DY 1: Statistical physics I (general)

Time: Monday 10:15–13:00 Location: HÜL 386

Invited Talk DY 1.1 Mon 10:15 HÜL 386

Heat transfer on the nanometer scale — Near-field thermal scanning microscopy — •Achim Kittel — Institute of Physics, University of Oldenburg, Carl-von-Ossietzky Str. 9-11, 26129 Oldenburg, Germany

Every body at a finite temperature emits heat radiation. Beside the propagating modes there exist evanescent modes which only can contribute to the heat transfer on short distances. Their contribution to the total heat transfer overcomes the one of the propagating modes at distances well below one micrometer between two bodies. Understanding the evanescent modes and the physics of the electromagnetic fluctuations at the nanometer scale will help to understand the coupling between nanoscale particles. The new possibilities of scanning probe microscopy offer experimental access to investigate these phenomena. Heat transfer mediated by the evanescent modes is detected by means of a modified scanning tunneling microscope (STM), whose tip is functionalized as a coaxial thermocouple with dimensions in the range of a few hundred nanometers. During the measurements the temperature of the sample can be reduced to about 110K or raised to 350K while the tip holder is kept at room temperature. By this means, the heat transfer between the cooled or heated sample and the tip can be measured while scanning over the surface at the tunnel distance. By retracting the tip from the surface the heat transfer in dependence on the distance can be studied. Methods of the experiment will be introduced and results of the measurements are presented and compared to model calculations.

DY 1.2 Mon 10:45 HÜL 386

Critical Casimir force for films in the crossover between various surface universality classes — •Thomas Friedrich Mohry[1,2], Anna Maciołek[1,2], and Siegfried Dietrich[1,2] — [1]Max-Planck-Institut für Metallforschung, Heisenbergstraße 3, 70569 Stuttgart, Germany — [2]Universität Stuttgart, Institut für Theoretische und Angewandte Physik, Pfaffenwaldring 57, 70569 Stuttgart, Germany

The critical Casimir force and the order-parameter profiles in thin films belonging to the Ising universality class are studied field theoretically, focusing on the crossovers between various surface universality classes. The corresponding universal scaling functions are calculated within mean-field theory. For both the crossover between the normal and the special transition and for the crossover between the normal and the ordinary transition, the scaling function of the critical Casimir force exhibits a rich structure, such as the emergence of several extrema. Depending on the choice of the surface properties, as described by surface fields or surface enhancement parameters, the critical Casimir force can change its sign once or twice by varying the temperature. A simple relation between the sign of the force and the values of the order-parameter at the surfaces and in the bulk is presented. The results are relevant for colloidal systems in the presence of a critical solvent and for wetting films near critical end points.

DY 1.3 Mon 11:00 HÜL 386

Critical Casimir Forces in Strongly Anisotropic Systems — •Matthias Burgsmüller and Hans Werner Diehl — Fachbereich Physik, Universität Duisburg-Essen, D-47048 Duisburg, Germany

Strongly anisotropic systems are considered in a d-dimensional film geometry. Such systems involve two (or more) distinct correlation lengths ξ_β and ξ_α that scale as nontrivial powers of each other: i.e. $\xi_\alpha \sim \xi_\beta^\theta$ with $\theta \neq 1$. Thus two fundamental orientations, $\perp$ and $\parallel$, for which the surface normal is oriented along an α or β direction must be distinguished. The confinement of critical fluctuations caused by the film's boundary planes is shown to induce effective forces $\mathcal{F}_C$ that decay as $\mathcal{F}_C \approx -(\partial/\partial L)\Delta_{\perp,\parallel}\, L^{-\zeta_{\perp,\parallel}}$ as a function of film thickness L, where the decay exponents $\zeta_{\perp,\parallel}$ and Casimir amplitudes $\Delta_{\perp,\parallel}$ differ for $\perp$ and $\parallel$ orientation. To corroborate these findings, n-vector models with an m-axial bulk Lifshitz point are investigated by means of RG methods below the upper critical dimension $d^*(m) = 4 + m/2$ under various boundary conditions. The exponents $\zeta_{\perp,\parallel}$ are determined, and explicit results to one or zeroth loop order are presented for several Casimir amplitudes $\Delta_{\perp,\parallel}$.

DY 1.4 Mon 11:15 HÜL 386

Ultrafast Converging Path Integral Approach for Rotating Ideal Bose Gases — •Antun Balaž[1], Ivana Vidanović[1], Aleksandar Bogojević[1], and Axel Pelster[2,3] — [1]Scientific Computing Laboratory, Institute of Physics Belgrade, Serbia — [2]Fachbereich Physik, Universität Duisburg-Essen, Germany — [3]Institut für Theoretische Physik, Freie Universität Berlin, Germany

Recently, we have developed an efficient recursive approach for analytically calculating the short-time expansion of the propagator to extremely high orders for a general many-body quantum system [1]. Here we apply this technique for numerically studying the thermodynamical properties of a rotating ideal Bose gas of ^{87}Rb atoms in an anharmonic trap [2]. First, the energy spectrum of the system is obtained by diagonalizing the discretized short-time propagator. Then the condensation temperature and the time-of-flight absorption pictures are calculated for varying rotation frequencies. The obtained results improve previous semiclassical calculations [3] and agree well with Path Integral Monte Carlo simulations [4].

[1] A. Balaž, A. Bogojević, I. Vidanović, A. Pelster, `arXiv:0806.4774`
[2] V. Bretin, S. Stock, Y. Seurin, J. Dalibard, *PRL* **92**, 050403 (2004)
[3] S. Kling, A. Pelster, *PRA* **76**, 023609 (2007)
[4] D. M. Ceperley, *Rev. Mod. Phys.* **67**, 279 (1995)

15 min. break.

DY 1.5 Mon 11:45 HÜL 386

Quench Dynamics of Harmonically Trapped Free Bosons — •Oliver Gabel[1] and Axel Pelster[1,2] — [1]Institut für Theoretische Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Fachbereich Physik, Universität Duisburg-Essen, Lotharstrasse 1, 47048 Duisburg, Germany

Within the path-integral formulation of density matrices we calculate the effect of a sudden quench of the trap frequency for N harmonically confined free bosons which are, originally, in thermal equilibrium. In order to derive the corresponding reduced one-particle density matrix, we explicitly integrate out $N-1$ irrelevant degrees of freedom in the N-particle density matrix. This yields a difference equation for the non-equilibrium contributions of the respective permutation cycles. Finally, we discuss the resulting explicit expressions in view of the emerging collective oscillations.

DY 1.6 Mon 12:00 HÜL 386

Dispersion of matter waves in gaussian disorder potentials — •Christian J. Harrer, Christopher Gaul, and Cord A. Müller — Universität Bayreuth, Germany

We wish to determine the effective dispersion relation of matter waves in disorder potentials by diagrammatic perturbation theory [1]. While conventional perturbation theory truncates the self energy at finite order, the recently developed momentum average method (MA) [2] approximates each diagram of the self energy series but retains all orders and all diagrams so that the whole asymptotic series is represented rather accurately. We use this idea for matter waves in gaussian correlated disorder [3] and, using Borel summation and related techniques, obtain an analytical result for the self energy, which allows to calculate the mean free path in good agreement with numerical results.

[1] R.C. Kuhn et al., NJP 9, 161 (2007)
[2] M. Berciu, PRL 97, 36402 (2006)
[3] M. Hartung et al., PRL 101, 020603 (2008)

DY 1.7 Mon 12:15 HÜL 386

Arbitrary rotation invariant random matrix ensembles and supersymmetry — •Mario Kieburg and Thomas Guhr — Universität Duisburg-Essen, Lotharstraße 1, 47048 Duisburg, Germany

The supersymmetry method is an essential tool for studies in random matrix theory and mesoscopic physics. Recently, this method was generalized from Gaussian ensembles to arbitrary rotation invariant matrix ensembles in two different approaches, the generalized Hubbard-Stratonovitch transformation [J.Phys. A39 (2006) pp. 13191] and the superbosonization formula [Commun. Math. Phys. 283 (2008) pp. 343]. In this presentation, we will demonstrate connections and differences of both approaches and their results for all symmetry classes of O(N), U(N) and USp(N) rotation invariance.

DY 1.8 Mon 12:30 HÜL 386

Variational Methods with and without Replicas for a Zero-Dimensional Disorder Model — •Markus Düttmann[1], Jürgen Dietel[1], and Axel Pelster[1,2] — [1]Institut für Theoretische Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [2]Fachbereich Physik, Universität Duisburg-Essen, Lotharstrasse 1, 47048 Duisburg, Germany

We analyze the stationary probability distribution of the Smoluchowski equation for an overdamped harmonic oscillator in a random potential with three analytic approximation methods. A standard method for tackling such a zero-dimensional disorder problem is the replica method [1]. However, the replica-symmetric solution breaks down for sufficiently small temperatures. Improved results are obtained by the replica symmetry breaking approach which was originally developed by Giorgio Parisi to treat spin-glass systems. Furthermore, we work out another variational approach, which does not rely on replicas and involves the temperature as a variational parameter. All three analytical approximation methods are compared with numerical results from Monte-Carlo simulations.

[1] A. Engel, Nucl. Phys. B **410**, 617 (1993)

DY 1.9 Mon 12:45 HÜL 386

Geometric Characterization of Phase Transitions in the Lipkin-Meshkov-Glick Model — •Daniel Scherer, Michael Kastner, and Cord Müller — Physikalisches Institut, Universität Bayreuth, Germany

At least two decades ago people have begun to realize that matter can be macroscopically ordered in ways that do not fit into the framework of the Ginzburg-Landau paradigm for classical degrees of freedom. Since the discoveries of high-temperature superconductivity and the quantum Hall effect, novel aspects such as quantum phase transitions and topological order have become the focus of both theoretical and experimental efforts. On the theoretical side, several quantities have been proposed to trace signatures of such exotic phase transitions and to characterize the physics within those phases. One of these approaches is given by the so called fidelity metric. This is a Riemannian metric on the state space of a quantum system, that might allow for a common description of both Ginzburg-Landau and topological order independently of knowledge, or even existence, of a local order parameter. We apply this approach to the Lipkin-Meshkov-Glick Model exhibiting conventional (Ginzburg-Landau) order at finite temperature. We obtain the fidelity metric for ordered and disordered phases in the isotropic model and show that in this case the metric can be expressed completely in terms of the free energy. Finally we point out similarities with Ruppeiner geometry.