [1], Valerio Peri [1], Agnes Valenti [1], Roni Ilan [2], Sebastian Huber [1]* *[1] ETH Zürich, ITP, [2] Tel Aviv University* We show that non-local orbits can arise in the presence of time-reversal symmetry (TRS), via full-lattice simulations of a system with four Weyl points subjected to an axial field [1,2]. Magnetic field, applied to a system with Weyl points, results in pseudo-Landau levels that disperse only along the field direction [3]. An appealing idea is to avoid breaking TRS, and rely on an axial field. We elucidate the interpretation of the orbit surface motion in the absence of an external magnetic field, and verify the semiclassical energy quantization by an effective surface theory approach. [1] Grushin et al., PRX 6, 1 (2016). [2] Peri et al., Nat. Phys. 15, 357 (2019). [3] Potter et al., Nat. Commun. 5, 5161 (2014).

157	**Spin States in a Gate-Defined Quantum Point Contact in an InAs Two-Dimensional Electron Gas** *Christopher Mittag [1], Matija Karalic, Zijin Lei [1], Candice Thomas [2], Geoffrey Gardener [2], Michael Manfra [2], Thomas Ihn [1], Klaus Ensslin [1]* *[1] ETH Zürich, [2] Purdue University* We present measurements of quantized conductance in a quantum point contact (QPC) defined entirely by electrostatic gating of a high-mobility InAs quantum well. Spin splitting is observed separately when applying a magnetic field in either parallel or perpendicular direction and in the latter case it is superimposed by magnetic depopulation. We resolve the energy levels of the QPC by finite bias spectroscopy and determine the g-factor for both magnetic field directions. Minute control over nanostructures of InAs is an important step towards potential applications such as topological quantum computing for which it is a prime candidate due to its high spin-orbit interaction and a low effective mass.
158	**Topological scars** *Seulgi Ok [1], Kenny Choo [1], Claudio Castelnovo [2], Claudio Chamon [3], Christopher Mudry [4], Titus Neupert [1]* *[1] University of Zürich, [2] University of Cambridge, [3] Boston University, [4] PSI Villigen & EPFL* We propose an exact construction for atypical excited states of a class of non-integrable quantum many-body Hamiltonians in one dimension (1D), two dimensions (2D), and three dimensions (3D) that display area law entanglement entropy. These examples of many-body “scar” states have, by design, other properties, such as topological degeneracies, usually associated with the gapped ground states of symmetry protected topological phases or topologically ordered phases of matter.
159	**The polar distortion and its relation to magnetic order in multiferroic $HoMnO_3$** *Nazaret Ortiz [1], Yoav William Windsor [2], Jose Renato Linares Mardegan [3], Gareth Nisbet [4], Christof Schneider [1], Urs Staub [1]* *[1] PSI Villigen, [2] Fritz-Haber-Institut der Max-Planck Gesellschaft, [3] DESY, [4] Diamond* The orthorhombic (Pbnm) $HoMnO_3$ is of particular interest due to its high magnetically-induced polarization values and magnetoelectric coupling strength. The high magnetic frustration results in a magnetic order that creates a distortion in the crystal lattice. This distortion breaks inversion symmetry and creates a macroscopic electric polarization P along the a-axis. We investigated the broken symmetry of Pbnm in thin films of $HoMnO_3$ at low temperature and the relation between the magnetic order and the structural distortion. Forbidden reflections for Pbnm show that the distortion does not exclusively affect to the atomic position along the polar axis. Moreover, studying reflections with component along the polar axis reveals the polar distortion directly, visualized by the difference diffraction intensity from opposite domains.
160	**Spin-strain effects in the frustrated magnet $Tb_2Ti_2O_7$** *Yulia Gritsenko [1], S. Mombetsu [2], Sergei Zherlitsyn [3], J. Wosnitza [3], A. A. Zvyagin [4], Tom Fennell [5], Michel Kenzelmann [5]* *[1] Institut für Festkörper- und Materialphysik, Technische Universität Dresden* *[2] Department of Physics, Hokkaido University* *[3] Hochfeld-Magnetlabor Dresden (HLD-EMFL), Helmholtz-Zentrum Dresden-Rossendorf* *[4] B. I. Verkin Institute for Low Temperature Physics and Engineering of the National Academy of Sciences of Ukraine* *[5] Laboratory for Neutron Scattering & Imaging, Paul Scherrer Institut* Here, we present results of ultrasound investigations of the frustrated $Tb_2Ti_2O_7$. This cubic material features a Curie-Weiss temperature of θ_{CW} = 19 K, but no magnetic ordering has been detected down to 50 mK, indicating a large frustration factor. Our ultrasound results evidence a strong spin-lattice coupling in $Tb_2Ti_2O_7$. We observed pronounced minima in the sound velocity of different acoustic modes at 0.5 K and an additional anomaly at approximately 0.15 K. Below 0.5 K, the acoustic properties show a pronounced thermal hysteresis. Moreover, some anomalies have been detected in magnetic fields applied along the [110] direction. Possible quadrupolar ordering and a spin-liquid state are discussed for $Tb_2Ti_2O_7$ in relation to our experimental observations.

161	**Ground state crossings on spin clusters from tunneling interference** *Ivo Aguiar Maceira, EPFL* We present a method on how to calculate analitically the energy splitting between the two lowest levels of spin models on non-frustrated clusters in lowest-order degenerate perturbation theory. We apply it to arbitrary size 1D chains and small 2D and 3D clusters and find that by tunning an external magnetic field, the ground can be made degenerate on N different fields, where N is the number of spins. We argue that this phenomena is independent of the geometry, requiring only competing terms in the model. We study the effect of disorder on the position of the crossings and on the tunneling rate to further show the robustness of the zeros.
162	**Bulk electronic and local magnetic properties of semiconducting 2H-molybdenum ditelluride** *Jonas Krieger [1], Igor P. Rusinov [2], Niels B. M. Schröter [1], Sourabh Barua [3], Pabitra K. Biswas [4], Aris Chatzichristos [5], Derek Fujimoto [5], Zurab Guguchia [1], Stefan Holenstein [1], Victoria L. Karner [5], Ryan M. L. McFadden [5], John O. Ticknor [5], W. Andrew MacFarlane [5], Robert F. Kiefl [5], Geetha Balakrishnan [3], Evgueni V. Chulkov [6], Vladmir N. Strocov [1], Zaher Salman [1]* *[1] Paul Scherrer Institut, [2] Tomsk State University, [3] University of Warwick, [4] Rutherford Appleton Laboratory, [5] University of British Columbia, [6] Donostia International Physics Center* Layered transition metal dichalcogenides are intensively investigated due to their rich optoelectronic, superconducting and topological properties and their potential usage as mono-layer building blocks. Surprisingly, in semiconducting 2H-$MoTe_2$ long-range magnetic order of unknown origin has recently been observed [1]. Here we present the full 3D band structure of 2H-$MoTe_2$, determined with soft X-ray ARPES. We find a pronounced kz dispersion in most bands, consistent with ab-inito calculations. Furthermore, we present results of beta detected ^{8}Li NMR measurements and show that the spin-lattice relaxation of the implanted Li ions is inconsistent with ferromagnetic order. Instead, our results suggest a magnetic structure that is coupled antiferromagnetic across the van der Waals gap. [1] Z. Guguchia, et. al., Sci. Adv. 4, eaat3672 (2018)
163	**Magnetism in semiconducting molybdenum dichalcogenides** *Zurab Guguchia [1,2], Alex Kerelsky [1], Drew Edelberg [1], Soham Banerjee [3]; Fabian von Rohr [4], Declan Scullion [5], Mathias Augustin [5], M. Scully [5], Daniel A. Rhodes [6], Zurab Shermadini [2], Hubertus Luetkens [2], Alexander Shengelaya [7], Chris Baines [2], Elvezio Morenzoni [2], Alex Amato [2], James C. Hone [6], Rustem Khasanov [2], Simon J. L. Billinge [3], Elton Santos [5], Abhay N. Pasupathy [1], Yasutomo Uemura [1]* *[1] Department of Physics, Columbia University, New York, NY 10027, USA* *[2] Laboratory for Muon Spin Spectroscopy, Paul Scherrer Institute, CH-5232 Villigen PSI,* *[3] Dep. of Applied Physics and Applied Mathematics, Columbia University, New York, NY 10027, USA* *[4] Department of Chemistry, University of Zürich, Winterthurerstrasse 190, CH-8057 Zürich* *[5] School of Mathematics and Physics, Queen's University Belfast, Belfast, UK* *[6] Department of Mechanical Engineering, Columbia University, New York, NY 10027, USA* *[7] Department of Physics, Tbilisi State University, Chavchavadze 3, GE-0128 Tbilisi* We report the discovery of magnetic order in bulk semiconducting transition metal dichalco- genides (TMDs) 2H-$MoTe_2$ and 2H-$MoSe_2$ [1]. The muon spin rotation (muSR) measurements show the presence of long-range magnetic order in both compounds. DFT calculations show that this magnetism is promoted by the presence of defects in the crystal. The STM measurements show that the vast majority of defects in these materials are metal vacancies and chalcogen-metal antisites. DFT indicates that the antisite defects are magnetic with a magnetic moment in the range of 0.9 to 2.8 μB. These observations establish 2H-$MoTe_2$ and 2H-$MoSe_2$ as a new class of magnetic semiconductors. [1] Z. Guguchia et. al., Science Advances 4, eaat3672 (2018).

164 Towards the fabrication of ZnO-based quantum cascade lasers with double-metal waveguides

Hanh Hoang [1], Borislav Hinkov [1], Werner Schrenk [1], Maxime Hugues [2], Jean-Michel Chauveau [2], Gottfried Strasser [1]
[1] Institute of Solid State Electronics, Technische Universität Wien
[2] Centre de Rechercher sur l'Hétéro-Epitaxie et ses Applications, Centre national de la Recherche Scientifique (CRHEA-CNRS), Valbonne, France

Zinc oxide is a rather new material for optoelectronic applications. Due to its high LO phonon energy (ELO ~ 72 meV), it is suitable for THz-devices like quantum cascade lasers (QCLs), which are currently limited to operation temperatures around ~200 K for typical GaAs material systems. In this work, we show the development of a full fabrication process for double metal waveguides, processed into ZnO/ZnMgO QCL structures. This includes the development of a CH_4-based RIE dry etching process with additional passivation for preventing surface leakage, a thermocompression bonding (wafer bonding) with a substrate removal procedure and the fabrication of low-resistance ohmic contacts. In addition, we will present first photoluminescence measurements from such ZnO-based QC structure at liquid nitrogen temperatures and above.

165 Magnetic order on a Kagome-like lattice

Virgile Favre, Ivica Zivkovic, Arnaud Magrez, Henrik Rønnow, LQM - EPFL

We report magnetic investigations of a novel Kagome-related compound. Single crystals of the compound Cu_2OSO_4 have been studied by neutron scattering, magnetization and susceptibility. We find that instead of the spin-liquid ground state expected for a kagome compound, Cu_2OSO_4 orders in a canted anti-ferromagnetic structure. The magnetic structure is solved through neutron diffraction. The phase diagram established through susceptibility and specific heat measurements. Inelastic neutron spectra are being analyzed to determine the magnetic exchange pathways, and eventually explain the observed behavior.

166 $RNiO_3$ (R = La_xPr_{1-x} ; x = 0.1 to 1.0) perovskites at the extreme: Where Metal-Insulator Transition reaches 0 K

Yannick Maximilian Klein, Dariusz Jakub Gawryluk, Marisa Medarde, Nicola Casati, Lukas Keller, Dennis Sheptyakov, Paul Scherrer Institut

$RNiO_3$ (R = trivalent rare earth ions) perovskites are a unique class of materials, where structural, electric and magnetic transitions are directly linked to the size of the incorporated rare earth ion. The transitions are temperature dependent, which allows a systematic study. Of special interest in this series is where the transition point reaches 0 K, which creates a frustrated system with several coexisting properties. With the unique equipment at PSI in Villigen we are able to synthesize $RNiO_3$ at high temperatures (up to 1200 °C) and high O_2 pressures (up to 2 kbar) in a scale of 5-10 g, suitable for neutron experiments. La/Pr perovskites of the type $RNiO_3$ (R = La_xPr_{1-x} ; x = 0.1 to 1.0) are presented.

167 Temperature-driven Topological Phase Transition and Intermediate Dirac Semimetal Phase in $ZrTe_5$

Bing Xu, Premysl Marsik, Fryderyk Lyzwa, Evgenila Sheveleva, Christian Bernhard
University of Fribourg, Department of Physics and Fribourg Center for Nanomaterials

We present an infrared spectroscopy study of $ZrTe_5$, which realizes a recent theoretical proposal that this material exhibits a temperature-driven topological quantum phase transition from a weak to a strong topological insulating state through an intermediate Dirac semimetal state around T_p = 138 K. Our study details the temperature evolution of the energy gap in the bulk electronic structure. We found that the energy gap closes around T_p where the optical response exhibits characteristic signature of a Dirac semimetal state. A comparison with previous studies suggests that the divergent results and conclusions about the topological nature of $ZrTe_5$ can be reconciled by a variation of T_p, depending on the crystal growth conditions.

168

Sparse Sampling in Scanning Probe Microscopy

Jens Oppliger, Fabian Natterer, University of Zürich

The serial nature of a scanning probe microscope (SPM) renders data taking not only slow but may even prevent complex measurement tasks due to time limitations. Here we introduce the concept of compressed sensing (CS) as an effective sampling routine for SPM, requiring a significantly smaller subset of data points without compromising the measured information content. Our approach relies only on the sparsity of information in a vector domain to fulfill the requirements of CS theory. As an example we demonstrate precise reconstruction of the Cu(111) surface state wavevector from a 10-fold undersampled measurement, where the sparsity is given in Fourier space. We expect that our approach will be transformative for laboratories involved in Quantum Point Interference studies.

169

Orbit of an oscillating scanning probe microscope tip

Lorena Niggli, Fabian Natterer, University of Zürich

The ability to resolve individual bonds within a single molecule represents one of the greatest feats of atomic force microscopy (AFM). The imaging mechanism is based on a functionalized tip that dynamically responds to tip-sample interactions. However, these interactions depend on a convolution of sample and tip that puts aspects of the tip's behavior into focus. Here we demonstrate how to trace the orbit of an oscillating AFM-STM tip in three dimensions. We construct the tip-trajectory by applying voltage pulses at varying phases within the oscillation cycle. Lateral shifts in topographic features indicate a skewed oscillation or a dynamical tilting of the functional tip unit. Our method allows to control aspects of AFM imaging and spectroscopy.

170

Magnetic and superconducting properties of the iron arsenide pnictides $Ba_{1-x}Na_xFe_2As_2$ as seen by infrared spectroscopy

Evgeniia Sheveleva [1], Bing Xu [1], Premysl Marsik [1], Fryderyk Lyzwa [1], Benjamin P. P. Mallett [2], Thomas Wolf [3], Christian Bernhard [1]
[1] University of Fribourg, Department of Physics and Fribourg Center for Nanomaterials
[2] Research Institute, Victoria University, [3] Institute of Solid State Physics, Karlsruhe Institute of Technology

The iron pnictides high T_c superconductors exhibit a rich phase diagram that is known for the close proximity of the superconducting (SC) and antiferromagnetic (AF) or commensurate spin-density-wave (SDW) orders. In the hole-doped $Ba_{1-x}Na_xFe_2As_2$ (BNFA) SDW develops a long-range order that competes with superconductivity and is accompanied by transitions between various structural and magnetic orders (like orthorhombic AF (o-AF) and tetragonal AF (t-AF)).
In this study we present IR reflectivity data together with respective optical conductivity spectra on BNFA compound in the range of dopings where both o-AF and t-AF states live together with superconductivity. Fitting the real part of optical conductivity spectra allows us to describe quantitatively the relation between magnetism and superconductivity in the BNFA samples.

171

Growth of Crystal Phase Engineered Planar Films of III-V Semiconductors

Philipp Staudinger [1], Nicolas Tappy [2], Svenja Mauthe [1], Kirsten Moselund [1], Anna Fontcuberta I Morral [2], Heinz Schmid [1]
[1] IBM Research Zurich, [2] EPFL

Crystal phase engineering in semiconductors has attracted considerable interest because of its potential applications in solid state lighting and group IV emitters. However, synthesizing materials in their thermodynamically less stable phase is challenging and so far, has mainly been realized in nanowires. Here, we present a general approach to controllably integrate both zinc-blende (ZB) and wurtzite (WZ) phases of III-V semiconductors in a catalyst-free epitaxy yielding large area substrates with exceptionally high material quality. We conduct comprehensive material analysis including HRTEM, PL and CL characterization and find phase purities of 100% and 97% for ZB and WZ InP, respectively.

172	**Heating and dynamics in Floquet conformal field theory** *Bastien Lapierre [1], Clément Tauber [1], Apoorv Tiwari [2], Titus Neupert [2], Ramasubramanian Chitra [1]* *[1] ETH Zürich, [2] University of Zürich* We study the generic dynamics of a special class of integrable periodically modulated quantum systems. Using conformal field theory and in particular a mapping to sine-square deformed field theories, we analytically obtain the full Floquet dynamics of a large class of conformal field theories. These integrable systems show both heating and non-heating phases. In our work, we explore the correlation between heating and the dynamical behaviour of excitations. We show that the excitations of the system propagate along light cones in curved space-time. This propagation serves to underpin the dynamical processes which lead to heating via an abrupt change in the dynamics. Our work uncovers unexpected rich physics present in integrable Floquet systems.
173	**Size Dependent Lattice Expansion in nanocrystalline BCC Tantalum: Unusual Superconductivity and Magnetism** *Subhrangsu Sarkar [1], Nilesh Kulkarni [2], Krishnamohan Thekkepat [3], Ruta Kulkarni [2], Susanta Mohanta [4], Umesh Waghmare [3], Pushan Ayyub [2], Surendra Nath Mishra [5]* *[1] Department of Physics, University of Fribourg* *[2] DCMPMS, Tata Institute of Fundamental Research, Mumbai, India* *[3] Theoretical Sciences Unit, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore, India* *[4] Government College of engineering KALAHANDI, Bhawanipatna, India* *[5] DNAP, Tata Institute of Fundamental Research, Mumbai, India* Particle size dependence of T_c and H_c in nanocrystalline (2-60 nm) BCC Tantalum was measured from electrical transport under magnetic field down to 50 mK. Both parameters show unexpected non-monotonic size dependence. Also, superconductivity is observed to persist for particle size even below the conventional estimate of Anderson limit. Again, when isolated Fe implants are embedded in Ta with particle size below 8 nm, a stable magnetic moment is observed (using the time differential perturbed angular distribution technique), whereas none is observed for larger particle sizes or BCT-Ta (β-Ta) films. The observations are explained using ab initio calculations indicating both effects are related to the strong size-dependent lattice expansion (~4%) in Ta, which influences the electronic and phonon band structure.
174	**Quantum Mechanical Simulations of sub-atomic resolution differential phase contrast imaging of magnetic materials** *Alexander Edström, ETH Zürich, Axel Lubk, Institute for Solid State and Materials Physics, TU Dresden, Jan Rusz, Uppsala University* In recent years it has been shown that electric fields in solids can be imaged, with sub-atomic resolution, using scanning transmission electron microscopy (STEM) and differential phase contrast imaging techniques. Here we use a Pauli equation based multislice method [Phys. Rev. Lett. 116, 127203 (2016)] to investigate the possibilities of imaging also microscopic magnetic fields with such STEM techniques. Considering an example of a hard ferromagnetic material FePt, We illustrate how sub-atomic resolution images of the microscopic magnetic fields can be extracted for thin samples and suitable electron beam conditions. We discuss related possibilities and limitations, and aspects regarding data interpretation.
175	**Neuromorphic Computing with coupled VO_2 oscillators** *Elisabetta Corti, Bernd Gotsmann, Kirsten Moselund, Siegfried Karg, IBM Research Zurich* Biologically-inspired computation schemes are more effective than standard digital-based approaches when dealing with complex, unstructured tasks as image recognition. In particular, systems of frequency-locked, coupled oscillators exhibit associative memory capabilities encoded in the phase difference of the signal. We are using oscillating neural networks as hardware accelerators for image recognition. In this work, nanometer scale relaxation oscillators are built using the insulator-metal transition of VO_2. Our experiments show that the relative phase of coupled oscillators can be configured with the tuning of the coupling strength, i.e. the magnitude of the coupling resistor. This offers the perspective of realization a compact, computational network of oscillators. Mathematical simulations prove the computing capabilities of these networks when scaled to larger sizes.

176	**Rf modulation of surface-emitting mid-IR ring DFB Quantum Cascade Lasers** *Borislav Hinkov [1], Jakob Hayden [1], Rolf Szedlak [1], Pedro Martin-Mateos [2], Borja Jerez [2], Pablo Acedo [2], Gottfried Strasser [1,3], Bernhard Lendl [4]* *[1] Institute of Solid State Electronics, TU Wien, [2] Universidad Carlos III de Madrid, [3] Center for Micro- and Nanostructures, TU Wien, [4] Inst. of Chemical Technologies and Analytics, TU Wien* The fast modulation characteristics of quantum cascade lasers (QCLs) up to the MHz-/GHz-range give insight into their dynamical properties and act as a prerequisite for QCL-based experiments like e.g. the injection locking of mid-infrared frequency combs, spectroscopic measurements or high data transmission optical free-space telecommunication applications. In this paper we present the first analysis of the optical high-frequency modulation characteristics of surface-emitting mid-IR DFB-ring QCLs up to 160 MHz. We compare them to DFB-ridge QCLs from the same gain material and show the existence of the (quasi) single-sideband ((q)SSB) regime, a special FM-state in QCLs, not present in regular diode lasers. Surface-emitting ring-QCLs are particularly relevant, since they show significant potential in array integration and monolithic (ring-in-ring) laser-detector schemes.
177	**Homogeneous, bound-to-continuum THz Quantum Cascade Laser: 1.65 THz spectral bandwidth and RF injection locking** *Andres Forrer, David Stark, Martin Franckié, Tudor Olariu, Mattias Beck, Jérôme Faist, Giacomo Scalari, ETH Zürich* We present a homogeneous, bound-to-continuum Quantum Cascade Laser (QCL) featuring a spectral bandwidth up to 1.65 THz centered at 3.45 THz in a bi-stable CW lasing point above the typically not accessible NDR regime due to voltage driven operation. Below the NDR a spectral coverage of ~1 THz is observed with an electrically detected single and narrow beatnote indicating frequency comb emission. Further, injection locking to an external RF synthesizer with powers down to roughly -55 dBm at the QCL was realized. For increasing injection power the locking range follows the prediction of the Adler's Equation. Therefore, the device features the advantages of low injection powers and low threshold current density, 115 A/cm^2, but bandwidths still comparable to heterogeneous devices.
178	**A polarization-rotating Vivaldi antenna for improved far-field patterns of broadband terahertz quantum cascade lasers** *Urban Senica, Elena Mavrona, Tudor Olariu, Andres Forrer, Mattias Beck. Jérôme Faist, Giacomo Scalari, ETH Zürich* Terahertz quantum cascade lasers based on double metal waveguides are compact sources of terahertz radiation with excellent properties in terms of covering a large bandwidth and exhibiting low waveguide dispersion. However, as the optical mode is confined to subwavelength dimensions, the emitted radiation produces a highly divergent far-field pattern. We designed and fabricated an antipodal Vivaldi antenna which adiabatically expands the optical mode while rotating its polarization from vertical towards horizontal polarization. Numerical simulations predict a single-lobed far-field pattern with a beam width of less than 20°, spanning over two octaves in frequency (1.5-4.5 THz). Far-field measurements agree well with simulations.
179	*cancelled*
180	**Elucidating the impact of B incorporation in GaAs through nanowire growth** *Hermann Detz [1], Suzanne Lancaster [2], Heiko Groiss [3], Josef Zeininger [1], Aaron Maxwell Andrews [1], Werner Schrenk [4], Gottfried Strasser [2,4]* *[1] Brno University of Technology, [2] Institute of Solid-State Electronics, TU Wien, [3] Johannes Kepler University Linz, [4] Center for Micro- and Nanostructures, TU Wien* Boron-containing III-V alloys have net yet been thoroughly characterized. Yet, the small lattice-constant of BAs enables applications in strain-engineering of nanowires. We report on the incorporation of B into self-catalyzed nanowires, grown by molecular beam epitaxy. Energy-dispersive X-ray spectroscopy scans in a scanning transmission electron microscope revealed a segregation of B atoms to the nanowire sidewalls, causing inverse pyramidal voids. Electrical measurements on harvested nanowires revealed a p-type conductivity due to anti-site incorporation of B. A rate equation-based model allowed to extract a reduced surface diffusion length at the order of 1000 nm for Ga-adatoms on B:GaAs nanowire sidewalls.

181	**Dispersion measurements of Terahertz Quantum Cascade Fabry-Perot cavities and VECSELs** *Tudor Olariu, Mattias Beck, Jérôme Faist, Giacomo Scalari, ETH Zürich, Institute for Quantum Electronics* A method for obtaining the dispersion of terahertz (THz) quantum cascade lasers (QCL) is presented. Previously shown in the mid-infrared (MIR) range, it involves measuring the relative phase of the center burst (0^{th} order harmonic peak) and first satellite (1^{st} order harmonic peak) from the interferogram of a THz QCL cavity, operated below threshold, emitting inside a Fourier Transform Infrared Spectrometer (FTIR). The electroluminescence spectrum is thus determined by performing Fourier Transform on the acquired signal and the group velocity dispersion can then be calculated. This method is applicable to any QCL – here shown for Fabry-Pérot (FP) ridge laser as well as vertical external-cavity surface-emitting laser (VECSEL) THz metasurface.
182	**Magnetic field-effect on the charge order in underdoped $YBa_2Cu_3O_y$.** *Fryderyk Lyzwa [1], Milan Orlita [2], Bing Xu [1], Premysl Marsik [1], Evgeniia Sheveleva [1], Christian Bernhard [1]* *[1] University of Fribourg, Department of Physics and Fribourg Center for Nanomaterials, Chemin du Musée 3, 1700 Fribourg* *[2] LNCMI, CNRS-UGA-UPS-INSA, 25, Avenue des Martyrs, FR-38042 Grenoble* Underdoped cuprate high T_C superconductors have been intensively studied, especially since the discovery of the pseudogap phenomenon in the 1990's. An important step towards the identification of the HTSC pairing mechanism was the discovery of a charge density wave (CDW) existing in large parts of the underdoped phase diagram. In zero magnetic field (B = 0) the short-ranged, static CDW is induced by defects, while a long-range CDW can be induced for high B-fields along the c-axis (perpendicular to the CuO_2 layers). Here we aim to search for the origin of this CDW and its relationship with superconductivity (competing or interwined order). We performed reflection experiments from THz-NIR region (50 cm^{-1} - 6000 cm^{-1}) while applying high magnetic fields up to B = 30 Tesla.
183	**Stability of the Q-phase of $CeCoIn_5$ in the presents of localized magnetic impurities** *Junying Shen [1], Damaris Tartarotti Maimone [1], Daniel G. Mazzone [2], Stephane Raymond [3], Nicolas Gauthier [1], R. Yadav [1], Jorge Gavilano [2], Marek Bartkowiak [1], Michel Kenzelmann [2]* *[1] Laboratory for Scientific Developments & Novel Materials, Paul Scherrer Institut, CH-5232 Villigen PSI* *[2] Laboratory for Neutron Scattering and Imaging, Paul Scherrer Institut, CH-5232 Villigen PSI* *[3] Univ. Grenoble Alpes and CEA, INAC/ MEM/MDN, FR-38000 Grenoble* The well-known Q-phase in $CeCoIn_5$ is a rare example of cooperative coexistence of superconducting and magnetic order. For $Nd_{0.05}Ce_{0.95}CoIn_5$, a second magnetic phase is stabilized at zero magnetic field with identical symmetry of Q-phase separated by a quantum critical point [1]. We present studies on 2% and 3.5% Nd-doped $CeCoIn_5$ which interestingly shows that the SDW phase vanishes with increasing magnetic fields before the Q-phase is stabilized. This suggests that the two phases are separated by a disordered magnetic phase for low Nd-doped $CeCoIn_5$, representing for two magnetic instabilities and suggesting different origins of the two phases. [1] S. Gerber et al, Nature Physics 10, 126 (2014).
184	**The sound of the Q-phase in $CeCoIn_5$ - an ultrasound investigation** *Damaris Tartarotti Maimone [1], Marek Bartkowiak [1], S. Zherlitsyn [2], Michel Kenzelmann [3]* *[1] Laboratory for Scientific Developments and Novel Materials, Paul Scherrer Institut, CH-5232 Villigen PSI* *[2] Hochfeld-Magnetlabor Dresden (HLD), Helmholtz-Zentrum Dresden-Rossendorf, DE-01314 Dresden* *[3] Laboratory for Neutron Scattering and Imaging, Paul Scherrer Institut, CH-5232 Villigen PSI* $CeCoIn_5$ is an intriguing d-wave superconductor with intertwined orders. A spin density wave exists only inside the superconducting phase [1], implying that superconductivity is an essential ingredient for the magnetic Q-phase. Its origin remain under debate. Since phonons couple to the electronic structure at MHz frequencies [2], ultrasound is suitable to investigate the properties of the Q-phase. Here we investigate the response of elastic constants and attenuation of different modes under rotating magnetic fields. The ultrasound technique is being developed at the PSI. We present our route to establish the technique using a data acquisition card and digital processing. [1] M. Kenzelmann et al, Science 321, 186-197 (2008). [2] T. Watanabe et al, Phys. Rev. B 70, 020506(R) (2004).

185

Polytypism in the $NbS_2 \pm \Delta$ system

Catherine Witteveen, Fabian O. von Rohr, University of Zürich

NbS_2 is a layered substance, which has recently shown great promise for building superconducting devices in the 2D limit. While the layers consist of covalently bound atoms, weak van der Waals forces hold the layers together. NbS_2 crystallises in two stable polymorphs, depending on the sulfur pressure during synthesis: the superconducting 2H phase and the metallic 3R phase.
We have in a systematic approach analysed this sensitive sulfur-pressure system by modifying the amount of sulfur and the temperature in the synthesis conditions. Based on the results, we established a phase diagram for the given synthesis conditions.
The here obtained synthesis parameters allow for an improved control of the phase purity and phase formation in the NbS_2 system.