Fachbereich Physik

GOETHE UNIVERSITÄT FRANKFURT AM MAIN

Vorträge im Physikalischen Kolloquium

Wintersemester 2013/14

Mittwochs 16 Uhr c.t., Hörsaal _.111 (EG), Max-von-Laue-Str. 1

16.10.13 **Dr. Dorothée Weber-Bruls**, Anwaltskanzlei Jones Day, Frankfurt

New Grounds in the Patent Landscape for Nanotechnology Inventions from a European Perspective

In 2014, at latest in 2015, extensive changes in the legal environment for patents in Europe are to be expected, having considerable impact on monopolizing inventions e.g. from the nanotechnology environment: With establishing the "European patent with unitary effect", for the very first time the grant of single patents with uniform coverage of (almost) the entire territory of the European Union will be available. Even more groundbreaking, the introduction of the new "Unified Patent Court" will establish a new legal basis for patent enforcement as well as invalidation.
With this talk, a comprehensive guide through the patent jungle of classifications, regulations and case law within Europe for nanotechnology inventors/applicants is given. At first, an overview of classifying nanotechnology inventions and trends in patent filings is presented. Thereafter follows a description of the current patent system and of some peculiarities of the forthcoming changes in Europe with their impact on nanotechnology patenting. The conclusion of the excursion into the world of patents is that scientists in the field of nanotechnology break new ground not only with respect to technology as such but also participate in building up a rapidly growing patent landscape. This creates ample opportunities, with a new challenge in form of the unified patent system just waiting around the corner.

23.10.13 **Prof. Dr. Martin Ammon**, Theoretisch Physikalisches Insitut,
Friedrich-Schiller Universität Jena

From gravity and black holes to Quark-Gluon Plasma & superconductors and back

What do black holes and quark-gluon plasma or high temperature superconductors have in common? Besides being interesting systems on their own and currently investigated by many different groups, they are intimately connected by relations between gravitational and non-gravitational theories. These relations might help to get new insights into the quark-gluon plasma, high temperature superconductors and other strongly coupled systems.

In this talk I will review the basic theoretical arguments leading to such surprising relations and focus on a few exciting applications towards real-world systems. In the end I will speculate about astonishing consequences for quantum gravity and our universe.

30.10.13 **Prof. Dr. Jochen Küpper**, Center for Free-Electron Laser Science, DESY, Hamburg

Getting complex molecules under control

The recording of molecular movies, the atomically resolved structural dynamics of complex molecules, is within reach. Corresponding modern experiments in the molecular sciences range from ultrafast attosecond electron dynamics investigations of diatomic molecules to the coherent diffractive imaging of nanocrystals or viruses of biological samples. The recording of temporally and spatially atomically resolved "movies" will rely on strongly controlled molecular samples. This includes the separation of individual structural isomers or even quantum states of complex molecules, the ability to strongly fix complex molecules in space, and to deliver them to the interaction point of the probe experiment, such as modern table-top laser systems, free-electron lasers, or electron beams. I will discuss our endeavors to get complex molecules under control, including the spatial separation of different species and the one- and three-dimensional alignment and orientation. The controlled samples of such many-body quantum systems have been successfully employed in various benchmark experiments toward the recording of molecular movies and the unraveling of the structure-function relationship.

6.11.13 **Prof. Dr. Selim Jochim**, Physikalisches Institut, Universität Heidelberg

One, two, three, many: Exploring quantum systems one atom at a time

Experiments with ultracold gases have been extremely successful in studying many body systems, such as Bose Einstein condensates or fermionic superfluids. These are deep in the regime of statistical physics, where adding or removing an individual particle does not matter.
For a few-body system this can be dramatically different. This is apparent for example in nuclear physics, where adding a single neutron to a magic nucleus dramatically changes its properties. In our work we deterministically prepare generic model systems containing up to ten ultracold fermionic atoms with tunable short range interaction.
In our bottom-up approach, we have started the exploration of such few-body systems with a two-particle system that can be described with an analytic theory. Adding more particles one by one we enter a regime in which an exact theoretical description of the system is exceedingly difficult, until the particle number becomes large enough such that many-body theories provide an adequate approximation.
Our vision is to use our deterministically prepared tunable few- body systems as a microscopic building block to prepare model systems that might help to gain insight into complex many-body systems in condensed matter or even QCD.

13.11.13 **Prof. Dr. Claudius Gros**, Institut für Theoretische Physik, Goethe Universität Frankfurt

Complex dynamical Systems and our Brain

Our brain is a complex dynamical system and an introduction to the basic concepts underlying its functionality, on a generic level, is given. We will then discuss the advantages of using generating functionals for the construction of complex and cognitive systems and discuss two examples based on information-theoretical concepts, the neural information entropy and the Fisher information for the synaptic flux operator. Discussing the results obtained for the respective neural networks we will argue, that generating functionals constitute a promising route for guiding self-organizational processes.

20.11.13 **PD Dr. Till Jahnke**, Institut für Kernphysik, Goethe Universität Frankfurt

Interatomic Coulombic Decay - Experimentelle Untersuchungen und Anwendungen

Mit Interatomic (oder Intermolecular) Coulombic Decay (ICD) wurde vor etwa 15 Jahren ein neuartiger Zerfallsmechanismus vorhergesagt [1], bei dem die Anregungsenergie eines Atoms an ein Nachbaratom oder Nachbarmolekül übertragen wird. Dies geschieht erstaunlicherweise in Verbänden von nur locker gebundenen Atomen und Molekülen und somit über große Entfernungen hinweg. Nachdem der Prozess vor einigen Jahren experimentell eindeutig nachgewiesen werden konnte [2] stellte sich heraus, dass ICD ein sehr allgemeines Phänomen ist. ICD tritt in einer Vielzahl von Szenarien auf, nach Ionisation, Anregung, aber auch nach lokalen Auger-Zerfällen, und wurde seither in vielen verschiedenen Systemen beobachtet. Seit der experimentellen Bestätigung der Existenz von ICD sind daher zu diesem Thema bereits etwa 150 Publikationen erschienen. In der letzten Zeit ist es endlich gelungen, den Ablauf des Zerfalls auf atomarer Ebene aufzulösen: in einem Experiment konnte die Bewegung der am Zerfall beteiligten Atome „gefilmt“ werden [3]. Diese Messung dient somit als Grundlage, weitere Aspekte von ICD verstehen zu können, aber auch andere atomare und molekulare Vorgänge zeitaufgelöst zu untersuchen. Ein weiterer Aspekt von ICD ist die Emission eines (typischerweise) niederenergetischen Elektrons. Da niederenergetische Elektronen als genotoxisch gelten, wurde mit dem Nachweis von ICD in kleinen Wassertropfen [4,5] vermutet, dass ICD der Entstehung von Strahlen-schäden eine Rolle spielen könnte. Da ICD auch nach einer resonanten Anregung von Atomen nachgewiesen wurde [6], könnte man es benutzen, um gezielt (durch die resonante Anregung) an einem einzigen Atom in einem komplexen System Energie zu deponieren und dort ICD auszulösen. Das dann entstehende niederenergetische Elektron könnte z.B. erkrankte Zellen angreifen, nachdem diese durch einen Markerstoff (der das resonant anregbare Atom enthält) markiert worden sind.

[1] Cederbaum, L. S., Zobeley, J., and Tarantelli, F., Phys. Rev. Lett., 79, 4778 (1997).
[2] Jahnke, T., Czasch, A., Schöffler, M. S., Schössler, S., Knapp, A. Käsz, M., Titze, J., Wimmer, C., Kreidi, K., Grisenti, R. E., Staudte, A., Jagutzki, O., Hergenhahn, U., Schmidt-Böcking, H., and Dörner, R., Phys. Rev. Lett., 93, 163401 (2004).
[3] F. Trinter, J. B. Williams, M. Weller, M. Waitz, M. Pitzer, J. Voigtsberger, C. Schober, G. Kastirke, C. Müller, C. Goihl, P. Burzynski, F. Wiegandt, T. Bauer, R. Wallauer, H. Sann, A. Kalinin, L. Ph. H. Schmidt, M. Schöffler, N. Sisourat, and T. Jahnke, Physical Review Letters, 111, 093401 (2013)
[4] Jahnke, T., Sann, H., Havermeier, T., Kreidi, K., Stuck, C., Meckel, M., Schöffler, M., Neumann, N., Wallauer, R., Voss, S., Czasch, A., Jagutzki, O., Malakzadeh, A., Afaneh, F.,Weber, Th., Schmidt-Böcking, H., and Dörner, R. Nature Physics, 6, 139 (2010).
[5] Mucke, M., Braune, M., Barth, S., Förstel, M., Lischke, T., Ulrich, V., Arion, T., Becker, U., Bradshaw, A., and Hergenhahn, U. Nature Physics, 6, 143 (2010).
[6] F. Trinter, M. S. Schöffler, H.-K. Kim, F. Sturm, K. Cole, N. Neumann, A. Vredenborg, J. Williams, I. Bocharova, R. Guillemin, M. Simon, A. Belkacem, A. L. Landers, Th. Weber, H. Schmidt-Böcking, R. Dörner, and T. Jahnke, Nature accepted for publication (2013)

27.11.13 **Dr. Pablo Richter**, Continental Automotive GmbH, Babenhausen

Head-up Display – der innovative Bestandteil von Fahrerassistenzsystemen im Auto von heute und morgen

Die Bedeutung des Head-up Displays (kurz: HUD´s) als besonders innovative Anzeigefläche im Automobil nimmt rasant zu, insbesondere als Teil von Gesamtkonzepten, die im Auto die Schnittstelle zwischen Mensch und Maschine (kurz: HMI, Human-Mashine Interface) beschreiben. Der Hauptvorteil eines Head-up Displays liegt darin, das Fahren sicherer und nebenbei komfortabler zu machen. Sicherer deswegen, weil der Fahrer während des Fahrens alle fahrerrelevanten Informationen, wie beispielsweise die aktuelle Geschwindigkeit oder Navigationshinweise über das optische System HUD und die Windschutzscheibe ins direkte Sichtfeld in einem Projektionsabstand von 2-2,5 m vor sich in Form eines virtuellen Bildes eingespiegelt bekommt.

Der Vortrag behandelt sowohl die Funktionsweise, die optische Auslegung als auch die Serienproduktion von HUD´s. Zudem wird auf die gesamte Vielfalt von HUD´s, vom Combiner- über Windschutzscheiben- hin bis zum Augmented-Reality-HUD eingegangen. Desweiteren wird die generelle Rolle des HUD´s im Gesamtkontext „Maschine-Mensch-Schnittstelle“ beschrieben.

4.12.13 **Dr. Susanne Heinicke**, Didaktik und Geschichte der Physik,
Carl-von-Ossietzky-Universität Oldenburg

Aus Fehlern wird man klug – ein Plädoyer für die Achtung des Messfehlers

In Selbstverständnis und Historie ist die Physik eine messende Wissenschaft. Weniger stark ausgeprägt als die Diskussion der Ergebniswerte dieser Messungen ist dabei allerdings die um ihre begrenzte Genauigkeit, und dies sowohl in Lehre als auch Forschung. Der sogenannte „Messfehler“ ist so schon dem Namen nach mehr Haushalter des Makels denn Träger interessanter Information.

In diesem Sinne gehört auch die konventionelle „Fehlerrechnung“ zu den unbeliebtesten Aufgaben im naturwissenschaftlichen Studium. Entsprechend zeigt ein Blick in Praktikumsanleitungen, Lehrbücher, Praktikumsprotokolle und auch Qualifikationsarbeiten, wissenschaftliche Veröffentlichungen oder populärwissenschaftliche Darstellungen, dass die Diskussion der begrenzten Genauigkeit dieser Messungen ein eher bescheidenes Dasein fristet. Vor allem aber werden bei kritischer fachlicher Analyse eine Vielzahl von Widersprüchlichkeiten und Inkonsistenzen in unserem konventionell-statistischen Umgang mit Messfehlern deutlich.

Es ist angebracht, über einen alternativen Umgang mit der begrenzten Genauigkeit unserer Messungen nachdenken, der fachlich adäquater und für die Lernenden logisch zugänglicher ist und der deutlich macht, dass ohne die Beschreibung der Unsicherheit einer Messung eine adäquate Interpretation ihres Ergebnisses gar nicht möglich ist. Ein Blick in die Geschichte der Physik zeigt, dass der vorgestellte Ansatz so modern gar nicht ist. Die grundliegenden Empfehlungen formulierte das BIPM 1995 in der Veröffentlichung einer internationalen Empfehlung des Umgangs mit Messunsicherheiten (GUM). Seine Wurzeln reichen allerdings noch sehr viel weiter in die Geschichte der Naturwissenschaften zurück.

Der Vortrag nähert sich dem Gegenstand des Messfehlers daher aus einer fachlichen, einer fachhistorischen und fachdidaktischen Perspektive und zeigt auf, was für ein Lern- und Informationspotential in der Diskussion der begrenzten Genauigkeit einer Messung tatsächlich stecken könnte, wenn wir sie adäquat nutzten.

11.12.13 **Prof. Dr. Andrey V. Solov'yov**, Frankfurt Institute for Advanced Studies (FIAS)

Multiscale physics of ion beam cancer therapy: nanoscale insights

The multiscale approach to the molecular level assessment of radiation damage in biological targets consequent to irradiation by ions was designed in order to qualitatively and quantitatively describe the effects that take place when energetic ions interact with living tissues, e.g. the Relative Biological Effectiveness (RBE) of radiation [1, 2]. A road towards the understanding physical aspects of ion-beam cancer therapy on the molecular level revealed that this problem has many temporal, spatial, and energy scales, while the main events leading to the cell death happen on a nanometer scale. The multiscale approach is interdisciplinary, phenomenon-based and, having started some years ago, passed several milestones making discoveries on different scales, for review see [1, 2]. Thus, in addition to the traditional pathways of biodamage often related to secondary electrons and free radicals production in cells after irradiation [3], the multiscale approach also considers a new efficient pathway of DNA damage caused by the nanoscopic shock waves created by the strong local heating in the vicinity of the ion tracks due to the energy deposited by ions [4].

References
[1] E. Surdutovich, A.V. Solov’yov, J. Phys.: Conf. Ser. 373, 012001 (2012)

[2] E. Surdutovich, A.V. Solov'yov, Eur. Phys. J. D, Colloquium paper (2013); http://xxx.lanl.gov/ arXiv:1312.0897v1 [physics.bio-ph] 3 Dec 2013
[3] P. de Vera, R. Garcia-Molina, I. Abril, A.V. Solov'yov, Physical Review Letters 110,148104 (2013)
[4] E. Surdutovich, A. Yakubovich, and A.V. Solov'yov, www.nature.com / scientificreports, 3, 1289 (2013).

18.12.13 **PD Dr. Piero Nicolini**, Frankfurt Institute for Advanced Studies (FIAS)

Journey to the shortest scale

By combining arguments from quantum mechanics and the theory of gravitation we present the concept of fundamental length, namely the shortest physically meaningful length scale in the Universe.

We also discuss a variety of Gedankenexperimente that can underline the necessity of a fundamental length and uncover the inadequacy of standard quantum mechanics in the extreme high energy regime.

Finally we offer a brief overview of possible repercussions. We discuss some experimental arenas in which evidences of a fundamental length are expected despite the difficulties one conventionally encounters to probing such extremely small distances.

15.01.14 **Prof. Dr. Mischa Bonn**, Max Planck Institute for Polymer Research, Department of Molecular Spectroscopy, Mainz

Carrier Dynamics in Graphene and Graphene Nanostructures studied using Ultrafast TeraHertz Spectroscopy

Owing to its 2 2-dimensional structure, vanishing bandgap and high electron mobility, graphene is a promising material for many optoelectronic applications. An important open question has been how photon energy is converted into electronic energy: initially, each photon creates one excited electron-hole pair, but this initially excited pair can get rid of its excess energy either by generating phonons, or by generating additional electrons and holes, in a process similar to carrier multiplication in conventional semiconductors. We quantify the efficiency of carrier multiplication, the transfer of energy from a single optical photon to multiple hot charge carriers, in monolayer graphene.

We further investigate how the quantum confinement in graphene nanostructures (carbon nanotubes and graphene nanoribbons) affect the photoconductive properties. The presence of a bandgap in these nanostructures make them promising candidates for, e.g., photovoltaic devices, but the photoconductivity in these materials has been debated.

Nature Chemistry doi:10.1038/nchem.1819 (2013).
Nano Letters doi: 10.1021/nl402978s (2013).
Nature Physics 9, 248-252 (2013).

22.01.14 **Dr. Giuliano Franchetti**, GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt

Nonlinear dynamics in the realm of high intensity beams

The transport and acceleration of charged particles requires technical development and clear understanding of the particle dynamics. However, the production of high intensity beams (FAIR,JPARC, LHC Intensity Upgrade) or of high energy beam (LHC) makes the design less obvious. An accelerator becomes a world where complex mechanisms takes place (nonlinear resonances, dynamics aperture, collective effects, instabilities, electron cloud, etc.). Mechanisms with short time scale conflicts with mechanisms of long time scale and new effects become important for the beam control. This lecture will introduce the physics of high intensity beams and the nonlinear beam dynamics, and address the ongoing studies of resonance crossing.

29.01.14 **Prof. Dr. Martin Plenio**, Institut für Theoretische Physik, Universität Ulm

Quantum Effects in Biological Systems

The exploration of quantum effects in biology is an emerging field of research that concerns itself with the experimental and theoretical exploration of quantum phenomena in biological systems. In this lecture I aim to bring out design principles that nature may be exploiting to make use of quantum effects and I will develop in particular one underlying theme - the dynamics of quantum dynamical networks in the presence of an environment and the fruitful interplay that the two may enter. For three biological phenomena whose understanding is held to require quantum mechanical processes, excitation and charge transport in photosynthetic complexes, magneto-reception in birds and the olfactory sense, I demonstrate that this underlying theme encompasses them all, thus suggesting its wider relevance for quantum biology.

5.02.14 **Dr. Paul Neumayer**, ExtreMe Matter Institute EMMI and GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt and FIAS, Frankfurt

Studying matter at astrophysical conditions in the laboratory

Matter at extreme pressures and densities is prevalent in the interior of compact astrophysical objects, such as giant planets. The theoretical description of matter at these high energy density (HED) conditions poses a great challenge and highly computing intensive calculations are employed to predict material properties crucial to modelling planetary structure and evolution. With the availability of powerful drivers, such as large laser facilities or intense heavy ion beams, matter at HED conditions can be produced and studied in the laboratory, allowing experimental tests of dense matter modelling.

This talk will give an introduction into the field of HED science and show selected recent as well as planned experiments. A particular focus is given to advanced x-ray diagnostic techniques which are being developed at GSI for future experiments at the FAIR facility.

12.02.14 **Prof. Dr. Markus H. Thoma**, Physikalisches Institut, Justus-Liebig-Universität Gießen

Cold Plasmas - From Space to Medicine

Cold or low temperature discharge plasmas have numerous applications in fundamental research as well as technological applications. Here I want to focus on three aspects of these plasmas:

1. Complex or dusty plasmas are low temperature plasmas produced in RF or DC discharges which contain microparticles, e.g. dust grains. Due to the high charges (103 – 105 e) the microparticles are strongly coupled and can arrange in regular structures called plasma crystal. Complex plasmas can therefore be used as model systems for strongly interacting many-body systems but also play a role in astrophysics (e.g. comets, planet formation) as well as technology (e.g. microchip production by plasma etching). Complex plasma experiments

onboard the ISS and in parabolic flights, in which the disturbing effects of gravity are absent, will be discussed.

2. Radiofrequency Ion Thrusters (RITs) as electric propulsion for spacecrafts have been developed at the University Giessen since 1962. Within the LOEWE program RITSAT these thruster are currently improved, constructed and tested for space applications.

3. Cold Atmospheric Plasmas (CAPs) have been prosed as an agent for medical treatments. Recent progress in the fields of sterilization and wound healing will be presented.