Fachbereich Physik

GOETHE UNIVERSITÄT FRANKFURT AM MAIN

Vorträge im Physikalischen Kolloquium

Wintersemester 2015/16

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

21.10.2015 **Prof. Dr. Paul Canfield,** Ames Laboratory, Department of Physics and Astronomy, Iowa State University, Ames, Iowa, USA

Cooking, Fishing and Jogging through PhaseSpace:
A Practical Guide to Discovering and Understanding New Materials

The design, discovery, characterization and control of novel materials is perhaps the most important research area for humanity as it moves into the 21rst century. A myriad of societal problems concerning energy, clean water and air, and medicine all need to be solved by the discovery of new compounds with dramatically improved, or even new, properties. The search for such materials requires a blending of skills and mind sets that, traditionally, have been segregated into different academic disciplines: physics, chemistry, metallurgy, materials science. In this colloquium I will outline the basic philosophy and techniques that we use to search for novel materials. These include a combination of intuition, experience, compulsive optimism and a desire to share discovery.

In the second half of the lecture, the specific case of superconductivity will be used as an example of one such search. Over the past couple of decades a growing sense of where and even how to search for new superconductors has been developing, with the recent discovery of the FeAs based materials providing, at least for me, clear guidance.

28.10.2015 **Dr. Alberica Toia**, Institut für Kernphysik, Goethe - Universität Frankfurt

- Antrittsvorlesung –

The primordial soup quark-gluon plasma: tastes and flavours of the early universe

The properties of strongly interacting matter at extreme conditions of temperature and energy densities are studied with heavy ion collisions at LHC and provide experimental evidence of the formation of a hot and dense medium, the Quark Gluon Plasma (QGP). Proton-nucleus collisions provide a reference to study the signatures already present in cold nuclear matter, due to the complex structure of the colliding nuclei which confirm that the suppression of high pT hadron production observed in heavy ion collisions is a genuine effect of the hot deconfined QGP. However, several measurements of particle production in the low and intermediate momentum region in small systems, as those produced in p-Pb collisions, indicate the presence of coherent and collective effects, questioning the validity of the perfect liquid paradigm.

04.11.2015 **Reinhard Dörner,** Institut für Kernphysik, Universität Frankfurt

Imaging wave function of few body systems: He dimers, trimers and the Efimov state of He_3

Two and three Helium atoms form very unusual and extreme quantum systems. Their typical extend is ten to hundred times bigger than radius of the atoms, the wavefunction lives almost completely in the classically forbidden tunneling region and the binding energy of these systems is about 8 orders of magnitude smaller than that of a normal molecule.

We will show how coincidence detection of charged fragments and super strong laser fields can be used to image the wave functions of these Helium quantum giants and will show the first experimental images of an Efimov state.

11.11.2015 **Prof. Dr. Theo Geisel,** Georg-August-Universität Göttingen, Max Planck Institute for Dynamics and Self-Organization,
Bernstein Center for Computational Neuroscience Göttingen

A Golden Era of Neurophysics

Scientific progress can develop particularly well when theoretical approaches happen to be synchronized with experimental developments. When I was hired as professor of theoretical physics at JWGU in 1989, a new experimental technique was implemented in a neighboring institute that made it possible to optically image pattern forming processes involving millions of nerve cells in the brain - a prerequisite for testing theories of neuronal circuit formation, neuronal plasticity, and learning. Meanwhile new experimental techniques are giving access to neuronal firing activity at high (single neuron) spatiotemporal resolution and are promising to unravel the many body dynamics of neuronal circuits underlying perception and cognition. In this colloquium I will discuss the past, present, and future of theoretical and experimental neurophysics.

18.11.2015 **Dr. Arthur Hebecker,** Universität Heidelberg, Institut für Theoretische Physik

The String Theory Landscape and Cosmological Inflation

The talk will start by motivating string theory as a theory of quantum gravity. Then the resulting 10-dimensional effective field theory and its compactification to 4 space-time dimensions will be discussed. It turns out that this leads to a very large number of possibilities - the "string theory landscape". This landscape is populated through eternal inflation, creating the so-called multiverse. To describe our observed cosmology, eternal inflation has to be supplemented by slow-roll inflation which leaves its imprint on the cosmological microwave background, measured e.g. by the Planck satellite. Recent progress in the string-theoretical understanding of this inflationary period of our universe will be briefly discussed at the end.

25.11.2015 **Prof. Dr. Heino Falcke,** Dept. of Astrophysics, Research Institute for Mathematics, Astrophysics and Particle Physics (IMAPP),
Radboud University Nijmegen

Black Holes, Event Horizons, and Relativistic Plasma Jets

Modern radio astronomy is now at the verge of imaging the event horizon of black holes for the very first time, using a technique called very long baseline interferometry (VLBI). What makes these black holes shine in the radio are powerful relativistic plasma jets, which are generated by strong magnetic fields near the black hole. Hence, if one wants to study the appearance of the event horizon in upcoming astronomical images, it is also important to understand the physics of these plasma jets in greater detail. The talk will give an overview of the properties of black hole jets in general, their formation mechanism, and their relevance for black hole imaging. It will also briefly summarize some of the experimental challenges associated with imaging jets and event horizons at the highest resolution possible.

02.12.2015 **Elke-Caroline Aschenauer,** Brookhaven National Laboratory, Upton, NY, USA

The Spin of the Proton - Why we should care

The question after the individual parton (quarks and gluons) contributions to the spin of the nucleon is even after 20 years of experimental efforts not yet solved. After several precise measurements in polarized deep inelastic scattering it is clear, that the spin of the nucleon cannot be explained by the contribution of the quarks alone. The talk will review the status of the field and how new results from polarized proton-proton collisions at RHIC help to get closer to unravel the puzzle, where the spin of the proton is hidden. It will further be demonstrated that studying the spin of the proton is an excellent tool to study the dynamic structure of the proton and to get tomographic pictures in momentum and coordinate space of the proton. The talk will be summarized by outlining the unique opportunities building a polarized electron-ion collider will present to the field.

09.12.2015 **Prof. Dr. Achim Rosch**, Universität Köln, Institut für Theoretische Physik

Whirls in magnets:from skyrmions to magnetic monopoles

In magnets lacking inversion symmetry, topologically quantized magnetic whirls, so-called skyrmions, form due to spin-orbit interactions. Skyrmions are tiny, stable, couple extremely efficiently to electric currents and can be manipulated by small forces. They are therefore promising candidates for, e.g., future magnetic memories.

The coupling of skyrmions to electrons arises from Berry phases, which can efficiently be described by an artifical electromagnetic field.
We investigate how the topology of skyrmion phase can be changed by singular magnetic defects which can be identified as emergent magnetic monopoles.

16.12.2015 **Prof. Dr. Reinhard Genzel,** Max-Planck-Institut für extraterrestrische Physik, Garching
University of California, Berkeley, USA

Massive Black holes and the Evolution of Galaxies

Evidence has been accumulating for several decades that many galaxies harbor central mass concentrations that may be in the form of black holes with masses between a few million to a few billion time the mass of the Sun. I will discuss measurements over the last two decades, employing adaptive optics imaging and spectroscopy on large ground-based telescopes that prove the existence of such a massive black hole in the Center of our Milky Way, beyond any reasonable doubt. These data also provide key insights into its properties and environment. Most recently, a tidally disrupting cloud of gas has been discovered on an almost radial orbit that reached its peri-distance of ~2000 Schwarzschild radii in 2014, promising to be a valuable tool for exploring the innermost accretion zone. Future interferometric studies of the Galactic Center Black hole promise to be able to test gravity in its strong field limit.

13.01.2016 **Prof. Dr. Stephen Blundell,** The University of Oxford, Department of Physics

Can you build superconductors with molecular bricks ?

Though biology is built using molecules, most materials studied in condensed matter physics are crystals made up of atomic building blocks. When even elemental silicon has numerous complications, physicists prefer to avoid chemical complexity. In this talk, I will explain that many interesting magnetic and superconducting materials can be constructed using molecular components to build up novel and unusual architectures. This approach provides an exciting opportunity for exploring the physics of magnetism and superconductivity. The dream is that gaining control of the building blocks of magnetic materials and thereby achieving particular characteristics will make possible the design and growth of bespoke magnetic and superconducting materials.

20.01.2016 **Prof. Dr. Kostas Kokkotas,** Theoretische Astrophysik,
Eberhard Karls Universität Tübingen

Neutron Stars: the dynamics of the densest objects in the universe

Neutron stars are the densest objects in the present Universe, attaining physical conditions of matter that cannot be replicated on Earth. These unique and irreproducible laboratories allow us to study physics in some of its most extreme regimes. More importantly, however, neutron stars allow us to formulate a number of fundamental questions that explore, in an intricate manner, the boundaries of our understanding of physics and of the Universe. The multifaceted nature of neutron stars involves a delicate interplay among astrophysics, gravitational physics, and nuclear physics. The focus of the talk will be on the gravitational physics of neutron stars, especially on the instabilities induced by rotation and the magnetic field. The conditions for the onset of these instabilities and their efficiency in gravitational waves will be presented. Finally, the dependence of the results and their impact on astrophysics and especially nuclear physics will be discussed.

27.01.2016 **Prof. Dr. Gisela Anton,** Erlangen Centre for Astroparticle Physics (ECAP),
Friedrich-Alexander-Universität Erlangen-Nürnberg

Astroparticle Physics with Neutrinos

Various messengers from astrophysical objects arrive at Earth. Among these photons have been used for astronomical observations over many centuries. But also other particles can be employed. One of the most exciting messengers are neutrinos. They can escape very dense sources and can travel huge distances. Directly related to these advantages is the weak interaction probabality of neutrinos which - as a draw back - makes it hard and challenging to detect them. The colloquium talk will cover possible sources and production mechanisms of neutrinos, will present recent results from running experiments and will give an outlook into the future of the field.

03.02.2016 **Prof. Dr. Dr. h. c. mult. Anton Zeilinger,** Institute for Quantum Optics and Quantum
Information Vienna, Austria

Quantum Teleportation, Entanglement, and Einstein’s Question “What is Light?”

It is well known that Einstein received the Nobel Prize for the groundbreaking idea of 1905, his annus mirabilis, that light consists of particles, today called photons. In 1935, he discovered together with Podolsky and Rosen that two quantum systems can be connected stronger than in classical physics. For that situation the Austrian Nobel Prize winner Erwin Schrödinger coined the name “entanglement” and called it “the essential feature of quantum mechanics” while Einstein, dismissed it as “spooky action at a distance”.
Technical progress in creating and handling entangled photon states not only led to experimental realization of such entangled states but also the discovery of novel phenomena, including, for example, multi-particle entanglement and quantum teleportation. These are not just intellectual curiosities, but they lay the foundations for a new information technology, with concepts such as quantum communication, quantum cryptography and quantum computation.
In the talk, I will present some of the most recent experimental results, particularly on long-distance quantum communication and on the implementation of quantum states in higher-dimensional Hilbert spaces. I will also discuss future possible applications in quantum information systems. These will, for example, include experiments using satellite-based quantum communication on a worldwide scale.
Towards the end of his life Einstein commented that despite years of conscious brooding, he did not come closer to answering the question “What is light?” It would be fascinating to know his position about these recent developments.

10.02.2016 **Prof. Dr. Manuel Calderon de la Barca,** Department of Physics University of California, Davis CA, USA

The quest for beauty in Heavy Ion collisions

We can study strongly interacting matter by colliding heavy ions, and the quarks and gluons they carry, at the highest possible energies. Simulations of Quantum Chromodynamics predict that a new state of nuclear matter exists at high temperature, known as the Quark-Gluon Plasma, where the color fields are not confined inside nucleons. One way to probe the high-temperature deconfinement effects is via the measurements of heavy quark bound states. These have a long history in the case of charm quark states, but only in the last few years have we reached energies allowing us to study beauty. The b-quark bound states, commonly called bottomonia, are expected to be modified in a hot Quark-Gluon Plasma. Experimentally, the Upsilon mesons are the members of the bottomonium family that are most readily accessible.
I will review the key ideas driving us to measure Upsilons in heavy ion collisions, and discuss the recent experimental results of this research.