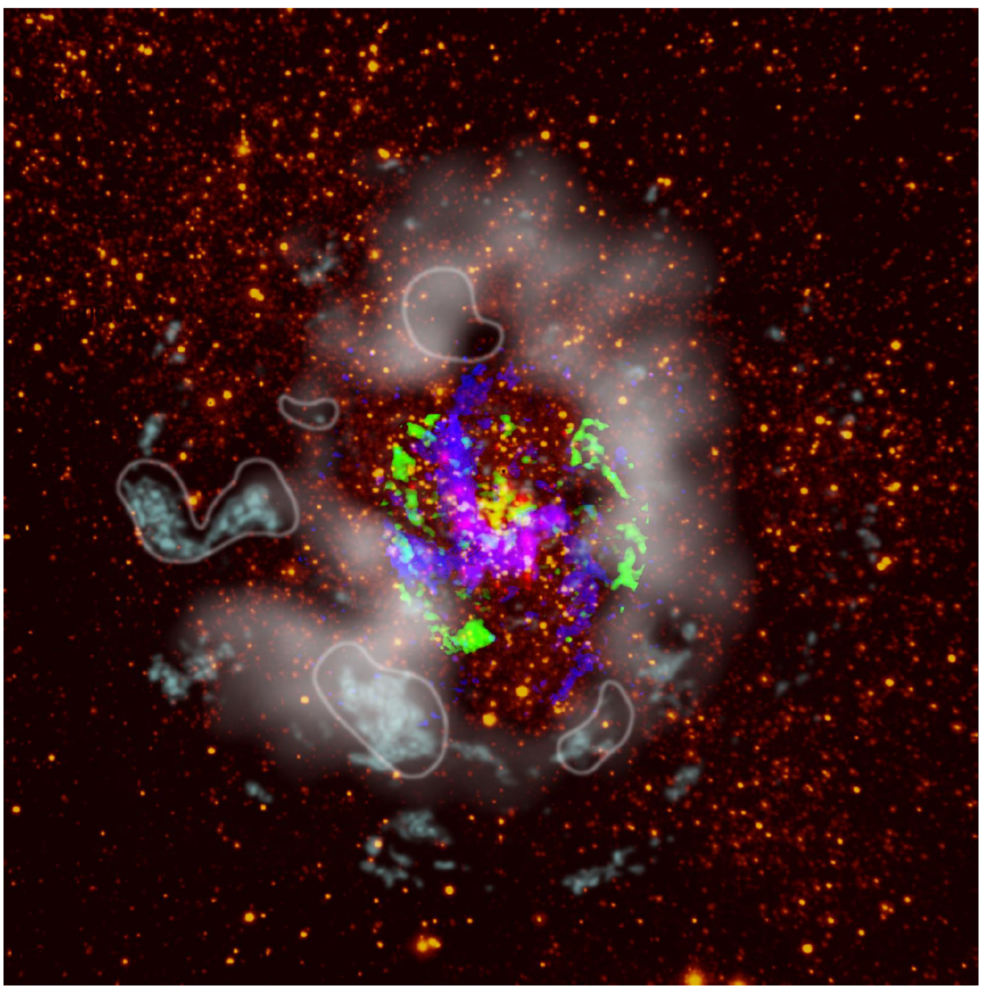
Deutsche Physikalische Gesellschaft DPG

Online Lectures
of the Matter and Cosmos Section

and the Divisions

Short Time-scale Physics and Applied Laser Physics, Plasma Physics

10 – 16 March 2021



VLT infrared

ALMA submillimeter

Chandra X-ray

view of the Galactic Center

~1.5 arcmin across (11 light years)

Eckart et al. 2019 (UAE Sharjah - FISICPAC Proceeedings)

„An image of the Galactic Center region combining results from the VLT (infrared), ALMA (submillimeter), and Chandra (X-ray)."

Programme

Wednesday, 10 March 2021, 08:55

Opening by the Speaker of the Matter and Cosmos Section

Karl-Henning Rehren, Universität Göttingen

Wednesday, 10 March 2021, 09:00

Heavy-ion physics, what have we learned with 10 years at the LHC

Anton Andronic, WWU Münster

I will explain how we study via collisions of nuclei at the Large Hadron Collider the deconfined quark-gluon matter, a state of matter which must have prevailed in our Universe in its first 10 microseconds of existence.
I will discuss how quark propagation through the hot and dense medium reveals its properties and what we learned about its still-mysterious transition to hadrons with confined quarks and gluons. An outlook to the plans and challenges for the coming years will be given.

Wednesday, 10 March 2021, 10:00

Origin of heavy elements: r-process in neutron star mergers and core-collapse supernovae

Almudena Arcones, TU Darmstadt

Our understanding of the origin of heavy elements by the r-process has made great progress in the last years. In addition to the gravitational wave and kilonova observations for GW170817, there have been major advances in the hydrodynamical simulations of neutron star mergers and core-collapse supernovae, in the microphysics included in those simulations (neutrinos and high density equation of state (EoS)), in galactic chemical evolution models, in observations of old stars in our galaxy and in dwarf galaxies. This talk will report on recent breakthroughs in understanding the extreme environment in which the formation of the heavy elements occurs, as well as open questions regarding the astrophysics and nuclear physics involved. Observations of old stars and meteorites can strongly constrain the astrophysical site of the r-process, once the nuclear physics uncertainties of extreme neutron-rich nuclei are reduced by experiments and by improved theoretical models.

Wednesday, 10 March 2021, 13:30

Physics of the sun with Solar Orbiter

Alexander Warmuth, Leibniz-Institut für Astrophysik Potsdam

Solar Orbiter is an ESA space mission that was successfully launched on February 10th, 2020, from Cape Canaveral. Its purpose is to improve our understanding of how the Sun creates and controls the heliosphere, which includes studying the nature of the solar dynamo, the origins of the solar wind and coronal magnetic fields, and the physics of solar eruptions and particle acceleration. To achieve this, the mission combines unique characteristics: going close to the Sun, going out of the ecliptic, and employing a comprehensive suit of 6 remote-sensing and 4 in-situ instruments. In the talk, I will introduce the mission, discuss the key science topics that it will address, and present some of the first-light observations. One particular focus will be on the X-ray instrument STIX, which provides imaging spectroscopy of both hot plasma and accelerated electrons in solar flares.

Wednesday, 10 March 2021, 14:30

Observing the birthplaces of planets

Cornelis Dullemond, Universität Heidelberg

It has been known for centuries that the planets in our Solar System formed from a disk of gas and dust orbiting the Sun right after it's formation. This process occurred 4.5 billion years ago, but the Solar System still contains clues about this planetary building phase. Until 1995, however, such "protoplanetary disks" had never been directly observed around young stars. During the last 25 years, however, the enormous advances in telescope and instrument technology, both ground-based and space-based, have allowed us to observe and study protoplanetary disks around hundreds of nearby young stars. Such observations are at the limit of what technology is able to do, because even a large protoplanetary disk (one that is ten times larger than the orbit of Neptune) is still tiny on the sky at the distance of the closest known young stars. During the last few years, however, we are finally obtaining spatially reasonably well resolved images of these disks, the birthplaces of planets. We can see structures in these disks that are both puzzling and exciting: rings, spirals, arcs, shadows and more. We also see evidence that some disks are warped. In this talk I give an overview of some of these observations and how theoretical astrophysicists are trying to explain them, and make the link to the formation of planetary systems.

Thursday, 11 March 2021, 09:00

Molecular structures in hadron and nuclear physics

Ulf-G. Meißner, Universität Bonn & Forschungszentrum Jülich

The Standard Model of the strong and electroweak interactions has successfully passed many tests. Arguably its last frontier is the formation of the bound states made of quark and gluons, the hadrons and nuclei. Traditionally, hadron and nuclear physics have been considered as two disjoint fields. Here, I am advocating a unified view and discuss the appearance of molecular structures in hadron and nuclear physics, triggered by the renewed interest in spectroscopy due to the findings of many so-called exotic states.

Thursday, 11 March 2021, 10:00

Combining Atomic and Nuclear Physics in Ion Storage Rings

Yuri A. Litvinov, GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt

Storage of freshly produced radioactive particles in a storage ring is a straightforward way to achieve the most efficient use of such rare species as it allows for using the same rare ion multiple times.

Employing storage rings for precision physics experiments with highly-charged ions (HCI) at the intersection of atomic, nuclear, plasma and astrophysics is a rapidly developing field of research. The central facilities for this research are the heavy-ion storage rings ESR and CRYRING at GSI. Beam manipulations like deceleration, bunching, accumulation, and especially the efficient beam cooling as well as the sophisticated experimental equipment make rings versatile instruments.
The number of physics cases is enormous. The focus here will be on the most recent highlight results achieved within FAIR-Phase 0 research program at the ESR. First, the measurement of the bound-state beta decay of fully-ionized ^205 Tl was proposed about 35 years ago and was finally accomplished in 2020. Here, the ESR is presently the only instrument enabling precision studies of decays of HCIs. Such decays reflect atom-nucleus interactions and are relevant for atomic physics and nuclear structure as well as for nucleosynthesis in stellar objects.
Second, the efficient deceleration of beams to low energies enabled studies of proton-induced reactions in the vicinity of the Gamow window of the p-process nucleosynthesis. Proton capture reaction on short-lived ^118 Te was attempted in 2020. Here, the well-known atomic charge exchange cross-sections are used to constrain poorly known nuclear reaction rates. With the dedicated low-energy CRYRING, this research will dramatically expand approaching even lower energies and addressing different kinds of reactions. The experiments and the preliminary results will be discussed.
The performed experiments will be put in the context of the present research programs at GSI/FAIR and in a broader, worldwide context, where, thanks to fascinating results obtained at the presently operating storage rings, a number of new exciting projects is planned.

Thursday, 11 March 2021, 12:30

Laser active fibres

Michael Steinke, Universität Hannover

Optical glass fibers are a key technology of our time and find widespread applications not only in nearly all industrial sectors from telecommunication to endoscopy but also in fundamental research. Today, finding novel fiber designs and material compositions is an active research field, constantly pushing the boundaries of application of glass fibers throughout the electromagnetic spectrum. Here, an overview about recent research activities regarding fibers doped with laser-active materials will be given. It will be discussed how such fibers are fabricated and which effects are relevant for their performance. This includes nanocrystal (e.g. quantum-dot) and nanoparticle doped fibers, fibers with semiconductor cores, and gas filled hollow core fibers. In addition, approaches and models to tailor the nonlinear response of novel glass compositions will be presented and discussed. Corresponding nonlinear fiber lasers are a promising concept to address spectral emission bands not covered by traditional doping concepts.

Thursday, 11 March 2021, 13:30

Entanglement entropy in quantum field theory

Ko Sanders, Dublin City University

Entanglement is a central concept in quantum physics and a key experimental resource, e.g. in quantum computing. The amount of entanglement that is present in a system can be quantified using an entanglement measure. In this talk, based on work with Stefan Hollands and Onirban Islam, I will present an overview of one such measure, the relative entanglement entropy, which originated in quantum information theory. This entanglement measure extends to quantum field theories, even in curved spacetimes, where it exhibits a surprisingly close relation to the spacetime geometry. Many details of this relation are still under active investigation.

Subsequently „Meet-the-speaker“, 16:00

- ***Ko Sanders***

Thursday, 11 March 2021, 14:30

The AdS/CFT Duality – from strongly coupled quantum field theories to holographic spacetimes and back

Martin Ammon, University of Jena

The AdS/CFT duality, arguably one of the most exciting conceptual developments in theoretical physics of recent years, gives rise to surprising relations between quantum field theories and gravitational theories. On the one hand, it provides tools for studying strongly coupled systems in a variety of areas in physics, including particle and condensed matter physics, while on the other hand it sheds new light on quantum gravity and puzzles of black hole physics.
In the first part of my talk I will motivate the AdS/CFT duality. The second part of the talk focuses on quantum gravity aspects of the AdS/CFT duality. In particular, I will sketch novel ideas how to resolve the famous information loss paradox of black hole physics with insights from non-equilibrium dynamics, and how to probe the structure of quantum spacetime by measures of quantum information theory.

Subsequently „Meet-the-speaker“, 15:30

- ***Martin Ammon***

Thursday, 11 March 2021, 17:00

Annual General Meeting of the Hadronic and Nuclear Physics Division

Thursday, 11 March 2021, 17:00

Annual General Meeting of the Plasma Physics Division

Friday, 12 March 2021, 09:00

The nature of the compact mass at the center of the Milky Way

Andreas Eckart, University of Cologne

The compact and very massive object located at the center of the Milky Way is currently the very best candidate for a super-massive black hole (SMBH) in our immediate

vicinity.
The outstanding importance of this phenomenon was underscored last year by the award of the Nobel Prize to three leading scientists in this field. I will summarize key results that led to this honor and highlight the Cologne contribution to it. The strongest evidence for the existence of a SMBH at the Galactic Center is provided by measurements of stellar orbits, variable X-ray emission, and strongly variable polarized near-infrared emission from the location of the radio source Sagittarius~A* (SgrA*) in the middle of the central stellar cluster. I will also explain the latest results obtained with the GRAVITY experiment on the Very Large Telescope Interferometer (VLTI).
In the light of the experimental results one can also speculate on the charge and the black hole itself or the charge of orbiting source components.

Friday, 12 March 2021, 10:00

The Binary Universe In Gravitational Waves

Frank Ohme, AEI Hannover

The data of two and a half observing runs of the gravitational-wave interferometers LIGO and Virgo have been fully analyzed to date.
The results have recently been published in the second transient catalogue, GWTC-2, which contains no fewer than 50 binary merger candidates, the majority of which are expected to be real astrophysical events. Apart from the sheer number of events, the most recent observations have added some exciting binaries that further push the boundaries of what we have observed. In this talk, I will summarize these most recent findings, highlighting binaries that are exceptional from an astrophysical or fundamental physics point of view.
In addition, statistical methods become more powerful in extracting properties of the binary population that becomes more and more visible in the gravitational-wave universe.

Friday, 12 March 2021, 13:30

Turbulent Transport at Wendelstein 7-X

Olaf Grulke, MPI für Plasmaphysik Garching

Understanding and control of the plasma energy and particle losses is one of the key challenges of magnetic fusion experiments to reach reactor-relevant operation regimes. Two main transport channels can be distinguished: On the one hand, the specific magnetic field geometry of the device induces a transport, the so-called neo-classical transport, which is much larger than the classical transport due to binary collisions of plasma particles. On the other hand, instabilities in the plasma develop vortex motions perpendicular to the confining magnetic field, which cause radial convection of particles and energy. Due to the complicated three-dimensional geometry of stellarators, they traditional suffer from strongly enhanced neo-classical transport.
It is, however, possible to optimize this unfavorable feature by carefully tailoring the magnetic field geometry. This was one of the main optimization criteria of Wendelstein 7-X and indeed the initial experimental campaigns clearly demonstrate that the neoclassical transport is strongly reduced and turbulent transport plays a much larger role in regulating the perpendicular losses. Also in this context, the optimized magnetic configuration has favorable effects on the evolution of the plasma instabilities. By control of the plasma profiles due to plasma heating and fueling, suppression of plasma instabilities are expected from numerical simulations and are observed experimentally. This led to record values of the triple product of stellarators and allowed high-performance operation. This presentation presents and discusses the achieved experimental results.

Friday, 12 March 2021, 14:30

Transient atmospheric plasmas – mastering the non-equilibrium

Achim von Keudell, Ruhr-Universität Bochum

Non equilibrium atmospheric plasmas form the unique basis for a multitude of applications ranging from thin films, surface modification, plasma chemistry to plasma medicine. In all these cases atmospheric pressure plasmas exhibit an intimate coupling to the bounding surfaces that trigger surface and conversion processes. The complexity of these processes makes a detailed understanding very challenging. Prominent examples are the combination of plasmas and catalysis and of plasmas and electrolysis. Plasmas provide either excited species to change the conversion reaction paths or they alter and may regenerate catalytic surfaces. The analysis requires detailed diagnostics of plasma excitation and surface processes at the plasma-solid or the plasma-liquid-solid interfaces. Two examples are being presented: (i) the conversion of CO2 and of volatile organic compounds is studied in atmospheric pressure plasmas revealing a strong non equilibrium with respect to excitation temperatures and plasma dynamics; (ii) the conversion of water by plasma excitation using nanosecond high voltage pulses that trigger extremely high density plasmas that are governed by field effects at the interfaces and by tunneling in between adjacent water molecules during plasma propagation.
The work is supported by the SFB 1316 “Transient atmospheric pressure plasmas – from plasmas to liquids to solids”.

Subsequently „Meet-the-speaker“ 15:30

- Achim v. Keudel (Thema Plasmaanwendungen)
- Olaf Grulke (Thema Fusionsforschung)
- Plasmaphysiker/innen in der Industrie
- Plasmaphysik in Studium und Promotion

Monday, 15 March 2021, 10:00

New Ideas on Dark Matter

Björn Malte Schäfer, University of Heidelberg

Dark matter is an essential concept in modern cosmology and is indispensable if Newtonian gravity is extrapolated to scales of galaxies and larger. In my talk I’ll review the necessity of dark matter and its role in cosmic structure formation and galaxy evolution, and discuss possible particle candidates, in particular axionic dark matter as a possible solution to outstanding dark matter problems in cosmology.

Subsequently „Meet-the-speaker", 12:30:

- Björn Malte Schäfer
- Alexander Grohsjean
- Federica Petricca

Monday, 15 March 2021, 10:50

Producing on Earth the missing matter of the Universe

Alexander Grohsjean, DESY

Understanding dark matter is one of the most tantalizing challenges in today's science. While its gravitational effect on large scale structures is well established, its nature remains obscure. An attractive solution to the dark matter problem is provided by new species of particles that are not contained in the Standard Model.
Producing and detecting these particles is one of the major quests of particle physics. The masses of these particles span a wide range from very light particles that could be produced through light in strong magnetic fields up to extremely heavy particles, which could be produced by high-energy accelerators such as the Large Hadron Collider at CERN.
I will discuss some of the most promising theory models to explain dark matter, give an overview of different experiments to search for dark matter particles, and will close with an outlook on the next major milestones.

Monday, 15 March 2021, 11:40

Detecting on Earth the missing matter of the Universe

Federica Petricca, LMU München

Nowadays, we have an extremely accurate model of our Universe, but still, most of its content eludes our observation. Detecting with Earth-bound experiments the missing matter is one of the most intriguing challenges in modern physics and is of compelling necessity for our understanding. The experimental efforts to decipher the nature of dark matter underwent amazing development in recent years, and a new generation of large exposure high sensitivity detectors is ready to accept the challenge.
In this contest, a multi-target multi-technology approach is needed to look into the different mass regions of possible dark matter candidates to maximise the detection probability. The most sensitive approaches that are opening new frontiers of this search will be reviewed together with a glance on future perspectives. Although not certain, a discovery might be at hand.

Tuesday, 16 March 2021, 09:00

Physics-Informed AI for Image Reconstruction in PET

Andrew Reader, King's College London, United Kingdom

The powerful capabilities of artificial intelligence (AI) have led to an exciting paradigm shift in methodology for many fields in medicine and physics, including inverse problems and image reconstruction. This presentation reviews the application and great promise of AI for image reconstruction in positron emission tomography (PET). Medical imaging with PET provides important information for disease diagnosis and research, but its full potential is constrained by noisy data, and limited spatial resolution.
Recently, AI has led to new methodologies for PET image reconstruction, which help tackle these limitations. Starting with direct AI methods, new hybrid reconstruction algorithms which combine the AI paradigm with imaging physics and statistical models for PET are then reviewed. These physics-informed AI methods unfold existing iterative reconstruction methods in order to include deep-learned neural networks within them. They use deep learning for the components which we do not confidently know (such as how exactly to remove noise and enhance spatial resolution), while preserving decades of research progress in image reconstruction for the components that we do know (the imaging physics and noise distribution). Physics-informed AI holds great promise not only for next-generation PET image reconstruction, but also for inverse problems in general throughout medicine and physics.

Please note:

The login access data for this programme will be sent to all registered participants in good time.
