Fachbereich Physik

Vorträge im Physikalischen Kolloquium

Wintersemester 2018/19

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

17.10.2018 Prof. Dr. Anna Watts
University of Amsterdam

Neutron stars in the spotlight

Densities in neutron star cores can reach up to ten times the density of a normal atomic nucleus, and the stabilising effect of gravitational confinement permits long-timescale weak interactions. This generates matter that is neutron-rich, and opens up the possibility of stable states of strange matter. Our uncertainty about the nature of matter under these conditions is encoded in the Equation of State, which can be linked to macroscopic observables like mass, radius, tidal deformation or moment of inertia. One very promising technique for measuring the EOS exploits hotspots that form on the neutron star surface due to the pulsar mechanism, accretion streams, or during thermonuclear explosions in the neutron star ocean. How the spots form is not always clear, and I will discuss some of the unsolved puzzles related to spot generation. I will then explain how the hotspot technique is being used by NICER, an X-ray telescope installed last year on the International Space Station - and why the technique is a mission driver for the next, larger-area generation of telescopes.

24.10.2018 Dr. Oleksandr Tsyplyatyev
Institüt fur Theoretische Physik, Goethe-Universität Frankfurt am Main

Interacting electrons in one dimension beyond the low energy limit

Quantum many-body phenomena fascinate physicists since the very development of the quantum mechanics due to their richness in various branches of physics ranging from atomic to solid-state and low temperatures. Interactions produce strong correlations (entanglement) between quantum particles resulting in an exponentially large Fock space and provide a huge room for a counterintuitive, from the naïve microscopic point of view, states of matter that can emerge. Contemporary examples that intrigue researchers nowadays include the quantum magnets that host the unconventional spin-liquid states and the strongly-correlated materials that undergo the phase transition to the superconducting state already at a high temperature. While the theoretical understanding of the quantum man-body systems is not complete at the moment, a number of the exact solutions to specific models such as the Bethe ansatz approach to the quantum spin chains in one dimension or the Richardson solution to the BCS model of the conventional superconductors in a grain and some systematic approaches in particular regimes such as the diagrammatic perturbation technique for Green functions are already available.
In this talk, I will give an overview of the effect of interactions on the low-lying electronic excitations in a solid body in the linear regime. Furthermore, I will briefly present the recent progress in the nonlinear regime beyond low energy in one dimension.

31.10.2018 **Prof. Dr. John W. Harris**
Yale University

Kolloquium zum 80ten Geburtstag von Prof. Reinhard Stock

A Confluence of Ideas and Experiments and the Pioneering Role of Professor Reinhard Stock

The field of Relativistic Heavy Ion Physics has blossomed from avant-garde notions of the creation of exotic states of compressed nuclear matter to today's billion-euro(dollar) enterprises that study the behavior of QCD matter at extreme energy densities, initially expected only within the first microseconds of the Big Bang,
Today, collisions of ultra-relativistic heavy ions at the Large Hadron Collider (LHC) at CERN and the Relativistic Heavy Ion Collider (RHIC) in the U.S. are able to create these large energy densities, with temperatures greater than $T \sim 2 \times 10^{12}$ K, where nuclear matter melts into a plasma of quarks and gluons and subsequently produces thousands of particles and anti-particles in a single event.
Progress in this field has necessitated a confluence of innovations in theory and experiment. The "Frankfurt theory school" has led conceptual and theoretical developments in the field. Professor Reinhard Stock has been the originator of ground-breaking ideas and pioneering experiments. I will give a brief motivation for this field of physics (for the uninitiated). I will then present an overview of its history and scientific accomplishments, while highlighting Reinhard Stock's pioneering role in its evolution. I will close by elucidating the remaining "big questions" of the field and how we seek to answer them.

21.11.2018 **Prof. Dr. Almudena Arcones,** TU Darmstadt, Institut für Kernphysik (Theory Center)

Are heavy r-process elements produced only in neutron star mergers?

The r-process occurs in neutron star mergers. This has been confirmed by the observation of the decay of neutron rich radioactive nuclei as a kilonova light curve after the neutron star merger detected with gravitational waves GW170817.

We will discuss the nucleosynthesis and kilonova light curves from different ejecta of neutron star mergers. We will address also the contribution of supernova to the chemical history of our universe.

05.12.2018 **Prof. Dr. Harald Pfeiffer**
MPI für Gravitationsphysik (Albert-Einstein-Institut), Potsdam

Black holes, gravitational waves and supercomputers

Black holes are among the most bizarre objects in nature - consisting solely of vacuum, they change causality by warping space and time. The gravitational wave observations by LIGO, Virgo and GEO have opened a new means to observe pairs of two black holes that orbit about each other and ultimately merge into a larger black hole. This talk describes the intricate behaviour of binary black holes, and what we have already learned about them, the universe and fundamental physics through observations of their gravitational waves. We will in particular highlight the central role of supercomputer calculations for realizing past and future gravitational wave observations. Despite the seeming simplicity of black holes and the impressive advances of computer calculations during the last years, tremendous further breakthroughs are required for the next generation of ground- and space-based gravitational wave observatories.

19.12.2018 **Dr. Anna Tauschwitz**
Fachbereich Physik, Goethe-Universität Frankfurt am Main

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

Hydrodynamik der Materie bei hoher Energiedichte

Die Physik der Materie bei hoher Energiedichte (HED) beschreibt Plasmen bei extrem hohen Dichten oder Temperaturen. Im allgemeinen spricht man von hoher Energiedichte, wenn die spezifische Energie der Materie über 1010 J/m3 liegt. Eine wichtige Aufgabe bei der Untersuchung der Plasmen bei HED ist die Beschreibung der Materie selbst und die Physik der Wechselwirkung zwischen Materie und Strahlung.

Im Labor untersuchte HED-Plasmen sind kurzlebig und können nur in dynamischen Experimenten erzeugt werden. Bei ausreichend hohen Dichten kann das mikroskopische Verhalten einzelner Teilchen vernachlässigt und das Plasma in der hydrodynamischen Näherung beschrieben werden.

In einer Zusammenarbeit des Keldysch Instituts (Moskau), dem EMMI Institut und der GU Frankfurt wird seit mehr als 10 Jahren an der Entwicklung des RALEF Codes gearbeitet, der verwendet wird, um ein großes Spektrum an unterschiedlichsten HED-Experimenten zu simulieren. RALEF gehört aufgrund seiner Stabilität, Präzision und Vielseitigkeit zu den leistungsfähigsten Codes auf diesem Gebiet. Dies wird sowohl anhand von Beispielen für lasergetriebene Plasmen gezeigt, deren Dynamik wesentlich durch die Strahlung bestimmt wird, als auch an Rechnungen für Materie im Flüssig-Gas-Zweiphasengebiet, in dem die Zustandsgleichung der Materie nicht eindeutig bestimmt ist.

09.01.2019 **Prof. Dr. Michael Kramer**
Max-Planck-Institut für Radioastronomie, Bonn, Germany
University of Manchester, UK
University of Bonn, Germany

New Results in Tests of Gravity with Radio Pulsars

We are living in a golden era for testing gravitational physics with precision experiments. This talk will present new results using a variety of tests with radio pulsars. These results will be placed in context of other experiments (including LIGO, EHT etc), and I will demonstrate how pulsars continue to provide unique constraints on gravity and fundamental physics in general, and how they complement other methods.

16.01.2019 **Prof. Dr. Angel Rubio**
Max Planck Institute for the Structure and Dynamics of Matter, Hamburg, Germany

Center for Computational Quantum Physics (CCQ),
The Flatiron Institute, New York, USA

Photons and matter cooperate: new states of matter from QED-TDDFT

Computer simulations that predict the light-induced change in the physical and chemical properties of complex systems, molecules, nanostructures and solids usually ignore the quantum nature of light. Recent experiments at the interface between materials science and quantum optics have uncovered situations where both the molecular system and the photon field have to be treated in detail. In this talk, we will show how the effects of quantum-photons can be properly included in the newly developed quantum electrodynamics density-functional formalism (QED-TDDFT). We provide an overview of how well established concepts in the fields of quantum chemistry and material sciences have to be adapted when the quantum nature of light becomes important in correlated matter-photon problems. We identify fundamental changes in Born-Oppenheimer surfaces, conical intersections, spectroscopic quantities, and quantum control efficiency. We also show how periodic driving of many-body systems allow to design Floquet states of matter with tunable electronic properties on ultrafast time scales.

23.01.2019 **Prof. Dr. Luca Amendola**
Institut für Theoretische Physik, Heidelberg University

Testing gravity with gravitational waves and cosmology

The recent measurement of the GW speed has already severely constrained the theories of gravity. In this talk I review the status of modifications of gravity and how they can be further constrained by future observations, in particular using GWs and large-scale surveys.

30.01.2019 **Prof. Dr. Gianluca Imbriani**
Physics Department, University of Naples "Federico II" Napoli, Italy

Direct measurements of cross sections of Astrophysical interest

New direct experimental methods and techniques, combined with the development of new theoretical tools have opened new avenues to explore nuclear reactions of significance for nucleosynthesis at or near the actual temperatures of stellar burning.
The main problem of direct measurements is determined by the background signals, which, together with the low cross sections, set a limit to the energy range that can be investigated with a simple setup on the Earth surface.
Essentially there are three sources of background, i.e. cosmic rays, environmental radioactivity and beam-target induced nuclear reactions.
Each of these sources produces background of different nature and energy, so that each reaction to be studied deserves a special care in suppressing the relevant background component.
I will show different experimental approaches that have been used to study processes of astrophysical interest with particular emphasis on underground nuclear astrophysics.

06.02.2019 Prof. Dr. Wolfram Weise
TUM Emeritus of Excellence, Technische Universität München

Phases of Strongly Interacting Matter - from Quarks to Nuclei and Neutron Stars

The strong interaction of quarks and gluons is at the origin of almost all of the mass of the visible universe. The emergence of multifaceted phases and structures, from quarks to hadrons, atomic nuclei and neutron stars, is one of the persistently challenging issues of modern science.
This colloquium reviews our current understanding of the phases of Quantum Chromodynamics (QCD). Empirical information from nuclear collisions at the highest available energies will be briefly surveyed together with results from Lattice QCD thermodynamics. It is pointed out that important constraints on the phase diagram arise from nuclear physics and the treatment of the nuclear many-body problem using effective field theory approaches based on the symmetry breaking pattern of low-energy QCD. The presentation includes a discussion of stringent constraints on the equation-of-state of dense baryonic matter implied by the existence of massive (two-solar-mass) neutron stars. This topic is presently in a special focus through the recent observation of gravitational waves from merging neutron stars.

13.02.2019 Prof. Dr. Laura Fabbietti
Technische Universität München

A new generation of hyperon-nucleon and hyperon-hyperon scattering experiments with ALICE

The study of the effective strong interaction among hadron pairs was pursued in the past via scattering experiments. For hyperon-nucleon pairs such as Λ−p, Σ−p, Ξ−p the nature of the instable hyperon beams makes such measurements very difficult and consequently only scarce experimental data are available. Hyperon-hyperon interactions can not be accessed at all with this technique. This kind of interactions is particularly interesting because of its connection to the physics of neutron stars. Indeed, these strong interactions drive the equation of state (EoS) of dense neutron-rich matter with strange quark content and such EoS can be tested against the measurements of neutron star masses, radii and newly detected gravitational wave signals. Since one of the hypotheses about the unknown content of neutron stars is that neutrons and hyperons are contained in the core, a detailed knowledge of the interaction becomes mandatory to investigate this hypothesis in a quantitative way.
In this talk we show how p+p and p+Pb collisions measured by ALICE at the LHC can be exploited to study these hyperon-nucleon and hyperon-hyperon interactions with unprecedented precision. Among others, we have observed for the first time the attractive pΞ-- strong interactions. Implications for neutron stars will be discussed. Our correlation analysis opens a new era for hadron physics with strangeness substituting scattering experiments. This will provide us with precise constraints for the EoS of neutron-rich matter with hyperon content.