TT 21: Solids at Low Temperature - Poster Session

Time: Wednesday 14:00–17:45 Location: Poster A

TT 21.1 Wed 14:00 Poster A

Mixtures of bosons and fermions in optical lattices — •Irakli Titvinidze, Michiel Snoek, and Walter Hofstetter — Institut für Theoretische Physik Johann Wolfgang Goethe-Universität, Max-von-Laue-Str. 1, 60438 Frankfurt am Main, Deutschland

We study a mixture of bosonic and fermionic atoms in an optical lattice using Dynamical Mean Field Theory. The bosons and fermions interact via on-site Hubbard interactions. In addition, there is a on-site interaction between the bosons and the fermions. Since all interaction parameters can independently be chosen to be repulsive or attractive, this system exhibits an exceedingly rich phase diagram. We pay particular attention to the effect of the bosons on antiferromagnetism and the shifting of bosonic Mott transition due to the presence of the fermions. This model can be extended by a Feshbach term, which transform a bosonic molecule into two fermionic atoms and vice versa.

TT 21.2 Wed 14:00 Poster A

Density Correlations in Ultracold Atomic Fermi Gases via the Richardson Solution — •Simon Staudenmayer[1], Christoph Bruder[2], and Wolfgang Belzig[1] — [1]Universitaet Konstanz, Fachbereich Physik, D-78457 Konstanz — [2]Institut fuer Physik, Klingelbergstr. 82, CH-4056 Basel

Ultracold fermionic atomic gases have attracted considerable attention both from a theoretical and experimental point of view recently. The crossover from a Bose-Einstein condensate (BEC) of strongly bound molecules to a weakly interacting Bardeen-Cooper-Schrieffer (BCS)-like state is of particular interest. Investigations of this BEC-BCS crossover and the ability to tune the mutual interaction between atoms in one and the same system via a Feshbach resonance are interesting from a fundamental many-body point of view. The BEC-BCS transition also yields a crossover in the statistics of number densities: the statistics is Poissonian on the BEC side and binomial on the BCS side [1]. We therefore present a method, adapting the concept of full counting statistics, that has the potential to be used as an experimental tool to gain information on the many-body ground state. Correlators of a canonical fermionic system are obtained using the so-called Richardson solution, i.e., the exact eigenstates of the BCS pairing hamiltonian. [1] W. Belzig, C. Schroll and C. Bruder, cond-mat/0412269

TT 21.3 Wed 14:00 Poster A

Strongly interacting bose gas in an optical lattice. — •Oleksandr Fialko, Christopher Moseley, and Klaus Ziegler — Institut für Physik, Universität Augsburg, Germany

We study the Bose-Hubbard model, projected onto the regions where two Mott-insulating phases merge. These projections can be described by a hard-core Bose gas which can be treated by locally paired spin-1/2 fermions.

This effective fermion model is analyzed in terms of a mean-field approximation and Gaussian fluctuations. The mean-field solution gives us the phase diagram with the two merging Mott insulators and an intermediate superfluid. The effect of quantum and thermal fluctuations are investigated. In particular, we study the role of gapless and gapped modes in the fluctuations, and calculate the static structure factor.

TT 21.4 Wed 14:00 Poster A

Fermionic Hubbard model with spin-dependent hopping amplitudes for ultracold quantum gases — •Tobias Gottwald and Peter G. J. van Dongen — KOMET 337, Institut für Physik, Universität Mainz, Staudingerweg 7, 55099 Mainz

In order to understand the properties of fermionic ultracold quantum gases in optical lattices, we analyze a Hubbard model with spin-dependent hopping amplitudes at low temperatures in the limits of weak and strong coupling. In both cases we consider attractive as well as repulsive interactions, for which we find suprafluidity and (generalized) antiferromagnetism, respectively. In experiment, interactions can be tuned via Feshbach resonances, and different hopping amplitudes arise from different atomic masses or different hyperfine states. We investigate this generalized Hubbard model between two extremes, on the one hand the Falicov-Kimball model and on the other the standard Hubbard model with equal hopping amplitudes for each pseudo-spin species.

TT 21.5 Wed 14:00 Poster A

Extended mean-field theory for disordered bosons in optical lattices — •Ulf Bissbort and Walter Hofstetter — Institut für Theoretische Physik, J.W. Goethe-Universität, D-60438 Frankfurt, Germany

We consider bosons in disordered optical lattices at zero temperature for various disorder realizations in a mean-field approximation of the Hubbard model. Hitherto the problem of random on-site disorder was tackled using modifications of the usual single site mean-field theory or spatially resolved methods, which use a limited number of sites. We propose a new extended mean-field theory, which takes dimensional effects into account and is applicable in the thermodynamic limit. Within this method we suggest criteria to distinguish between the Mott insulating, the Bose glass and the superfluid phases. Results are presented for the ground-state phase diagram and experimental accessibility is discussed.

TT 21.6 Wed 14:00 Poster A

Transport of Bose-Einstein condensates through two-dimensional disorder potentials — •Michael Hartung, Klaus Richter, and Peter Schlagheck — Institute for Theoretical Physics, University of Regensburg, D-93040 Regensburg, Germany

The rapid progress in the experimental techniques for Bose-Einstein condensates permits detailed studies of mesoscopic transport dynamics of interacting matter waves with rather high accuracy and high flexibility in the control of parameters. We particularly focus on the transport of a Bose-Einstein condensate through a two-dimensional disorder potential. To this end we developed, in analogy with our previous study on one-dimensional condensate transport [1], a two-dimensional numerical method to simulate the time-dependent propagation process within the mean-field approximation of the condensate. We discuss the influence of the repulsive atom-atom interaction on the transport process of the condensate, and focus here in particular on the phenomena of coherent backscattering and weak localization.
[1] T. Paul, P. Leboeuf, N. Pavloff, K. Richter, and P. Schlagheck Phys. Rev. A **72**, 063621 (2005)

TT 21.7 Wed 14:00 Poster A

Mott transition and region of existence of excitonic BEC — •Felix Richter, Rico Schwartz, Tim Schmielau, Klaus Henneberger, and Heinrich Stolz — Institut für Physik, Universität Rostock, 18051 Rostock

We show predictions for the regions of existence of excitons and their BEC in the n, T-plane. Therefor we compute the lowering of the continuum edge as well as shifts in the exciton binding energy due to self-energy shifts. Degeneracy, correlation and exchange are taken into account. Former approaches to this problem yielded a large area of bistability. The exchange shift caused by the bound particles is shown to lead to a significantly smaller area of bistability, which is restricted to densities close to the Mott transistion.

In addition, our algorithm is capable of calculating the density of the condensate. In cuprous oxide, a BEC is predicted to build up at densities lower than that of the Mott transition, making up a considerable amount of the total density.

We compare our results for the binding energy shifts to absorption spectra obtained by pump-probe experiments, which allows for a more precise estimate of the total electron-hole-pair density at any temperature. This provides new insight into the balance between condensation and the Mott transition in an excitonic system.

TT 21.8 Wed 14:00 Poster A

Ultracold bosons in one-dimensional incommensurate superlattices — •Tommaso Roscilde and Juan Ignacio Cirac — Max-Planck-Institut fuer Quantenoptik, Garching b. Muenchen

Motivated by recent experiments (L. Fallani et al., cond-mat/0603655), we numerically investigate the ground-state properties of strongly interacting ultracold bosons in a one-dimensional quasi-periodic superlattice, modeled by the Bose-Hubbard Hamiltonian in an incommensurate cosine potential. In the weakly interacting regime, the incommensurate potential (IP) is known to lead to Anderson localization when exceeding a given critical strength. We find that strong repulsion, lead-

ing to a Mott-insulating state for the system without the IP, introduces an extremely rich physical scenario. For repulsion values away from the Tonks limit an IP added to the Mott phase is effectively screened by a fraction of the particles, and drives the system to a superfluid phase for the remaining fraction. For larger IPs a cascade of incompressible insulating states appears with incommensurate fractional fillings. The change of filling from a state to the next is usually accompanied by significant particle number fluctuations without superfluidity, namely by Bose-glass behavior in narrow parameter ranges.

TT 21.9 Wed 14:00 Poster A

Schnelle Spin Relaxation in festem ^{3}He bei mK Temperaturen — •Matthias Kath, Erwin Schuberth und Simone Bago — Walther-Meissner-Institut, 85748 Garching

Zur Aufklärung der Spinstruktur der kernspingeordneten Phasen von festem ^{3}He ist Neutronenstreuung einzigartig geeignet. Ausschlaggebend für dieses Experiment ist die Zucht von Einkristallen in feinporigen Sintern - einerseits um den Festkörper auf eine Temperatur im Bereich von 0,5 mK kühlen zu können, andererseits um einen Großteil der durch den n-Einfang entstehenden Wärme abzuführen.

In diesem Zusammenhang wurde die Zucht möglichst guter Einkristalle in Silbersintern mit unterschiedlicher Porengröße untersucht. Der Übergang in die kernspingeordneten Phasen konnte im Fall der U2D2-Phase durch den Abfall der NMR-Intensität, im Fall der Hochfeld-Phase durch einen Anstieg um ca. 30 % nachgewiesen werden. Unterhalb von $T_{\mathrm{Neel}} = 0{,}9\,\mathrm{mK}$ war die für die U2D2-Phase charakteristische Linienaufspaltung zu beobachten: Einerseits ca. 4 kHz auf der niederfrequenten Seite der Larmorlinie bei 240 kHz, andererseits ca. 20 kHz auf der hochfrequenten Seite bei 1980 kHz. T_2-Messungen in der paramagnetischen Phase ergaben einen Wert von $4{,}6 \pm 0.2$ ms. Bei T_1-Messungen zeigte sich ein unerwartet effektiver longitudinaler Relaxationsprozess, der einer gewöhnlichen T_1 Relaxation (250 ms bei 10 mK) vorgelagert war. Die schnelle anfängliche Relaxation von M_z beruht wahrscheinlich auf einem starken Entmagnetisierungsfeld der Probe. Sie verhinderte in der Nähe von T_{Neel} sogar gänzlich die Bestimmung des eigentlichen T_1.

TT 21.10 Wed 14:00 Poster A

Dynamical mean-field theory of half-metallic ferromagnets — •Eberhard Jakobi, Nils Blümer, and Peter van Dongen — KOMET 337, Institut für Physik, Universität Mainz, Staudingerweg 7, 55099 Mainz

Spintronics applications require materials with high spin polarization; therefore, half-metallic ferromagnets are of strong practical interest. Candidates for half-metallic behavior at sufficiently high temperatures include Heusler compounds as well as double perovskites. Previous studies for these materials were mostly restricted to density functional theory (DFT) within local spin-density approximation (LSDA). We investigate multi-band Hubbard models as relevant for half-metallic ferromagnets within Dynamical mean-field theory (DMFT) using weak-coupling perturbation theory and quantum Monte Carlo (QMC) simulations. Thereby we are able to treat electronic correlations beyond the level of conventional band structure calculations.

TT 21.11 Wed 14:00 Poster A

Magnetic and spectroscopic investigations of $SmCr_3(BO_3)_4$ — •Patric Scheib[1], Elena Popova[2], Alexander N. Vasiliev[2], I. Gugim[3], L. N. Bezmaternykh[3], Dirk Menzel[1], Joachim Schoenes[1], and Peter Lemmens[1] — [1]Institut für Physik der kondensierten Materie, TU Braunschweig, Braunschweig — [2]Faculty of Physics, Moscow State University, Moscow, Russia — [3]Kirensky Institute of Physics, Siberian Division, Russian Academy of Science, Krasnoyarsk, Russia

We report on the magnetic properties and structural investigation of a rare-earth chromium borate. This system is isostructural to the recently discussed multiferroic rare-earth iron borate $GdFe_3(BO_3)_4$. Magnetic Raman scattering and susceptibility show evidence for antiferromagnetic correlations within the Fe chains and a complex phase diagram. Work supported by DFG and ESF-HFM.

TT 21.12 Wed 14:00 Poster A

Spectroscopic and thermodynamic characterization of epitaxially grown $La_{1-x}Ca_xMnO_3$ films — Alexander Hirsch[1], Dirk Menzel[2], Ana Maria Racu[2], •Patric Scheib[2], Stefan Weber[2], Peter Lemmens[2], Joachim Schoenes[2], Wolfram Brenig[3], and Meinhard Schilling[1] — [1]Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, TU Braunschweig, Braunschweig — [2]Institut für Physik der kondensierten Materie, TU Braunschweig, Braunschweig — [3]Institut für Theoretische Physik, TU Braunschweig, Braunschweig

$La_{1-x}Ca_xMnO_3$ (LCMO) thin films with different calcium concentrations are grown using Pulsed Laser Deposition (PLD). These films are characterised by optical spectroscopy, Raman scattering as well as SQUID measurements. Annealing studies demonstrate the interplay of oxygen nonstoichiometry and lattice mismatch on the substrate.

TT 21.13 Wed 14:00 Poster A

Low-temperature investigation of the thermal properties of glasses — •Astrid Netsch, Sabine Wolf, Andreas Fleischmann, and Christian Enss — Kirchhoff-Institut für Physik, Universität Heidelberg, INF 227, 69120 Heidelberg, Germany

The thermal conductivity of glasses at low temperatures is generally believed to be due to the propagation of phonons. However, a second transport channel for heat should exist in these materials because of the existence of tunneling systems that interact with each other and allow for a diffusion of energy via resonant flip-flop processes. This contribution is expected to be much smaller than that due to phonons. In search of such a contribution we have performed measurements on two planar glass samples which contain holes of different size on a triangular lattice that serve as extra scatterers for phonons. For measuring thermal conductivity of such diminutive magnitude we used a SQUID-based contact-free technique because of its extremly small parasitic heating. Our results show that the thermal conductivity varies roughly with T^3 down to about 50 mK as expected for phonons in the boundary scattering regime. Below this temperature, the thermal conductivity follows a weaker power law. Though this is expected for thermal transport via mutually interacting tunneling systems the absolute value appears to be surprisingly high compared to theoretical predictions. Therefore it remains an open question whether the observed deviation is indeed caused by a non-phononic contribution, or whether this is a consequence of the wave length of the phonons becoming larger than the lattice constant of the array of holes.

TT 21.14 Wed 14:00 Poster A

Numerical simulation of the influence of nuclear moments on two- pulse polarization echoes in glassy glycerol — •Gudrun Fickenscher[1], Masoomeh Bazrafshan[1], Kathrin Reinhold[1], Marek Bartkowiak[2], Herbert Zimmermann[3], Andreas Fleischmann[1], and Christian Enss[1] — [1]Kirchhoff-Institut für Physik-Universität Heidelberg — [2]Forschungszentrum-Rossendorf-Dresden — [3]Max-Plank-Institut für Medizinische Forschung-Heidelberg

At low temperatures - below a few Kelvin - the properties of glasses are dominated by the tunneling motion of atomic tunneling systems in a double well potential. A few years ago it was shown that tunneling particles having a nuclear qudrupole moment experiencing electric field gradient cause magnetic field effects in non-magnetic glasses. This effect is observed using the method of two pulse polarization echoes, looking at the magnetic field dependence as well as the time dependence of echo amplitude. Recently, we observed that the presence of interacting magnetic dipole moments leads to qualitatively similar effects on a smaller magnetic scale. In this work we developed numerical techniques to simulate the amplitude of the two- pulse polarization echo, having flexibility of including any number of dipole and quadrupole moments corresponding to H and D atoms in partially deuterated samples. The simulations are done assuming a specific microscopic model of tunneling motion with specific distributions for tunneling parameters. The results of such simulations are presented comparing to experimental data.

TT 21.15 Wed 14:00 Poster A

Electronic transport properties of C-doped Mn_5Si_3 films — •B. Gopalakrishnan[1], Christoph Sürgers[1], and Hilbert v. Löhneysen[1,2] — [1]Physikalisches Institut, Universität Karlsruhe, D-76128 Karlsruhe — [2]Forschungszentrum Karlsruhe, Institut für Festkörperphysik, D-76021 Karlsruhe

The incorporation of carbon into the antiferromagnetic Mn_5Si_3 compound gives rise to ferromagnetic order with a Curie temperature above room temperature. The microscopic origin of the C-induced ferromagnetism still needs to be explored. Here we report on the electronic transport properties of 100-nm thick $Mn_5Si_3C_x$ ($0 \leq x \leq 1.2$) films prepared by simultaneous magnetron sputtering of elemental Mn, Si, and C [1]. We observe distinct differences in the temperature depen-

dence of the resistance R, magnetoresistance, and Hall effect of the ferromagnetic C-doped films compared to antiferromagnetic Mn_5Si_3. In particular, for films with an optimum doping level $x = 0.8$ inferred from previous magnetization measurements, we observe a metallic behavior of R and the lowest residual resistivity. At temperatures below 20 K a behavior $R \propto -\ln T$ is found, reminiscent of electron-electron interaction or weak-localization effects, although the films are much thicker than all relevant scattering lengths.

[1] C. Sürgers et al., Phys. Rev. B **68**, 174423 (2003)

TT 21.16 Wed 14:00 Poster A

Thermally and Optically Switched Spin States in $[Fe(pmd)(H_2O)\{Au(CN)_2\}_2] \cdot H_2O$. A revised phase diagram — Vladimir Gnezdilov[1], •Peter Lemmens[2], Patric Scheib[2], Yuri Georgii Pashkevich[3], Karina V. Lamonova[3], Elena S. Zhitlukhina[3], Virgine Niel[4], and Jose A. Real[4] — [1]Institute for Low Temperature Physics and Engineering, NASU, Kharkov, Ukraine — [2]Institut für Physik der kondensierten Materie, TU-Braunschweig, Braunschweig — [3]Donetsk Phystech, NASU, Ukraine — [4]Institut de Cienca Molecular / Departement de Química Inorg ànica, Iniversitat de València

Raman scattering in the spin-crossover $[Fe(pmd)(H_2O)\{Au(CN)_2\}_2] \cdot H_2O$ reveals a complex three-step spin-state transitions in contrast to observations in magnetization measurements. The switching between different spin states is recorded as function of temperature and irradiation with electromagnetic radiation in the visible spectral range. Work supported by DFG topical research center "Molecular Magnets" and ESF-HFM.

TT 21.17 Wed 14:00 Poster A

Analysis of mechanical loss processes of low loss materials for interferometric gravitational wave detectors in the low temperature range — •Daniel Heinert[1], Anja Zimmer[1], Ronny Nawrodt[1], Wolfgang Vodel[1], Andreas Tünnermann[2], and Paul Seidel[1] — [1]Institut für Festkörperphysik, FSU Jena, Helmholtzweg 5, 07743 Jena — [2]Institut für Angewandte Physik, FSU Jena, Albert-Einstein-Straße 15, 07745 Jena

Thermal noise introduced by mechanical losses is one main limitation in the detection frequency band of interferometric gravitational wave detectors. Cooling of the optical components could produce a relief insofar as materials featuring low mechanical losses at cryogenic temperatures are used. Influences of different loss mechanisms on the mechanical quality factor are presented, especially under consideration of the excited mode shape.

This work was supported by the DFG under contract SFB Transregio 7.

TT 21.18 Wed 14:00 Poster A

Mechanical Loss Measurements on Calcium Fluoride Bulk Material at Low Temperatures — •Christian Schwarz[1], Ronny Nawrodt[1], Anja Zimmer[1], Sandor Nietzsche[1], Wolfgang Vodel[1], Andreas Tünnermann[2], and Paul Seidel[1] — [1]Friedrich-Schiller-University Jena - Institute of Solid State Physics, Helmholtzweg 5, 07743 Jena, Germany — [2]Friedrich-Schiller-University - Institute of Applied Physics, Albert-Einstein-Straße 15, 07745 Jena, Germany

Interferometric gravitational wave detectors are one of the most sensitive devices ever developed. The detectors currently in use are limited by different kinds of noise. One of the fundamental noise sources is thermal noise. To lower thermal noise within the detection band it is necessary to use low mechanical loss materials as optical components.

One promissing candidate as a low loss material is calcium fluoride. Detailed measurements of the mechanical loss of single crystal calcium fluoride samples (Dia. 76.2 $mm \times 75$ mm) are presented within a temperature range from 5 to 300 K. The lowest loss was observed at 65 K as 3.6×10^{-9}. Possible damping mechanisms are discussed and compared with the experimental results.

This work was supported by the DFG under contract SFB Transregio 7.

TT 21.19 Wed 14:00 Poster A

Soft phonon modes in phase change materials — •Dominic Lencer[1], Blazej Grabowski[2], Jörg Neugebauer[2], and Matthias Wuttig[1] — [1]I. Physikalisches Institut (1A), RWTH Aachen, D-52056 Aachen — [2]Max-Planck-Institut für Eisenforschung, Max-Planck-Straße 1, D-40237 Düsseldorf

Among the candidates for non-volatile memories succeding Flash *phase change RAM (PCRAM)* is attracting much interest from basic and industrial research groups. It is based on reversible electrically induced switching of small cells between an amorphous and crystalline state.

In general, the employed metastable crystalline phases of alloys used for PCRAM devices resemble slightly distorted cubic structures. In order to investigate the particular distortions, phonon dispersions were calculated for the symmetric cubic phases of GeTe, Sb_2Te_3 and $GeSb_2Te_4$ using density functional calculations using both the linear response and a direct method. Soft phonon modes were identified and sampled to yield models for the distorted phases. Properties of both undistorted and distorted phases are presented and compared to experimental data.

TT 21.20 Wed 14:00 Poster A

Low-temperature phonon dispersion in 2H-$NbSe_2$ by inelastic neutron scattering and ab-inito calculations — •Karin Schmalzl[1,2], Arno Hiess[2], Dieter Strauch[3], and Helmuth Berger[4] — [1]Forschungszentrum Juelich, 52425 Juelich, Germany — [2]Institut Laue Langevin, 38042 Grenoble, France — [3]Universitaet Regensburg, 93040 Regensburg, Germany — [4]Ecole Politechnique Federale de Lausanne, 1015 Lausanne, Switzerland

2H-$NbSe_2$ belongs to the group of quasi-two-dimensional layered transition metal dichalcogenides. The 2H polytypes consist of stacked hexagonal planes. Several interesting properties like superconductivity ($T_c \approx 7$ K), anisotropic electrical properties, incommensurate charge-density wave (CDW) instability ($T_{\mathrm{CDW}} \approx 35$ K), and very anisotropic k-dependent electron-phonon coupling are found. Also, many lattice properties like thermal expansion, sound velocity, etc. are very anisotropic. Superconductivity and CDW order coexist at low T.

It is suspected that in these systems there is a connection between the charge-density wave, a strongly anisotropic electron-phonon coupling, lattice distortion, and phonon anomalies. The CDW is slightly incommensurate with a wavevector near $\frac{1}{3}(1,0,0)$.

We have now investigated the low-frequency branches of the phonon dispersion at 50 K in frequency, width, and intensity, also along non-main-symmetry directions around the phonon wavector $\mathbf{q} = \frac{1}{3}(1,0,0)$ by inelastic neutron scattering. The experiments are accompanied by ab-initio calculations.