DANISH PHYSICS SOCIETY ANNUAL MEETING 2012

June 19st-20nd 2012

PROGRAM AND ABSTRACTS

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Danish Physical Society
Annual Meeting 2012

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Atomic, molecular and Optical Physics and Condensed Matter Physics

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Atomic, molecular and Optical Physics and Condensed Matter Physics

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ISOMORPHS IN NANO-CONFINED SYSTEMS
Trond S. Ingebrigtsen ,

2

Plenary

talks

PL 1 Excited charge carriers in C60, graphite and graphene

By Petra Rudolf and

Zernike Institute for Advanced Materials, University of Groningen, The Netherlands

In this talk I shall present methods to monitor excited charge carriers and their decay in carbon based materials. First I shall discuss the core-hole-clock method as convenient means to study the charge transfer dynamics at the interface between a C60 monolayer and a metal substrate with the lifetime of the core-hole as an internal reference clock to follow the charge transfer process. Next I shall illustrate how time-resolved electron diffraction is a unique tool for providing direct and detailed information on the structural dynamics of graphite following an electronic excitation. Here femtosecond lasers are used to generate ultrashort light and electron pulses. Light initiates a process in the sample - an electronic excitation in our case - and by recording snapshots of the electrons diffracted from the sample in a stroboscopic fashion, one can image the photo-induced motion of the structure. In graphite, the anisotropic decay of the initial laser excitation causes a selective population of phonon modes and an ultrafast contraction. Finally I shall detail how the lifetime of excited electrons in graphene on Ni(111) can be monitored by time- and angle-resolved photoelectron spectroscopy measurements on graphene epitaxial grown on a Ni(111) single crystal surface. Polarization dependent final state effects have been observed in the photoelectron cross section of graphene states. The band structure has been investigated and a time resolution of about 37 fs has been achieved in a first XUV pump IR probe experiment.

PL 2 The birth and evolution of galaxies: Prospects with ALMA (Atacama Large Millimetre Array)

By Frank Bertoldi and

Argelander-Institute for Astronomy, University of Bonn

A major goal of contemporary astrophysics is to develop an understanding of the formation and evolution of galaxies from the earliest epoch of galaxy formation to the present day. Deep optical and near-infrared surveys have first traced the evolution of galaxies and of the star formation history of the Universe, as a function of environment, stellar mass, black hole growth and star formation rate, back to the epoch of cosmic reionization.Recently, much insight has come from spatially- and spectrally-resolved studies of galaxies using large ground-based optical telescopes, space telescopes, and millimeter- or radio-interferometers. Spectroscopic and continuum studies at centimeter through submillimeter wavelengths are ideal to reveal the properties of the dust-obscured regions where stars form, and of the cool, dense gas that fuels star formation. In this respect the Atacama Large Millimeter Array and the Expanded Very Large Array represent a vast improvement over existing observational capabilities, promising to revolutionize our understanding of galaxy formation.

PL 3 Dirac fermions in HgTe quantum wells

By L.W. Molenkamp and

Institute of Physics, EP3, University of Wuerzburg

HgTe quantum wells have a linear band dispersion at low energies and thus mimic the Dirac Hamiltonian.

Changing the well width tunes the band gap (i.e., the Dirac mass) from positive, through zero, to negative.

Wells with a negative Dirac mass are 2-dimensional topological insulators and exhibit the quantum spin Hall effect, where a pair of spin polarized helical edge channels develops when the bulk of the material is insulating.

Our transport data provide very direct evidence for the existence of this third quantum Hall effect.

Wells with a thickness of 6.3 nm are zero gap Dirac systems, similar to graphene. However, zero gap HgTe wells possess only a single Dirac valley, which avoids inter-valley scattering.

3

Invited

talks

IN 1 Do simple liquids exist?

By K. Niss[1] and D. Gundermann[1] U. R. Pedersen[2] T. Hecksher[1] N. P. Bailey[1] B. Jakobsen[1] T. Christensen[1] N. B. Olsen[1] T. B. Schrøder[1] D. Fragiadakis[3] R. Casalini[3] C. M. Roland[3] J C. Dyre[1]

[1] DNRF Center "Glass and Time", IMFUFA, NSM, RUC [2] Department of Chemistry, University of California, Berkeley, USA [3] Chemistry Division, Naval Research Laboratory, Washington, USA

The glass transition is a universal phenomenon which in its essence is independent of the interactions between the atoms or molecules of the liquid forming the glass. The universal character of the transition has led physicists to believe that there is one underlying simple explanation of the phenomenon. More than 15 years ago the Nobel laureate P.W. Anderson stated that understanding the glass-transition is deepest unsolved problem in solid state physics [1], but a satisfactory explanation is still lacking. Understanding the glass-transition implies understanding the dynamics (e.g. diffusion, vibration, relaxation) and the physics in general of the viscous liquid forming the glass. Gasses can to a great extend be understood via the ideal gas model where the interactions between particles are ignored. In crystalline solids the physics can be understood by exploding the periodic nature of the structure. No similar simplification can be made for liquids. Here we need to consider the interaction between the molecules, the kinetic energy and the amorphous structure. This is a challenge to a model systems or a theory explaining the glass transition and the physics of liquids in general.The "Glass and Time" group on RUC has during the last five years succeeded in identifying a class of simple liquids and a theory for describing these has been developed [2]. This theory, called the isomorph theory, has proven very effective in describing computer simulated liquids with simple interactions (e.g. Lennard Jones liquids). But how useful is the theory when it comes to understanding the physics the liquids we deal with in the laboratory? In 2011 wepublished the first experimental results supporting the isomorph theory [3]. Here we showed how the relative effect of density and temperature on the glass transition can be understood in terms of the isomorph theory. There are several other predictions of the theory, many of these are directly related to the glass transition. Our current and future experimental work focusses on these testing these predictions.[1] Science 267, 1609 (1995)[2] J. Chem. Phys. 131, 234504 (2009) [3] Nature Physics 7, 816 (2011)

IN 2 Exotic quantum states in matter waves

By Jan Arlt and

Institut for Fysik og Astronomi, Aarhus Universitet, Ny Munkegade 120, 8000 Aarhus C

Recently, exotic quantum states of light, such as squeezed states, have moved from an experimental curiosity to the first application in precision measurements. By improving the achievable precision of a length measurement, they e.g. support the search for gravitational waves. A similar question arises in other fields of physics where metrology plays an important role: Can we enhance the precision of our measurements by using tailored quantum states?

Atom interferometers represent such a field of precision metrology. Since the 1960s our time is defined by the inner oscillation frequency of the cesium atom. To construct a highly precise atomic clock, this oscillation frequency is measured with an atom interferometer. However, these interferometers are fundamentally restricted by the shot noise limit, which can only be overcome by creating quantum entanglement among the atoms. I will show how spin dynamics in Bose-Einstein condensates was used to create large ensembles of up to 104 pair-correlated atoms in a so called twin Fock state. This state allows for an interferometric sensitivity -1.6 dB beyond the shot noise limit. These proof-of-principle results open exciting perspectives for a new generation of atom interferometers.

IN 5 The Earliest Stages of Star and Planet Formation: the Era of New Telescopes

By Jes K. Jørgensen[1] and

[1] Centre for Star and Planet Formation and Niels Bohr Institute, University of Copenhagen

Low-mass stars like our Sun are formed in the centers of dark clouds of dust and gas that obscure their visible light. Deep observations at infrared and submillimeter wavelengths are uniquely suited to probe the inner regions of these young stellar objects and unravel their structures, as well as the physical and chemical processes important for the star formation process. These earliest stages are particularly interesting because the properties of the deeply embedded objects reflect the star formation process itself and how it relates to its environment. It is for example during this stage that the final mass of the star and the properties of its disk - and thus ability to form planets - are determined. In this talk I will discuss our current understanding of the earliest stages of young solar systems. I will highlight a few recent results, including some of the exciting discoveries from first data from the Atacama Large Millimeter Array (ALMA).

4

Atomic, molecular and optical physics (AMO)

talks

AMO 1 Charge exchange in 2 keV/amu one electron ions on CH4. Why do the one electron projectiles behave differently?

By John R. Sabin[1,2] and
[1] Institute for Physics, Chemistry, and Pharmacology, University of Southern Denmark [2] Quantum Theory Project, Department of Physics, University of Florida

Recent experiments on collision processes of O7+ and N6+ ions colliding with methane at the same velocity show unexpected differences in the fragmentation cross sections of the methane. Despite the expected similarity of these two processes, as both projectiles are hydrogenic, the mechanisms of electron transfer are different and lead to different fragmentation cross sections. In the present work, the collisions between N6+ and O7+ ions and methane are investigated theoretically at equal velocities corresponding to projectile energies of 30 and 35 keV, respectively. Electron-nuclear dynamics is used to study multiple electron transfer processes occurring in these collisions. Several multiple charge transfer probabilities are calculated and results, averaged over various orientations of the methane molecule, are reported. The collisions proceed in two stages: a fast stage of electron transfer from methane to the ion, and a much slower stage of breakup of the methane. We find and explain the intuitively unexpected result that the total charge transfer cross section for N6+ is slightly larger, but that the O7+ leaves the methane in a higher charged state with higher probability, leading to more fragmentation in the collisions with O7+.

AMO 2 Faraday imaging of Bose-Einstein condensates

By Miroslav Gajdacz and Poul Pedersen, Troels Mørch, Jacob Sherson, Jan Arlt

Institute for Physics and Astronomy, Aarhus University

Faraday rotation has a long and fruitful history in atomic physics and quantum optics. The effect has been employed very successfully in atomic gases at room temperature and in laser cooled atomic ensembles, resulting in e.g. squeezing and entanglement of atomic spins and for quantum information protocols. Here we demonstrate the use of Faraday rotation to non-destructively image ultra cold atomic clouds and Bose-Einstein condensates. We show that dark ground Faraday imaging allows us to take many images of a single ultra cold cloud and present a detailed analysis of the destructiveness. This ability allows us to monitor e.g. the condensation process or the inherent oscillation of these atomic samples in a single experimental realization. Our experiments are performed with ultra cold 87Rb samples using light at a blue detuning of 0-1.5 GHz from the D2 transition. We present the laser system to generate the off-resonant light and show that we have obtained good quantitative agreement between the observed and predicted Faraday rotation both in room temperature and ultra cold samples. In the future we will extend this technique to high resolution imaging of atomic samples in optical lattices and to multi component quantum gases. This will allow for probing and control of these systems beyond the quantum noise level.

5

Atomic, molecular and optical physics (AMO)

posters

AMOP1 Laser ablation of the protein lysozyme

By J. Schou[1] and S. Canulescu[1], S. Amoruso, X. Wang, R. Bruzzese[2], A. Matei, C. Constantinescu, M. Dinescu[3].

[1]DTU Fotonik, Risø Campus, DK-4000 Roskilde, Denmark [2]Dipartimento di Scienze Fisiche & CNR-SPIN, Università degli Studi di Napoli Federico II, I-80126 Napoli, Italy [3]3)National Institute for Lasers, Plasma and Radiation Physics, RO-077125 Magurele-Bucharest, Romania

Lysozyme is a well-known protein, which is used in food processing because of its bactericidal properties. The mass (14307 amu) is in the range in which it easily can be monitored by mass spectrometric methods, for example by MALDI (Matrix assisted laser desorption ionization). We have recently produced thin films of average thickness up to 300 nm, which not only contained a significant amount of intact molecules, but also maintained the bioactivity. These films were produced by a nanosecond laser in the UV regime at 355 nm with 2 J/cm2. The surprising fact that these molecules can be transferred to a substrate as intact molecules by the violent laser impact ($\sim$ up to 50 mJ/pulse) has not yet been understood. One issue is that up to 150 ng/pulse is removed by the laser, and much of the material is ejected from the target in relatively large chunks. We have explored as well the excitation mechanics by laser impact. Samples of pressed lysozyme prepared in the same manner as in ns-experiments have been irradiated at 527 nm with ¿¿300-fs pulses and at at similar fluence as in ns ablation. Even though the pulse energy was much smaller, there was a considerable ablation weight loss of lysozyme from each shot. This is the first time the ablation by fs-lasers of a protein has been recorded quantitatively. Films of lysozyme produced by fs-laser irradiation were analyzed by MALDI and a significant number of intact molecules in the films with fs-laser deposition was found as well.

AMOP2 Progress towards quantum degenerate K-Rb molecules

By L. Wacker and N. Winter, J. Sherson and J. Arlt

Institut for Fysik og Astronomi, Aarhus Universitet, Ny Munkegade 120, 8000 Århus C

In recent years the production of multi component Bose-Einstein condensates has enabled a new generation of experiments in atomic and molecular physics. We present an experimental apparatus for the production of ultracold potassium-rubidium mixtures and the association of ultra-cold molecules. The apparatus employs a dual magneto optical trap, magnetic transport of the atoms and a hybrid conservative trap to cool and store the atoms. The hybrid trap combines the advantages of a magnetic- and a dipole-trap. The experiment has reached Bose-Einstein condensation of rubidium in the hybrid- , as well as a pure dipole trap. The cooling of potassium is in progress at the moment, which will permit the production of mixtures and the association of molecules in near future. Based on these weakly bound Feshbach molecules we will initially investigate the reactive properties in various trap geometries and internal states.

6

Bio- and medical physics

talks

BF 1 Small-angle neutron scattering study of reversible chloroplast membrane reorganizations during photosynthesis

By Dorthe Posselt[1] and G. Nagy (2,a), J.K.K. Kirkensgaard (1,b), J.K. Holm (1,c), L. Kovács[3], L. Rosta[4], P. Timmins[2], G. Garab[3]

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Most photosynthetic organisms have evolved highly organized multilamellar membrane systems, thus increasing the efficiency of light capturing. In higher plants, the photosynthetic pigment–protein complexes are embedded in the thylakoid membranes, which are located in the chloroplast, and are surrounded by an aqueous matrix, the stroma. The membrane systems exhibit a large structural flexibility, as evidenced by our structural investigations, allowing the system to adapt to changes in environmental conditions. It is well-known from electron microscopy that the thylakoid membrane is organized into closely appressed (regularly stacked) flattened vesicles, the granum thylakoids, and non-appressed stroma lamellae interconnecting the grana stack. In a scattering context, the stroma lamellae can be viewed as a loose regular stack of lamellae, i.e. the structure is characterized by two repeat distances, belonging to the grana stack and the stroma lamellae, respectively.

We have performed transmission small-angle x-ray and neutron scattering on thylakoids freshly isolated from spinach or pea and suspended in an aqueous medium under near physiological conditions. SAXS on pea thylakoids show two well developed broad peaks at ~ 0.09Å-1 and ~ 0.16Å-1 which change in position and intensity with varying concentration of osmoticum, reflecting changes in contrast and repeat distances (Holm, 2004 and Kirkensgaard et al , 2009). SANS show a broad peak at $\sim$0.02 Å-1 which is ascribed to diffraction from domains of ordered, unappressed stroma lamellae, revealing a repeat distance of 294 Å$\pm$7 Å in spinach and 345 Å$\pm$11 Å in pea. The repeat distance of the stroma lamellae is strongly dependent on the osmolarity and the ionic strength of the suspension medium, as demonstrated by varying the sorbitol and the Mg++-concentration (Posselt et al, 2012). The stroma repeat distance decreases when illuminating the sample with white light. The change is reversible and using time-resolved SANS we have investigated this effect on a seconds-to-minutes time scale (Nagy et al, 2011). The structural changes observed are associated with functional changes, as e.g. evidenced by the observation that addition of an uncoupler prohibits the light-induced structural changes, strongly indicating that the light-induced changes are driven by the transmembrane proton gradient.

References

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Posselt, D., Nagy, G., Kirkensgaard, J.K.K., Holm, J.K., Aagaard, T.H., Timmins, P., Rétfalvi E., Rosta, L., Kovács, L. and Garab, G., Biochimica et Biophysica Acta, In Press, 2012 (http://dx.doi.org/10.1016/j.bbabio.20

BF 2 Twist Neutrality and the Diameter of the Nucleosome Core Particle

By K. Olsen[1] and J. Bohr[1]

[1] DTU Nanotech, Building 345B Ørsteds Plads, Technical University of Denmark, 2800 Kongens Lyngby, Denmark

What determines the diameter of the nucleosome core particle?

In this work, we raise the question of why the dimension (the diameter) of the nucleosome core particle is preserved across the eukaryotes? Would another size have worked equally well, e.g. twice the size? We suggest that there is an underlying physical principle which will only work for a unique size. In short, the concurrent action of having a densely packed structure and of having a rotationally neutral response to strain set the size. Our numerical calculation of 82 Å is within a few percent of the value known from crystallographic studies.

The size of the nucleosome core particle is therefore not determined by what is inside it (the histones), but rather by geometry!

7

Condensed matter physics

talks

FF 1 First three-in-one measurement of a complete set of thermoviscoelastic response functions

By Jon Josef Papini and Tage Christensen and Jeppe C. Dyre

DNRF Centre "Glass and Time", IMFUFA, NSM, Roskilde University, Postbox 260, DK-4000 Roskilde, Denmark

Systems with long relaxation times like biomembranes, glass-forming liquids, polymers, etc, present a special experimental challenge. For such systems one must not only wait long time to ensure thermal equilibration, but also the thermodynamic linear response functions become complex and frequency dependent. On the other hand, these response functions provide useful macroscopic information about the nature of the relaxation processes, which are usually probed by microscopic methods such as inelastic neutron scattering.

The fundamental thermodynamic and mechanical control variables are temperature/entropy and pressure/volume, respectively. The control variables are related in pairs by the response functions, for instance, the constant pressure specific heat c_p relates a perturbation in temperature to a change in entropy while pressure is kept constant while the adiabatic compressibility κ_S relates volume and pressure at constant entropy. Altogether there 24 possible ways to combine the control variables and for relaxing systems the 24 response functions are complex and frequency dependent, in which case one refers to them as (linear) thermoviscoelastic response functions. However, the 24 thermoviscoelastic response functions are not independent - a knowledge of three properly selected of them is enough to determine all remaining 21.

Given this theoretical simplification one might expect an abundance of linear thermoviscoelastic data. This is certainly not the case, in fact there are very few reliable measurements of a full set of three independent thermoviscoelastic response functions for a relaxing system. Here we present the first ever measurement of a complete set of thermoviscoelastic repsonse functions - measured on one sample, in one device.

FF 2 Isomorph invariance of the SLLOD equations of motion

By L. Separdar[1,2] and N. P. Bailey[1], S. Davatolhagh[2] J. C. Dyre[1]

[1] DNRF Center "Glass and Time", IMFUFA, Dept. of Sciences, Roskilde University, P. O. Box 260, DK-4000 Roskilde, Denmark. [2]Department of Physics, College of Sciences, Shiraz University, Shiraz 71454, Iran.

Non-equilibrium molecular dynamic simulation was performed to study the isomorph invariant of thermodynamic, structural and dynamical quantities for two different systems. One of the systems simulated is simple component Lennard-Jones and the other one is a binary mixture Lennard-Jones liquid. Both of these systems have isomorphs, that is, curves in the phase diagram along which structural, dynamical and some thermodynamic quantities are invariant when expressed in thermodynamically reduced units. The SLLOD equations of motion were used to simulate Couette shear flow. It can be shown that these equations are isomorph-invariant provided the reduced strain rate is fixed along the isomorph. Different shear rate was used to cover both linear and non-linear regime. For both systems the radial distribution function and intermediate scattering function, when represented in reduced unit, collapse on each other for different steady state points that are isomorphic. Our results at strain rate zero are in very good agreement with those obtained by NVT simulations for equilibrium molecular dynamic simulation. It

was shown in paper (J. Ge, B. D. Todd, G. Wu, and R.J. Sadus, Phys. Rev. E 67, 061210 (2003)) that for a Lennard-Jones dense liquid at given state point the potential energy and pressure can be fitted by a power-law dependence on strain rate where thecommon exponent depends on state point. We find the same but that the exponent is constant along an isomorph, as must follow from the isomorph invariance of the SLLOD equations.

FF 3 ISOMORPHS IN NANO-CONFINED SYSTEMS

By Trond S. Ingebrigtsen[1], and Thomas M. Truskett[2], Jeffrey R. Errington[3], Jeppe C. Dyre[1]

[1] DNRF Center "Glass and Time", IMFUFA, Dept. of Sciences, Roskilde University, [2] University of Texas at Austin, [3] University at Buffalo

Liquids near interfaces show rich and complicated behavior. For instance, a liquid confined to the nanoscale may change its dynamic properties several orders of magnitude compared to the bulk system. Predicting these changes isan important challenge relevant for biological systems, engineered devices, etc.We consider here whether it is possible to apply a recently introduced concept in statistical physics, namely iso-morphs [N. Gnan et al., J. Chem. Phys. 131, 234504 (2009)], to the understanding of nanoscaled confined systems.Isomorphs are invariance curves in a liquid's phase diagram, along which certain thermodynamic, all structural anddynamic quantities are invariant in so-called reduced units. We consider also in the framework of isomorphs, a recentlyestablished thermodynamic-kinetic-relationship among bulk and confined systems for predicting the dynamic changesinduced by the nanoscale confinement.

8

Condensed matter physics

posters

FFP1 Curves of invariant structure and dynamics in model liquids with semi-flexible molecules.

By Arno A. Veldhorst[1] and Jeppe C. Dyre[1], Thomas B. Schrøder[1]

DNRF Center "Glass and Time", IMFUFA, Dept. of Sciences, Roskilde University, P.O. Box 260, DK-4000 Roskilde, Denmark

A large group of (model) liquids are strongly correlating, i.e., have regions of their phase diagram where constant-volume equilibrium fluctuations in the virial and potential energy are strongly correlated. The instantaneous values of these fluctuations define the scaling variable γ, which can be used to find isomorphs, which are curves in the phase diagram along which structure and dynamics are invariant.Here, the results of molecular dynamics simulations of different model liquids consisting of semi flexible molecules are presented. The results show that these flexible molecules also have isomorphs. Different models have been used to simulate the intra-molecular bonds; a harmonic spring and a rigid bond. For the liquid with harmonic springs, the γ obtained from the instantaneous values of the energy and the virial cannot be used to find isomorphs. Instead, a frequency dependent $\gamma(\omega)$ can be defined. The low frequency value of $\gamma(\omega)$ is the value that should be used to find isomorphs.

FFP2 Incommensurate Antiferromagnetic Order and Competing Superconductivity and in BaFe2(1-x)Co2(x)As2

By G. Stieper[1] and S. Holm[1,4] Ch. Niedermayer[2] J. Larsen[2,3] K. Lefmann[1,4]

[1] Niels Bohr Institute, University of Copenhagen. [2] Laboratory for Neutron Scattering, Paul Scherrer Institut. [3] Department of Physics, Technical University of Denmark. [4] European Spallation Source.

The pnictides are iron based type-2 superconductors. Like in the cuprates the superconductivity coexist with long range magnetic order[1]. This long range order might be the paring mechanism in type-2 superconductors. In Contrast to the insulating cuprates the parent compounds of pnictides are metallic conductors. The pnictide BaFe2(1-x)Co2(x)As2 with doping x¡0.06 orders antiferromagneticly (AFM) below the Néel temperature (for x=0.0495 TN=38K) and below TC (=20K for same doping) the systems becomes superconducting (SC), while a competing magnetic order still exist.[2,3] The system also has a doping driven phase transition between commensurate (C) and incommensurate (IC) magnetic order.[4] Previous work indicates that the magnetic order becomes IC for dopings x¿0.055.[4]

However, recent muon spin rotation work on a sample with doping of x=0.0495 by Christof Nidermayer indicates the presence of a broad field distribution,[5] which could be explained by an IC magnetic order.

Here we present neutron scattering data on the same sample. We investigate the temperature (in the range 1K-52K) and magnetic field (0-13.5T) dependence of the AFM phase and SC phase. We observe a suppression of SC under applied magnetic fields. We do not find any evidence of an IC order in the sample.

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FFP3 Tackling the Challenges of Long Neutron Guides

By Kaspar Hewitt Klenø[1] and K Lieutenant[2] K Lefmann[1]

[1] Niels Bohr Institute [2] Helmholtz-Zentrum Berlin, Germany

The European Spallation Source (ESS) will be a long-pulsed source, the first of its kind in the world. Therefore, the instrument concepts as ESS are new and untested, and many different designs must be tried out to find the optimal one. In general, the long pulsed ESS source produces far more neutrons than other sources, but with less precision in flight time determination. Therefore ESS instruments need to be longer that instruments at other sources, giving rise to additional complications with neutron transport from source to sample.The building of long test instruments is too costly. Instead of building the instrument, their designs are being tested by computer Monte Carlo ray-tracing methods using the world leading neutron simulation package McStas.We will present calculations showing that neutron transport through long guides is feasible, and we will show the quality of the divergence profile of the beam transported by such guides. Our results show that cold neutrons can be transported over a 150 m distance with 85 % efficiency for 2 ° divergence. And wavelengths as low as 1 Å$\sim$ can be transported with 85 % efficiency for divergences of $\pm 0.5°$. We have also found that waviness below 0.01° does not have a noticeable effect.Additionally we will show the effect real-world non-idealities such as gravity and guide waviness has on the quality of the beam profile.

FFP4 Beyond power law density scaling

By Lasse Bøhling[1] and Arno Veldhorst[2] Trond Ingebrigtsen[3] Jeppe Dyre[4] Thomas Schrøder[5]

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The rapid increase in relaxation time upon cooling a liquid near its glass transition temperature has drawn a lot attention in the last decade. For small density changes it has been shown, both experimentally [1] and numerically [2, 3], that for a certain class of liquids, these obey power law density scaling where the relaxation time

$$\tau$$

is a function of density to some power divided by temperature $\tau = f(\rho^\gamma/T)$. We show that for large density changes this density scaling breaks down and we derive a more general form of the density scaling where the density dependence ρ^γ is replaced with a function of density $g(\rho)$, as originally suggested by [4]. For Lennard-Jones systems this function contain only one parameter which can be estimated independently. For systems interacting with inverse power law potentials, as the Lennard-Jones, we have an analytical expression for $g(\rho)$. For the Kob-Andersen binary mixture, we show simulation results in excellent agreement with this new form of density scaling.[1] D. Gundermann et al Nature Physics, nphys2031 (2011)[2] U. R. Pedersen et al PRL 105, 157801 (2010)[3] D. Coslovich and C. M. Roland, JCP 115, 151103 (2009)[4] C. Alba-Simionesco et al EPL, 68 pp. 58-64 (2004)

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Nanophysics and nanomaterials

posters

NAP1 Femtosecond Laser Ablation of Dielectric

By Ditte Både Sandkamm and Peter Balling, Kristian Wædegaard

Femtosecond laser pulses can be used to remove material from dielectrics (a phenomenon known as ablation). A model has been developed to describe the electronic excitation and the light absorption throughout the dielectric material. This allows for a determination of how much material is removed at certain laser energies, band gaps, pulse lengths etc. Simulations based on this model show that for low-band-gap materials, the threshold for removing material is lower and the depth of the hole is smaller than for larger band gaps. The model is compared with single-shot experiments on well-defined single-crystal dielectric samples. The ablated holes are analyzed by SEM and AFM and the results are consistent with the model with appropriate choice of material parameters.

10

Nuclear and elementary particle physics

talks

NF 1 Long Range Charged Particle Correlations – What Can We Learn ?

By Carsten Søgaard and
Niels Bohr Institute, University of Copenhagen

Processes in proton-proton collisions are governed by Quantum Chromo Dynamics. When the momentum transfer between the two quarks is large, the process can be described analytically. For each of these so-called "hard-scatterings" there are many at low momentum transfer. Such "soft" processes can not be described analytically and at present can only be studied through models.Many models are available. Although their descriptions of the collision differ significantly, they predict many physical observables accurately. In order to discriminate between the models, a physical observable with a more distinct signal is desired. Measurements of forward-backward correlations is one such observable. When performed on simulated data the results show significantly different results, making the discrimination possible. These results will be shown together with measurements from proton-proton collisions. The data has been recorded with ALICE at the LHC, providing measurement of very long range correlations. The physical interpretation of the comparison will be discussed.

NF 2 Near-Conformal Gauge Theory and a Realization of Miransky Scaling

By E.T. Mølgaard[1], and O. Antipin[1], S. Di Chiara[1], M. Mojaza[1], F. Sannino[1]

[1] CP3-Origins, the Danish Institute for Advanced Study (DIAS), and the University of Southern Denmark.

We present a gauge theory model consisting of quantum chromodynamics with an arbitrary number of flavors and colors, an adjoint Weyl fermion, and elementary mesons. We find that this model has a rich phase structure brought on by the fixed points of its beta functions. In this talk I will focus what happens when the number of flavors change, and see that as we move from the conformal to the running region, we pass through a phase of slow running, known in the literature as walking dynamics.

NF 3 Radiation emission from ultrarelativistic electrons in crystals and amorphous materials

By Kristoffer K. Andersen and
Dept. of Physics and Astronomy Aarhus University

The radiation spectrum from an electron moving in a very high electromagnetic field is strongly affected by quantum effects like quantum recoil and the spin of the electron. These effects essentially lead to a modification of the well known classical synchrotron radiation spectrum when the field is comparable to the so-called critical field of 4 GT. One way of investigating these effects are by channeling GeV electrons along an axis of a crystal, where the field of the individual nucleons add coherently. We will present experimental results from the NA63 collaboration at CERN, compare the measurements with theoretical calculations and discuss the importance of these effects. Another quantum effect which changes the spectrum of low-energy photons from relativistic electrons travsersing amorphous materials

is connected to the so-called photon formation length. We will present measurements on the radiation from electrons penetrating a structured target where a shoulder in the radiation spectrum is observed. The position of this shoulder is closely related to the finite formation length of photons.

NF 4 Neutron to proton mass difference, parton distribution functions and baryon resonances from dynamics on the Lie group u(3)

By Ole L. Trinhammer and

Department of Physics, Technical University of Denmark

We develop a hamiltonian framework on the Lie group u(3), which we call allospace and which is supposed to carry all the colour dynamics needed to describe the baryon spectrum. The energy eigenstates of our particular Schrödinger equation tends to predict realistically all certain baryon resonances in the N-Delta sector. The grouping and number of resonances is predicted by the model from a single fitting of the ground state N(939). The Hamiltonian also contains terms from the group space Laplacian to take care of spin and the superimposed hypercharge and isospin flavour structure. Scarce neutral flavour singlet resonances are predicted and may show up around 4500 MeV in neutron diffraction dissociation experiments above the threshold in the free charm system SigmaCplus(2455)Dminus. They should also be visible in photoproduction of pPiMinus on neutrons and lower lying singlets may show up in pPiMinus invariant mass in B decays. We give a controversial prediction of the relative neutron to proton mass difference 0.138 % as originating in period doublings of certain parametric states. The group space dynamics communicates with real space via the exterior derivative which projects out quark and gluon fields from the allospatial state. The allostate in turn is excited from space by the momentum operators which act as toroidal generators on the group manifold. Such generators can be used to trace out parton distribution functions and examples are shown to mimic the valence quark content of the proton.

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Nuclear and elementary particle physics

posters

NFP1 Improvements in the Stopping Power Library libdEdx and Release of the Web GUI dedx.au.dk

By Jakob Toftegaard[1] and Armin Lühr[2] Niels Bassler[2]

[1] Dept. of Physics and Astronomy, Aarhus University, Aarhus C, DENMARK [2] Dept. of Experimental Clinical Oncology, Aarhus University Hospital, Aarhus C, DENMARK

Purpose: In particle therapy electronic stopping power data enter in a number of different disciplines, such as dose planning, dosimetry, and radiobiology, where dose or linear energy transfer (LET) have to be determined. Depending on the ion energy values of stopping powers are only known within an accuracy of 5%-10%. In order to investigate the impact of these finite accuracies on the different disciplines as well as on particle therapy as a whole one may profit from a fast and easy access to different stopping power sources from a single software library. To solve this issue we started the software library project libdEdx which unifies data from several well-known stopping power sources into one ready-to-use package. Currently, PSTAR, ASTAR, MSTAR and ICRU49+73 are implemented along with a version of the Bethe formula including a Lindhard-Scharff description at low particle energies. libdEdx is released under GPL, but commercially compatible sources may be made available upon request. A web based front end to libdEdx was programmed and is available at http://dedx.au.dk.Methods:The library is programmed in the language C to provide broad portability and high performance. A clean API, defined by a single header file, gives full access to the basic underlying functions. A complete list of ICRU materials with elemental compositions and mean excitation energies (I-values), is included. Compounds can be constructed from individual elements, and individual I-values of each element are automatically scaled to match the total I-value of the compound as given in the ICRU material list. The modified Bethe formula can in principle be used for all combinations of ions and target materials which are not covered by any of the other stopping power sources. Results: Tests were made where the I-values of the individual constituents were scaled non-homogeneously with up to 30 % difference. In the worst case the impact on the resulting stopping power was a relative difference of the order of 0.1 %. A new API was defined, where a single function is required to configure the preferred configuration and which returns relevant values set by the respective algorithm. The new API works with a user-defined workspace, which ensures thread safety in multi threaded applications. Furthermore we introduced a collection of tools e.g. CSDA range calculation and its inverse, as well as inverse stopping power lookup.In connection with libdEdx we released a web GUI, which is available at http://dedx.au.dk The web GUI provides some default configurations of libdEdx, with options for the user to download graphs and data for further use. Simplicity and ease of use was a paradigm, making stopping power data available with just a few mouse clicks.Conclusion:A new version of libdEdx with version number 1.2 has been released with new API and web based GUI. Future development will focus on implementing stopping powers from other sources, for electrons as well as nuclear stopping power.See http://libdedx.sf.net/

NFP2 Film dosimetric validation of dose distribution calculations for moving targets in dynamic treatments

By Mai Lykkegaard Schmidt[1] and Lone Hoffmann[2], Esben Worm[2,3], Per R Poulsen[3,4]

[1] Department of Physics and Astronomy, Aarhus University, Denmark. [2] Department of Medical Physics, Aarhus University Hospital, Denmark. [3] Department of Oncology, Aarhus University Hospital,

Denmark. [4] Institute of Clinical Medicine, Aarhus University, Denmark

Purpose:

Organ motion during treatment delivery may lead to target dose distributions that differ markedly from the planned dose to a static target. In this study, we present a simple method that enables a commercial TPS to accurately calculate the dose distribution delivered to moving targets. The calculations, which can be performed for all treatment types, were validated with film dosimetry in a lung motion phantom for conformal treatment, IMRT, and VMAT.

Materials/Methods:

A planning CT scan was acquired of a thorax phantom (CIRS, model 008A) with a moveable lung equivalent rod with a cylindrical tumor insert of solid water (24 mm high, 25 mm diameter). In a TPS (Eclipse, Varian Medical Systems), the tumor insert was delineated as a GTV. A PTV was constructed by adding margins of 5 mm in the axial directions and 10 mm in the cranio-caudal (CC) directions. The heart, spinal cord, esophagus and lungs were delineated as organs at risk. A 5-field conformal plan, a 5-field sliding windows IMRT plan, and a 2-arc VMAT plan were generated giving minimum target doses of 95% (GTV) and 67% (PTV) of the prescription dose (3 Gy). The treatment plans were delivered to the thorax phantom both without tumor motion and with a CC sinusoidal tumor motion (20 mm peak-to-peak, 4 sec period). For each treatment, the target dose distribution was measured with a 63 mm x 130 mm Gafchromic EBT film mounted in the moving rod and compared with a calculated reference dose distributions using a 2mm/2 % γ-test. For static delivery, the reference dose was the dose of the original treatment plan. For treatments with motion, an in-house made Matlab computer program used the tumor motion, MLC motion, gantry rotation and monitor unit delivery of the treatment to construct a dynamic treatment plan that reflected the synchronized tumor motion and treatment delivery. The program first divided the tumor motion into 1mm position bins and then constructed subfields that represented the MLC motion, gantry rotation and dose delivery for each position bin. The target motion was modeled by shifting the isocenter of the subfields according to the target positions during treatment. The resulting motion including treatment plan was imported into the TPS for calculation of an individualized reference dose distribution for each treatment with motion.

Results:

For static delivery, the mean γ pass rate was 99.7%. For treatments with motion, the mean γ pass rate was 78.2% when compared with the static plans and 99.6% when compared with the motion including dose calculations (see Table).

	Static treatment vs. static calculation (%)	Motion treatment vs. motion calculation(%)	Motion treatment vs. static calculation (%)
Conformal	99.7	99.8	74.8
IMRT	99.8	100	70.5
VMAT	99.5	99.0	89.3
Mean	99.7	99.6	78.2

Conclusions:

A method for accurate calculation of the dose delivered to moving targets in dynamic treatments was developed and validated by film dosimetry. The method can be integrated into a commercial TPS and is suitable for reconstruction of the dose delivered to moving targets or for testing the possible dosimetric impact of target motion on a given treatment plan.

NFP3 Towards multi-photon ionization of Positronium: Ps formation in porous silica.

By S.L. Andersen and R.R. Johansen H. Knudsen J.K. Mortensen U. Uggerhøj

Department of Physics and Astronomy, Aarhus University, 8000 Aarhus C, Denmark.

When a high intensity laser field is applied to a Positronium atom in vacuum, there is a possibility to ionize the Positronium atom by simultaneous absorption of multiple photons. The cross section for multi-photon ionization of Positronium depends on the number of photons absorbed by the Positronium atom, and, by scaling the results obtained for Hydrogen, it turns out that the probability of ionizing Positronium becomes larger by several orders of magnitude, compared to that of Hydrogen. However, to measure the cross section, a large density of Positronium atoms in the region of overlap between the laser pulse and the Positronium atoms is required. An efficient conversion of positrons into Positronium can be obtained by making sure that the Positronium atoms can escape from the target into the surrounding

vacuum. For this purpose a series of specially manufactured Si and SiO2 targets has been produced by a method, where the porosity can be controlled. We will present the most recent results from our measurements performed at 300K, which shows a conversion of positrons into ortho-Positronium as high as 80% of the conversion found in a Ge(111) crystal at 1000K.

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Physics education

talks

UU 1 Peer evaluation using clickers

By I. G. Bearden and
Niels Bohr Institute University of Copenhagen

Student response sytems or "clickers" are now widely used and the term has nearly become synonymous with peer–instruction. While clickers are clearly useful in the context of peer instruction, they can also be used for peer evaluation. Peer evaluation, that is students "grading" the performance of other students provides both a more nuanced feedback than that given by an instructor and gives students an opportunity to develop the competences necessary to evaluate the work of others. In this talk, I will discuss how this has been implemented at the Niels Bohr Institute, discuss preliminary results and share ideas for futures improvements.

UU 2 Does the FCI predict early university performance?

By I.G. Bearden and
Niels Bohr Institute University of Copenhagen

The Force Concept Inventory has been used extensively in measuring the gain in conceptual understanding of classical mechanics of students taking introductory physics courses. The initial (pre-instruction) test provides a measure of initial understanding. This talk will explore the efficacy of this measure as a predictor of later success in physics.

UU 3 PeerWise: promoting engagement and learning through student-generated content

By Ross Galloway and Simon Bates Karon McBride

University of Edinburgh, UK

Over the course of a physics degree, undergraduate students will probably solve thousands of physics questions, but generally create very few questions themselves. The act of inventing a well-considered, challenging and correct physics problem is a sophisticated task, and one that provides useful experience for students. We have used a free, online system called PeerWise with our first year undergraduate physics classes: PeerWise allows students to write, share, answer and provide feedback on multiple choice questions. We have found high levels of engagement with the system: in general, our students produced high quality questions (the best of which were outstandingly good), and greater use of PeerWise was correlated with improved results on the course exam. I will discuss our implementation of PeerWise and the workshop activities that we believe promoted effective student engagement with the system.

UU 4 De studerende kan ingenting længere!

By Sonja Rosenlund Ahl and Louise Pagh Sperling
Adgangskursus, DTU

Denne konstatering høres oftere og oftere fra undervisere, men kan det tænkes, at de studerende faktisk kan noget andet, end det, de kunne tidligere? Med baggrund i erfaringer fra fysikundervisningen på Adgangskursus på DTU, skitserer vi den nye generation af studerende og præsenterer idéer til forbedring af de studerendes udbytte af undervisningen.

13

Physics education

posters

UUP1 Newton's craddle and a yeast cell in physics teaching at ADK?

By Mirka Smrcinova and

Technical University of Denmark, Adgangskursus

Newton's craddle and a yeast cell in physics teaching at ADK?

From oscillations in mechanical systems to biooscillations.

During the first half of the semester oscillations was one of the chapters one would have liked to explain students a bit more and preferentially with a handful of practical examples.

One needs to start basically with seawaves to explain the fundamentals or a physical pendulum can be easily hung up.

I wanted to give my students a survey of different oscillatory phenomena. Newton's craddle can be seen as a set of mathematical pendulae and is particularly attractive because of approximate energy and momentum conservation. One clearly sees the energy bulging back and forth.

Conservation of momentum is a supplement to the curriculum and is used here as an application of solving a system of two coupled equations. Apart from the mechanical oscillations an example of regular changes in some biological property or in some chemical item can be introduced, e.g. biorhythms or oscillations in concentration of a specific chemical compound in time in a single cell.

UUP2 PeerWise: promoting engagement and learning through student-generated content - (accompanying poster)

By Ross Galloway and Simon Bates Karon McBride

University of Edinburgh, UK

(Accompanying poster)Over the course of a physics degree, undergraduate students will probably solve thousands of physics questions, but generally create very few questions themselves. The act of inventing a well-considered, challenging and correct physics problem is a sophisticated task, and one that provides useful experience for students. We have used a free, online system called PeerWise with our first year undergraduate physics classes: PeerWise allows students to write, share, answer and provide feedback on multiple choice questions. We have found high levels of engagement with the system: in general, our students produced high quality questions (the best of which were outstandingly good), and greater use of PeerWise was correlated with improved results on the course exam. I will discuss our implementation of PeerWise and the workshop activities that we believe promoted effective student engagement with the system.

UUP3 Evaluating the development of student data handling skills

By Ross Galloway and Simon Bates Helen Maynard-Casely Hilary Singer Kate Slaughter

University of Edinburgh, UK

During the laboratory component of a physics undergraduate degree, we expect that our students will develop skills in processing, analysing and interpreting data. However, these skills frequently fall into the 'implicit curriculum': we expect students to absorb them as a consequence of general lab work. We have developed a diagnostic test of data handling skills in the physical sciences, and have deployed it to a large number of undergraduates in various universities. Our findings suggest that implicit absorption

of these skills is ineffective, and that student competency should be promoted by explicit tuition of data handling.

UUP4 The Øresund Region – a hub for materials science

By Stine Stenfatt West (a,b) and Kim Lefmann (a) Marius Simonsen (a) Mathias Rosdahl Jensen (a)

Jessica Bolinsson (c)

a)Niels Bohr Institute, University of Copenhagen b)Øresund Materials Innovation Community c)Department of Physics, Lund University

In the coming years, we will see the building of three extraordinary facilities in Northern Europe. The XFEL free electron laser in Hamburg, the MAX IV synchrotron in Lund and the ESS neutron spallation source in Lund and Copenhagen will be the best instruments available, and Northern Europe will be the central hub for scientific research in hard, soft and biological materials.

It is important to see to the entire scientific food chain in order to ensure qualified scientists and excellent science. The XFEL and MAX IV will begin operation in 2015-16 and the ESS will begin operation in 2019, and by that time, the personnel and infrastructure should be in place in order to take full advantage of the facilities for research as well as industry. This poster will focus on the subject of public outreach, which is important to ensure sufficient quality and quantity of students as well as public and private investments in the region.

A number of outreach activities that are in the pipeline will be reported and a workshop to discuss further work will be announced.

14

Women in physics (KIF)

talks

KF 1 Structural changes in block copolymer thin films during solvent vapour treatment

By Dorthe Posselt[1] and Zhenyu Di[2], Alessandro Sepe[2], Christine Papadakis[2] Detlef-M. Smilgies[3]

[1]IMFUFA, Department of Science, System and Models, Roskilde University, 4000 Roskilde, Denmark

[2]Technische Universität München, Physikdepartment, Physik weicher Materie, 85747 Garching, Germany

[3]Cornell High-Energy Synchrotron Souce (CHESS), Wilson Laboratory, Cornell University, Ithaca NY, USA

The morphologies formed in diblock copolymer thin films are useful for a number of nanotechnology applications, such as molecular sieves, templates or sensors. However, samples prepared by spin-coating have a number of defects and annealing is necessary to improve the quality. While thermal annealing may result in a chemical degradation of the polymer and application of an electric field only works in special cases, solvent annealing offers a simple and flexible method with a potentially high degree of controllability through careful choice of solvent and partial vapour pressure as function of time. The rearrangement processes during vapour treatment of block copolymer thin films are complex. The solvent not only swells the polymers, but also increases the chain mobility and reduces the interfacial tension between the blocks.We have investigated thin films of lamellar poly(styrene-b-butadiene) (PSPB) which were vapour treated with toluene, a good and non-selective solvent [1] or with cyclohexane [2,3], a slightly PB selective solvent. Time resolved grazing-incidence small-angle x-ray scattering (GISAXS) enabled us to follow the changes of the inner film structure in-situ. I.e. the swelling and the rearrangement of the lamellae were investigated with a time resolution of a few seconds, and the underlying processes on the molecular level were identified. When solvent vapour enters the film, the lamellae swell linearly, and the blocks stretch uniaxially. Then, the blocks relax to a more Gaussian molecular conformation, and the lamellar thickness abruptly shrinks again. The increased interfacial area culminates in an instability causing a major rearrangement of the lamellar stack and the formation of new lamellae. Finally, the lamellar thickness approaches a steady-state value, and the interfaces flatten again. Prolonged treatment with solvent vapour leads to disordering. [1] C.M. Papadakis, Z. Di, D. Posselt, D.-M. Smilgies, Langmuir (Letters), 2008 Vol. 24,13815 - 13818. [2] Z. Di, D. Posselt, D.-M. Smilgies, C.M. Papadakis, Macromolecules, 2010 Vol. 43, 418 -427. [3] Zhenyu Di, Dorthe Posselt, Detlef-M. Smilgies, Ruipeng Li, Markus Rauscher, Igor I.Potemkin, Christine M. Papadakis, Accepted for publication in Macromolecules

KF 2 Women in Science - why so few?

By Petra Rudolf and

Zernike Institute for Advanced Materials, University of Groningen, The Netherlands

Do women do research differently from men? Is the productivity of female researchers judged differently from that of their male colleagues? Do women judge success differently? I shall discuss these three questions based on comparative studies carried out in Europe, U.S.A. and Japan concerning the peer-review system, the number ofpapers published by male and female researchers and the behaviour during job interviews. I shall comment on how female scientists view themselves and how others view

them, as well as on how family and work influence each other for scientists of both sexes. Based on the trends which emerge from these studies, I shall also suggest some measures to be taken to ensure that women stay in science.