Fachbereich Physik

GOETHE UNIVERSITÄT FRANKFURT AM MAIN

Vorträge im Physikalischen Kolloquium

Sommersemester 2018

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

11.04.2018 **Dr. Stefan Gillessen,** Max-Planck-Institut für extraterrestrische Physik, Garching

The Galactic Center: A unique astrophysical laboratory

Located at a distance of 8kpc only, the Galactic Center allows studying a galactic nucleus in unparalleled detail. With the advent of high-resolution, near-infrared instrumentation in the last decade it became possible to follow individual stellar orbits around the radio source Sgr A* with orbital periods as short as 12 years. The orbits provide compelling evidence for the massive black hole paradigm. The next generation near-infrared instrument GRAVITY aims at interferometrically combining the light of the four telescopes of ESO's VLT. The higher resolution will allow monitoring stellar orbits with orbital periods of 1 year only, and the relativistic prograde periastron precession gets accessible. The astrometric accuracy of GRAVITY is of order of the event horizon size of Sgr A*. This means that we might have access to measuring the spin of Sgr A*. In the past few years the small gas cloud G2 has been approaching Sgr A*. We were able to follow the tidal evolution of G2 for a decade, beautifully showing how the object got stretched ever more and how it passed the point of closest approach in 2014. The cloud is a unique probe of Sgr A*'s atmosphere.

25.04.2018 **Prof. Werner Maurer,** Zürcher Hochschule Winterthur, Schweiz

Physik der dynamischen Systeme (Systemphysik)

Die Systemphysik basiert auf dem Karlsruher Physikkurs und der von Jay Forrester begründeten Systemdynamik (System Dynamics). Impuls, Drehimpuls, Entropie und Stoffmenge werden analog zur Masse oder zur elektrischen Ladung als bilanzierfähige Mengen behandelt, die gespeichert und transportiert werden können. Die zugehörigen Potentialgrössen heissen Geschwindigkeit, Winkelgeschwindigkeit, Temperatur und chemisches Potential. Konstitutive Gesetze verbinden die Mengen und ihre Ströme mit den Potentialgrössen, wobei der Energie die Rolle einer alles umfassenden Buchhaltungsgrösse zukommt.
Unter dem Titel „Physik und Systemwissenschaft für Aviatik“ ist in den letzten zwölf Jahren an der Zürcher Hochschule für Angewandte Wissenschaften (ZHAW) ein neuartiger Lehrgang entstanden, der die Gebiete Hydrodynamik, Elektrodynamik, Translationsmechanik, offene Systeme, Rotationsmechanik und Thermodynamik umfasst. Bilanzgleichung der Basismenge, konstitutive Gesetze und die spezielle Rolle der Energie bilden in all diesen Gebieten das Grundgerüst. Ein nachhaltiges Verständnis für Strukturen und Prozesse wird mittels systemdynamischer Modellbildung gezielt gefördert.
In diesem Vortrag wird anhand je eines Beispiels aus der Hydrodynamik, der Translationsmechanik, der Kalorimetrie und der Thermodynamik aufgezeigt, wie mit dieser Strukturierungsmethode komplexe

Probleme modelliert, validiert und erweitert werden können. Die vier Beispiele, kommunizierende Gefässe, stossende Körper, Temperaturausgleich sowie Gasdruckfeder mit Wärmeaustausch, zeigen eine erkennbaren Analogie, unterscheiden sich aber sowohl in den konstitutiven Gesetzen als auch in ihrer Komplexität.

30.05.2018 **Dr. Hendrik van Hees**, Institut für Theoretische Physik, Goethe-Universität Frankfurt

A n t r i t t s v o r l e s u n g

Dileptons and photons Messengers from strongly interacting matter under extreme conditions from the hot and dense state

The understanding of the properties of matter from the fundamental laws describing its elementary building blocks and their interactions is among the most interesting goals of physics. In this talk I will first give an overview over the efforts to explore the phase diagram of strongly interacting matter under extreme conditions of high temperature and densities as present in Nature for the first few microseconds after the Big Bang and today in neutron stars and supernovae explosions.
In the laboratory such a medium can be created in the laboratory in ultra-relativistic heavy-ion collisions for a duration of about 10−23s (∼10fm/c). Among the many observables measured in heavy-ion collisions the socalled "electromagnetic probes", i.e., electron-positron and muon-anti-muon pairs (dileptons) as well as photons, are unique, because they do not participate in the strong interaction. They are created during the entire evolution of the fireball and are leaving the medium nearly unaffected by final-state interactions. In this way they are the only probes that can reveal the spectral properties of their strongly interacting sources deep inside the fireball. I will describe recent theoretical research that has lead to a good understanding of the underlying processes.
A careful experimental and theoretical investigation of electromagnetic probes in heavy-ion collisions at a broad range of heavy-ion-beam energies may lead to a more precise understanding of the phase structure of strongly matter like the observation of a first-order phase transition or even a critical point.

06.06.2018 **Prof. Dr. Andrea Markelz**, Department of Physics, University at Buffalo, Buffalo, New York, USA
Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Regensburg

Terahertz Light Fingerprints Biomolecular Dynamics

20 years ago Grischkowsky and coworkers began a revolution in the terahertz (THz) optical range. Zhang and others extended this new field so that measurements unimagined previously became accessible in table top systems. An immediate effort began to determine intramolecular dynamics of biomacromolecules such as RNA's and proteins. In this talk I will discuss how THz polarization and nonlinear techniques can be used to both fingerprint specific biomolecules and reveal their biologically important changes . I will also discuss ongoing challenges that need to address to fully realize THz light's impact on the biomedical community. This work was made possible by National Science Foundation MRI^2 grant DBI2959989, IDBR grant DBI1556359, and MCB grant MCB1616529, and the Department of Energy BES grant DE-SC0016317.

13.06.2018 **Prof. Dr. Vladimir Falko**,
National Graphene Institute, University of Manchester, Manchester, UK

Moiré superlattices and magnetic minibands in graphene heterostructures

When graphene lattice is aligned with the hBN lattice, a long-wavelength periodic moiré pattern forms due to a weak incommensurability of the two lattice structures, leading to a long-range superlattice affecting properties of electrons in graphene, including formation of miniband spectra for Dirac electrons and reappearance of magnetic minibands at the rational values of magnetic field flux through the supercell area (in units of $\varphi0=h/e$), also known as Hofstadter butterfly.
Here, we show that the quantum effect of the minibands formation in long-period moiré superlattices (mSL) in graphene/hBN heterostructures affect their transport measurements up to the room temperature. In relation to the low-field behavior, we find that the overall temperature dependence of resistivity displays the opening in a new scattering process: the umklapp electron-electron scattering in which two electrons coherently transfer the mSL Bragg momentum to the crystal. The formation magnetic minbands and their manifestation in magneto-oscillation of the diagonal conductivity tensor persist up to the room temperature, too, with full hierarchy of features that are attributed to the rational flux values $\varphi=(p/q)\varphi0$, with p=1, 2 and up to 3 (and $7<q<1$), now, observed at the intermediate range of $50K<T<200K$.

20.06.2018 **Prof. Dr. Klaus Blaum**, Max-Planck-Institut für Kernphysik, Heidelberg

Precision Experiments with Stored and Cooled Ions

An overview is given on recent measurements with extreme precision on single or few cooled ions stored in Penning traps. On the one hand, mass measurements provide crucial information for atomic, nuclear and neutrino physics as well as for testing fundamental symmetries. On the other hand, g-factor measurements of the bound electron in highly-charged hydrogen-like ions allow for the determination of fundamental constants and for constraining Quantum Electrodynamics. For example, the most stringent test of CPT symmetry in the baryonic sector could be performed by mass comparison of the antiproton with H- and the knowledge of the electron atomic mass could be improved by a factor of 13.

27.06.2018 **Dr. Nadine Schwierz-Neumann**, Emmy Noether Nachwuchsgruppenleiterin,
Max-Planck-Institut für Biophysik, Goethe-Universität Frankfurt

Metal cations and RNA - a highly charged problem with a dynamic future

Ribonucleic acid (RNA) is one of the most diverse biomolecules on Earth. RNA molecules are much more than information carriers between the DNA and the proteins. They play key roles in every vital process including protein synthesis and transport or gene expression. However, RNA molecules are highly charged polymers. Therefore, they can only fold into a compact and functional structure in the presence of positively charged ions. Our research focuses on the role of metal cations in the folding and function of RNA. Resolving the role of metal cations is challenging experimentally since the resolution is typically insufficient to characterize the exact interactions. Here, computational methods such as molecular dynamics simulations can contribute significant insight. However, these simulations are challenged by the fact that they have to cover a broad spectrum of time scales ranging from femtoseconds to minutes and hours.
As a way to quantitatively describe cation-RNA interactions, I will discuss optimized atomistic models for the metal cations. These optimized models in combination with advanced sampling techniques allow us to resolve ion specific effects and to gain atomistic insight into the kinetics of cation binding. Subsequently, I will discuss the role of different metal cations in systems of increasing complexity starting from small structural RNA motifs and ranging to large and biologically relevant RNA macromolecules.

04.07.2018 **Prof. Dr. Hartmut Wittig**, Institut für Kernphysik, Johannes Gutenberg-Universität, Mainz

The limits of the Standard Model and the role of Lattice QCD

The particle content of the Standard Model has been completely established following the discovery of the Higgs boson. While the Standard Model describes all known phenomena in accelerator-based experiments, it leaves many important questions unanswered: what is the reason for the large asymmetry between the abundance of matter and anti-matter? What is the nature of dark matter? In this talk I describe several attempts to detect signals for physics beyond the Standard Model using precision experiments at low energies. Furthermore, I discuss the role of lattice Quantum Chromodynamics for these efforts.

11.07.2018 **Prof. Dr. Werner Mäntele**, Institut für Biophysik, Goethe-Universität Frankfurt

A b s c h i e d s v o r l e s u n g
Bioanalytical Infrared Spectroscopy: Quo vadis ?

Infrared (IR) spectroscopy has long been established as a routine analytical technique in chemistry, but applications for biological samples seemed impossible due to instrumental limitations such as low emissivity of thermal sources and long recording times. In addition, water as a strong absorber prevented "real" biological samples from being analysed. The introduction of Fourier transform IR (FT-IR) techniques in the 80's marks the first milestone for bioanalytical IR spectroscopy, and new techniques for the preparation of biological samples led to a rapidly growing field. FT-IR techniques are since used, as reaction-modulated difference techniques, for the analysis of biopolymers, complemented by ultrafast laser techniques. Our community has since then learnt to track and analyse individual bonds in macromolecules, their dynamics and their reactivity, from picoseconds to seconds or minutes. IR spectroscopy is now an established technique complementing structure analysis e.g. by X-ray crystallography or 2-D-NMR spectroscopy.
The advent of quantum cascade lasers (QCL) in the late nineties, powerful narrow-band single wavelength IR emitters, multi-wavelength sources, or, with an external cavity (EC), tunable EC-QCLs presents a further milestone in bioanalytical IR spectroscopy. Their power reaches to hundreds of mW and their tunability can extend over several 100 cm-1, sufficiently broad to scan the entire IR fingerprint region within some msec. This opened IR spectroscopy for biomedical applications ex vivo and in vivo, for sensors and mobile devices.
The lecture presents bioanalytical and biomedical applications of IR technology at some typical examples. We will start from earlier work on the structure, function and dynamics of proteins an move to most recent developments for the analysis of body fluids in vitro and skin parameters in vivo.

18.07.2018 **Prof. Dr. Joachim Frank,** Frank Lab, Columbia University, New York, USA
N o b e l p r e i s t r ä g e r

The future of cryo-EM

Now that close-to-atomic resolution can be reached almost routinely in many cases, single-particle cryo-EM is about to fill a large gap in the structural database, and this will have a significant impact on the war chest of Molecular Medicine. In terms of future developments I'd like to single out two promising directions: time-resolved cryo-EM (the ability to image short-lived states), and mapping of a continuum of states of a molecule (especially molecular machines) in a system in equilibrium.