Fachbereich Physik

GOETHE UNIVERSITÄT FRANKFURT AM MAIN

Vorträge im Physikalischen Kolloquium

Wintersemester 2023/2024

Mittwochs 16 Uhr c.t., Hörsaal _0.111 (EG), Max-von-Laue-Str. 1

08.11.2023 Prof. Dr. Pascal Klein, Universität Göttingen

Das Nichtsichtbare sichtbar machen - Visuelle Aufmerksamkeit als Zugang zum Verständnis physikalischer Repräsentationen

Visuelle Repräsentationen wie Diagramme, Vektorfelder oder Gleichungen haben in der Physik eine zentrale Bedeutung als Kommunikationsmittel, spielen eine Rolle beim Wissenserwerb und werden für das Problemlösen genutzt. Der kompetente Umgang mit verschiedenen Darstellungsformen („Repräsentationskompetenz“) ist daher ein wichtiges Lernziel in eigenem Recht. Doch welche Schwierigkeiten treten beim Umgang mit verschiedenen Repräsentationen auf und wie gelingt eine gezielte Förderung von Repräsentationskompetenz insbesondere bei komplexen Themen?

Im Vortrag argumentiere ich, dass Eye-Tracking einen Zugang zu diesen physikdidaktischen Fragestellungen bietet. In kontrollierten Laborstudien rekonstruieren wir den Umgang von Lernenden mit verschiedenen Darstellungsformen auf einer Prozess-Ebene; ohne dabei störend Einfluss auf die Gedankenprozesse zu nehmen. Ich zeige anhand eigener Studien zum Verständnis von vektoriellen Differentialoperatoren, wie die gewonnenen Informationen über die visuelle Aufmerksamkeit genutzt werden, um Einblicke in Lösungsstrategien zu erhalten, Lernschwierigkeiten zu identifizieren, oder die Komplexität von Aufgaben aufzuklären. Eye-Tracking eignet sich darüber hinaus auch als Feedbackinstrument in der Ausbildung von Lehrkräften, wodurch ein enges Wechselspiel zwischen Forschung und Lehre zum Ausdruck kommt.

Im Vortrag möchte ich gezielt die empirisch-forschungsorientierte Seite der Physikdidaktik aufzeigen und Einblicke in die Forschungsfragen und -methoden dieses Fachgebiets geben, die an den Schnittstellen zwischen Fachdidaktik, Fachwissenschaft und den Kognitionswissenschaften angesiedelt sind.

local host: Prof. Dr. Thomas Wilhelm | wilhelm@physik.uni-frankfurt.de

22.11.2023 Prof. Hans-Thomas Janka, Max-Planck Institut for Astrophysics, Garching

Core-Collapse Supernovae in 3D: From the Explosion Mechanism to Observational Properties

Core-collapse supernova explosions terminate the lives of massive stars, produce and disseminate a major fraction of the heavy elements, play an important role as neutrino and particle laboratory, and give birth to neutron stars and stellar-mass black holes, which have recently become sources of measured gravitational waves. Self-consistent 3D simulations lend support to the neutrino-driven explosion mechanism for powering the far majority of the core-collapse supernovae. Building up on this paradigm it has been shown that 3D explosion models can explain a large variety of observed properties of these supernovae and their remnants. This fact also permits to deduce new constraints on particle possibilities beyond the standard model of particle physics. However, crucial physics ingredients in the supernova models are still uncertain, for example the nuclear equation of state and the question of neutrino flavor oscillations. Tension between the detected Supernova 1987A neutrino signal and predictions from state-of-the-art models might point to such gaps in our understanding. The talk will provide a survey of these recent developments in supernova theory.

local host: Sarah Pitz | pitz@itp.uni-frankfurt.de; Apl-Prof. Dr. Jürgen Schaffner-Bielich | schaffner@astro.uni-frankfurt.de

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13.12.2023 Prof. Korinna Zapp (Lund University, Sweden)

Probing the Quark-Gluon Plasma with jets

Collisions of heavy atomic nuclei at collider energies offer a unique opportunity to study strongly interacting matter in extremely dense and hot systems. Under these conditions quarks and gluons are no longer confined in bound states, but propagate as quasi-free particles in a state of matter known as the Quark-Gluon Plasma. In this talk I will discuss how highly energetic quarks and gluon traveling through this plasma can help to understand its properties and how the plasma forms. Energetic quarks and gluons fragment into collimated sprays of particles, so-called jets, that can be measured in experiments. The internal structure of jets reflects the radiation pattern of energetic quarks and gluons and is the subject of intense research. For instance, it is believed to be sensitive to coherence phenomena.

local host: Prof. Dr. Dirk Rischke | drischke@itp.uni-frankfurt.de

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20.12.2023 Prof. Dr. Irene Burghardt, Institut für Physikalische und Theoretische Chemie, Goethe-Universität Frankfurt

Excitons at work in organic photovoltaics: Quantum dynamical simulations and 2D electronic spectroscopy

The elementary steps of organic photovoltaics involve the conversion of excitons into free charge carriers, giving rise to a photocurrent. As highlighted by time-resolved spectroscopic observations, these elementary events often feature coherent transients, necessitating a description beyond conventional rate theories. In

order to understand how coherent effects influence the transfer dynamics, and to what extent they are robust against static and dynamic disorder, quantum dynamical approaches are the method of choice. In this talk, we present a protocol that combines first-principles parametrized lattice Hamiltonians with accurate quantum dynamics simulations using advanced multiconfigurational methods. We show that this approach permits to resolve the subtle interplay of site-to-site transport, exciton and charge delocalization, and vibronic effects. Applications will focus on the molecular-level mechanism of exciton migration, singlet exciton fission, and exciton dissociation in regioregular donor-acceptor materials. We further present simulations of 2D electronic spectroscopy (2DES) signals that reveal the ultrafast signatures of these processes.

local host: Prof. Dr. Jens Bredenbeck | bredenbeck@biophysik.uni-frankfurt.de

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10.01.2024 Prof. Angel Rubio (MPI für Struktur und Dynamik der Materie, Hamburg)

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.

local host: Prof. Dr. Thomas Wilhelm | wilhelm@physik.uni-frankfurt.de

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24.01.2024 Prof. Toni Font (University of Valencia, Spain)

Update on the LIGO-Virgo-KAGRA searches of gravitational waves

The observations of gravitational waves (GW) by the Advanced LIGO and Advanced Virgo detectors have opened an entirely new window to study the universe. The detection of the first signal in 2015, GW150914, associated with the merger of two black holes, confirmed a century-old prediction of General Relativity. Less than two years later, the first GW signal produced by a binary neutron-star merger, GW170817, was observed. Through the unprecedented coordinated action of LIGO, Virgo and dozens of astronomical facilities, this landmark detection provided key evidence to start addressing some long-standing open issues. At present, the LIGO-Virgo-KAGRA (LVK) Collaboration has published three GW Transient Catalogs corresponding to the first three observational campaigns (O1 to O3). Those catalogs comprise 90 events exceeding the threshold to be considered of astrophysical origin, all of them associated with coalescing compact binaries. This talk will

present an overview of the current state of the LVK detections, discussing the main findings from O3 and taking a brief look at the ongoing run O4.

local host: Prof. Dr. Luciano Rezzolla | rezzolla@itp.uni-frankfurt.de

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31.01.2024 PD Dr. Manuel Lorenz (Institut für Kernphysik, Goethe-Universität Frankfurt) – Antrittsvorlesung

Quarks, Hadrons and In-Betweens

Die Kollision von schweren Ionen bietet eine einzigartige Möglichkeit zur Erzeugung stark wechselwirkender Materie unter kontrollierten Laborbedingungen. Treffen die Ionen aufeinander, entsteht kurzzeitig ein dichtes und heißes Medium in der Kollisionszone. Dessen Temperatur und das Materie-Antimaterie-Verhältnis werden durch die kinetische Energie der Ionen bestimmt. Bei den am LHC im Cern verfügbaren Schwerpunktsenergien von einigen TeV stellt sich ein Gleichgewicht zwischen Materie und Antimaterie ein. Hingegen entsteht bei Energien von wenigen GeV, die am SIS18 in Darmstadt erzeugt werden, ein von Materie dominiertes Medium mit ähnlichen Temperaturen und Dichten, wie sie bei Kollisionen von Neutronensternen zu erwarten sind. Die Untersuchung dieses Mediums kann Einblicke in die mikroskopische Zusammensetzung und die Eigenschaften dieser Materie liefern. Insbesondere die Erzeugung der Quarkflavor Strangeness, der im Grundzustand der Kerne nicht vorkommt, lässt Rückschlüsse auf die Eigenschaften und Freiheitsgrade der neu geformten Materie zu.

local host: Prof. Dr. Roger Erb | roger.erb@physik.uni-frankfurt.de

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07.02.2024 Dr. Karim Zantout (Potsdam Institute for Climate Impact Research)

From correlated electrons to climate migration: A professional journey

Following my PhD studies at the Institute for Theoretical Physics, University of Frankfurt, I decided to work as a Data Scientist in the software development company emsys grid services GmbH. The software solutions are tailored to grid operators that generate electricity from renewable sources and ensure stability and security of the electrical grid.

In the second part of my presentation I outline my move from the energy sector to climate mobility research which I am conducting as a Post-Doc researcher at the Potsdam Institute for Climate Impact Research (PIK). Within the HABITABLE project we investigate mechanisms of climate-related migration and develop future scenarios.

By presenting both my personal considerations and a thematic overview of the work domain I aim to deliver a perspective for a professional career for physicists.

local host: Gleichstellungsrat Physik | GleichstellungsratPhysik@dlist.uni-frankfurt.de