Plenary Talk PV I Mon 9:00 HSZ/AUDI

Low Temperature Plasma – About a Hidden Champion or a Silent Revolution — •Klaus-Dieter Weltmann, Thomas von Woedtke, Jürgen F. Kolb, Torsten Gerling, and Angela Kruth — Leibniz Institute for Plasma Science and Technology, Greifswald, Germany

The plenary lecture presents an overview of the achievements and future potentials of low-temperature plasma physics and technology. Such plasmas are particular states of matter consisting of neutral, ionized and excited species, free electrons as well as radicals, photons and excited species. While the electrons have a mean energy of a few eV to 10 eV, the temperature of the heavy species is several orders of magnitude lower. These properties make them very attractive for applications. The fundamental knowledge gained so far supported the worldwide boom in the automotive industry, lighting, materials processing, optics, electronics, textile processing, and other fields. Basic research is the common prerequisite for the successful development of processes, technologies and products. Low-temperature plasma physics has steadily opened up new fields. It belongs to the cross-cutting technologies. In this contribution, the opening to new and interdisciplinary research topics is demonstrated by the example of plasma medicine. In particular, the research and development of plasma sources and their transfer into medical practice is reported. Low-temperature plasmas will play an important role to face "older" and new scientific challenges by interdisciplinary approaches, representing a renewed growth opportunity for the plasma community.

Plenary Talk PV II Mon 9:45 HSZ/AUDI

Thin film technology for fabrication of nonlinear active optical components and its future application in photonic circuits — •Marco Jupe — Laser Zentrum Hannover e.V., Hollerithallee 8, 30419 Hannover

The development of optical components is currently at a point where traditional concepts need to be extended. In particular, applications in the field of communications as well as highly innovative approaches for photonic quantum computing and quantum communications require not only high optical performance but also massive parallelization. Such concepts can only be sensibly implemented if the integration density of the optical circuits is massively increased. Concepts such as those used in telecommunications applications also appear to be target-oriented for applications in quantum technology. In addition to the "traditional" passive components, which are just as indispensable here as in classical signal processing, there is an increasing demand for ultra-fast active components. Such components must integrate seamlessly into the concepts. The mass market suitability of current solutions is a particular challenge that should not be underestimated. For this reason, various institutes are working on such components in particular. The presentation gives an overview of the components that are already established and new concepts especially in combination with interference films like FTMs for the frequency tripling, and Kerr band switches for fast optical switches, as well as for electro-optical components using Pockels effect.

Prize Talk PV III Mon 12:30 HSZ/AUDI

Two milestones in the life of the Universe: Last Scattering Surface and Black Body Photosphere — •Rashid Sunyaev — Max Planck Institute for Astrophysics — Institute for Advanced Study, Princeton — Laureate of the Max-Planck-Medal 2023

Our Universe is filled by cosmic microwave background (CMB) radiation which is extremely isotropic and has an excellent black body spectrum with a temperature of 2.7 Kelvin, and no spectral deviations from the blackbody have yet been detected in the CMB monopole.

However, the theory of Thomson scattering by hot Maxwellian electrons predicts the shadows of the CMB toward galaxy clusters filled with dark matter and hot gas. This prediction (thermal SZ effect) dates back to 1970, and only in 2011, the first three unknown galaxy clusters were discovered using this method. Now many thousands of galaxy clusters are being discovered using such shadows. Any energy release in the early Universe (due to the decay or annihilation of unknown particles, dissipation of the low-scale density perturbations due to radiative viscosity, etc, hydrogen recombination at redshift 1300) should lead to the CMB spectral distortions. Detecting such specific spectral deviations is one of the key goals of microwave radioastronomy.

There are other theoretical predictions that led to the experimental discovery of the "acoustic peaks" in the power spectrum of the CMB angular fluctuations and enabled the measurement of key parameters of our universe with unprecedented accuracy. The kinematic SZ effect enabled the measurement of galaxy cluster velocities relative to the local coordinate system in which the CMB is isotropic. The kSZ effect permitted the proof of Copernicus' principle up to redshift z∼2, where the most distant galaxy clusters and protoclusters are observed.

A decrease in the CMB temperature in the course of the Universe expansion leads to the recombination of hydrogen, transparency of the Universe for photons, and appearance of the "surface of the last scattering". The "acoustic peaks" are formed due to the presence of this surface. The recombination rate (and the effective thickness of this "surface") is determined by the two-photon decay of the 2s level of the hydrogen atom.

Emission of low-frequency photons due to the double Compton effect and their redistribution along the spectrum due to multiple Thomson scatterings on hot electrons manage to maintain the blackbody spectrum while the redshift exceeds z=2 million. This value determines the position of the "blackbody photosphere" of the Universe. Spectral distortions of the CMB can be observed only if the energy release occurred at redshifts of less than 2 million.

Plenary Talk PV IV Tue 9:00 HSZ/AUDI

Characterising exoplanet atmospheres with the Webb space telescope — •Pierre-Olivier Lagage — CEA Paris-Saclay, Gif-sur-Yvette, France

Thanks to its large collecting area (25 square meters) and its large wavelength coverage (0.6 * 28 microns), the Webb space telescope is a game changer. In the exoplanet domain, it takes us right into what can be called the second chapter of the study of exoplanets: the characterization of their atmosphere (atomic and molecular composition, presence of hazes and clouds, vertical temperature-pressure profile, presence of zonal circulation, just to name a few). Such information is needed to test and improve the chemistry and dynamics incorporated in the atmospheric models applied to alien worlds which have no equivalent in the Solar System. Two types of observations are in use: direct imaging thanks to coronagraphic observations and spectroscopic observations of transiting exoplanets. A large diversity of exoplanets, ranging from giant exoplanets with masses several times that of Jupiter to Earth-sized rocky exoplanets, has started to be characterized. In this talk, I will discuss the first results, which are remarkable, and show the great perspectives in front of us.

Plenary Talk PV V Tue 9:45 HSZ/AUDI

The European Destination Earth initiative – a paradigm change for weather and climate prediction — •Peter Bauer — ECMWF, Reading, UK

Destination Earth is a new European Commission funded activity to create a so-called digital twin of the Earth. Digital twins create unprecedented opportunities to generate and interact with highly realistic digital replica created from the combination of computer simulations and observations. Destination Earth's primary focus is on the use of twinning for dealing responsibly with extreme weather and climate change.

Weather and climate prediction are high-performance computing and big data applications with outstanding societal and economic impact ranging from the daily decision-making of citizens to that of civil services for emergency response, and from predicting environmental impacts on food, agriculture and energy markets as well as for risk and loss management by insurances. The uncertain evolution of weather extremes with climate change adds significant political pressure to accelerate scientific development and turn science into societal benefit.

Destination Earth is the result of a decade worth of planning by leading European climate, geoscience and computing scientists. The activity will create a new information system in support of the European Green Deal and Digital Strategy.

Prize Talk PV VI Tue 12:30 HSZ/AUDI

The Higgs boson at the (HL)LHC – precisely! — •Adinda de Wit — Universität Zürich, Switzerland — Laureate of the Hertha-Sponer-Prize 2023

In the ten years since the discovery of the Higgs boson, the precision on its cross section and property measurements has continued to increase. In this talk, the latest measurements, their prospects, and how they could help us find new physics, will be discussed.

As the CMS and ATLAS experiments prepare to upgrade their detectors, we will also look towards the future of Higgs physics at the HL-LHC.

Ceremonial Talk PV VII Tue 15:45 HSZ/AUDI
The once unattainable – new breakthroughs in particle physics — •Monica Dunford — Kirchhoff-Institut für Physik (KIP), Ruprecht-Karls-Universität Heidelberg

The dynamics of the Standard Model of particle physics play a central role in the properties of not only the microscopic world but also the biggest structures of our universe. The Higgs boson, for example, plays a critical part in how particles obtain their masses but also perhaps to dark matter and how our universe evolved. In this talk, I will focus on a handful of recent developments in particle physics that were considered out of reach, but through innovative ideas and powerful data science are now attainable. I will highlight how these results have connections beyond the microscopic world to dark matter, matter and anti-matter differences and beyond.

Plenary Talk PV VIII Wed 9:00 HSZ/AUDI
25 years of the AdS/CFT correspondence: Current status and future prospects — •Koenraad Schalm — Institute Lorentz, Leiden University, Leiden, The Netherlands

Maldacena's 1997 discovery that certain gauge theories have an equivalent description in terms of anti-de-Sitter quantum gravity in one extra dimension has led to several dramatic new physics insights. Three of these are: 1) From the gauge theory perspective the gravitational force is emergent and recent research on black holes and wormholes has elucidated that this is best phrased in terms of quantum entanglement. 2) The classical gravity limit dual to strongly coupled physics has a universal hydrodynamic limit at low energies. This fluid/gravity aspect has shed new light on the century-old physics of fluids from computational control to non-thermal fixed points. 3) Finally in context of condensed matter physics AdS/CFT indicated the existence of novel IR fixed points, subsequently validated in Sachdev-Ye-Kitaev models. Moreover, these fixed points are strong candidates to explain high Tc superconductors. We review each briefly and discuss how these new insights can point the way for current experiments as well as possibly test quantum gravity holographically in the lab.

Plenary Talk PV IX Wed 9:45 HSZ/AUDI
The origin of the chemical elements — •Marialuisa Aliotta — School of Physics and Astronomy, University of Edinburgh, EH9 3FD Edinburgh, UK

Questions around the composition and origin of our material world have fascinated mankind since ancient times, but it wasn't until the advent of the Mendeleev's periodic table in 1869 that it became clear how ordinary matter is made up of a finite number of different building blocks, the chemical elements. Yet, deeper questions remained: where, when, and how did the chemical elements originate?

These questions are still at the core of nuclear astrophysics research today. Thanks to the advances of the last century and to the interplay of astronomical observations, nuclear physics experiments, and astrophysical models of stellar evolution and nucleosynthesis, we now know that only hydrogen, helium and few other light species were produced during the first few minutes of existence of the Universe, while all other elements, from carbon to gold, to uranium, were (and still are!) forged through nuclear reactions in different stages of stellar evolution.

In my talk, I will present an overview of the main processes responsible for the creation of the elements and recall the astrophysical sites in which these processes occur. I will also address the experimental challenges that we face in replicating stellar reactions on Earth in our attempt to reveal the origin of every chemical element and the intimate connection we bear with long-gone stars.

Prize Talk PV X Wed 12:30 HSZ/AUDI
News from the Flavour Expedition to the Zeptouniverse — •Andrzej Buras — TUM Institute for Advanced Study (IAS) , Garching, Germany — Laureate of the Max-Planck-Medal 2020

After finding an important cornerstone of the Standard Model (SM) through the Higgs discovery, particle physicists are waiting for the discovery of new particles either directly with the help of the Large Hadron Collider (LHC) and its upgrade (HL-LHC) or indirectly with the help of experiments like LHCb, NA62 and Belle II through quantum fluctuations causing certain rare processes with a change of quark flavour to occur at different rates than predicted by the SM. While the latter route is very challenging, requiring very precise theory and experiment, it allows the resolution of short distance scales as short as the Zeptometer corresponding to energies of order 100 TeV or even shorter scales. In the coming flavour precision era, in which the accuracy of the measurements of rare processes and of the relevant theory calculations will be significantly improved, this goal could be reached. The main strategies for reaching this goal will be explained in simple terms including the most recent advances. We will summarize the present status of deviations from SM predictions for a number of flavour observables and discuss possible explanations of these so-called anomalies. A short outlook for coming years will be given.

Lunch Talk PV XI Wed 13:15 HSZ/AUDI
From ab initio to nemo tenetur – Working on cyber crime as an IT analyst with the State Criminal Police Office — •Wojciech Morawiec — LKA Rheinland-Pfalz

While many workplaces pride themselves with providing 'unique challenges every day', I believe that working in law enforcement is one of the rare fields where this statement might be true for the whole length of one's career. As an IT analyst with the Landeskriminalamt Rheinland-Pfalz, the State Criminal Police Office of Rhineland-Palatinate, one faces new and complicated puzzles almost daily. Solving these puzzles, doing proper documentation on them and explaining the results to detective colleagues and later to the prosecutor's office lie at the core of the support of ongoing investigations. Additionally there is some research-like work, where new tools, tactics and procedures have to be developed to expand the possibilities of the state police.

In this talk, after giving an overview of the legal framework, I would like to present how an analyst might work on a fictitious case to collect evidence pointing towards the perpetrator of a cyber crime. While there are no differential equations to solve and also no density functional theory simulations to run in such a case, a strong analytical mindset and simple procedures in data analysis can greatly improve the end result of an investigation.

Evening Talk PV XII Wed 20:00 HSZ/AUDI
Max-von-Laue Lecture: Risikokompetenz – informiert und entspannt mit Risiken umgehen — •Gerd Gigerenzer — Direktor des Harding-Zentrums für Risikokompetenz an der Universität Potsdam — Direktor emeritus des Forschungsbereichs „Adaptive Behavior and Cognition“ (ABC) am Max-Planck-Institut für Bildungsforschung, Berlin

In dieser Welt ist nichts gewiss, außer dem Tod und den Steuern – so schrieb Benjamin Franklin vor mehr als 200 Jahren. Dennoch suchen noch heute Menschen nach Gewissheiten die nicht existieren und vertrauen auf Horoskope und Marktvorhersagen. Statt der Illusion der Sicherheit und dem Wunsch nach Nullrisiko braucht eine lebendige Demokratie Menschen, die kompetent und entspannt statt ängstlich und verunsichert mit Risiken umgehen können. Risikokompetenz kann man lernen – und darüber geht dieser Vortrag.

Risikokompetenz ist die Fähigkeit, die Gefahren und Möglichkeiten einer technologischen Welt zu verstehen statt diese zu verdrängen, und mit Unsicherheit emotional entspannt leben zu lernen. Unsere Gesellschaft ist von einem rationalen Umgang mit Risiken noch weit entfernt, ein Zustand, der jedes Jahr beträchtliche finanzielle Mittel, Ängste und das Leben von Bürgern kostet. In diesem Vortrag berichte ich über die mangelnde Fähigkeit von Ärzten, Richtern, Journalisten und Politikern, Risiken zu verstehen und zu kommunizieren. Dann zeige ich anhand meiner Forschung, wie man mit nachhaltigen Methoden diese allgemeine Konfusion in Einsicht verwandeln kann.

Plenary Talk PV XIII Thu 9:00 HSZ/AUDI
The role of artificial intelligence in modern radiation therapy — •Guillaume Landry — Department of Radiation Oncology, University Hospital, LMU Munich, Munich, Germany

As in many other fields, artificial intelligence (AI) has found applications in radiation therapy. By now, the most widespread use of AI is for the automatic delineation of organs on computed tomography or magnetic resonance images of the patient, which serve as basis for radiation delivery planning. For this task, the ubiquitous U-net convolutional neural network has been widely adopted, and several commercial solutions are available. Just as AI is continuously evolving, radiation therapy has seen exciting developments, notably the clinical introduction of online adaptive radiotherapy at MR-linacs, which allows daily plan adaptation and tumor tracking using cine-MRI. MR guided radiotherapy (MRgRT) is ideally suited for the adoption of AI methods, since it generates large amounts of data with imaging at every fraction, and there is a need to reduce the time patients spend in the MR-linac bore waiting for plan adaptation. Thus, besides automatic segmentation, in MRgRT AI may allow to generate pseudo-CT

images from MR images and to help track and predict tumor motion on cine-MRI. Even for segmentation, some specific approaches such as patient-specific model fine tuning may find a role in MRgRT. Finally, for radiotherapy in general, AI may allow to correlate imaging and treatment outcomes.

Plenary Talk PV XIV Thu 9:45 HSZ/AUDI
Machine Learning Advances in Particle Physics — •Lukas Heinrich — Technical University of Munich

The year 2012 has been marked by two breakthroughs in science. One is very familiar to particle physicists: the discovery of the Higgs. The other would would soon capture the attention of scientists and non-scientists alike: the breakthrough of deep learning which started with the "AlexNet" moment and kicked off a decade of impressive advancements in a wide range of domains, including fundamental physics. However, applications in fundamental physics must go beyond black-box point prediction and typically enable a rich interpretation of the data, including robustness to systematic uncertainties, interpretability and optimization with respect to multiple possibly competing objectives. In this talk I will review recent successes in ML that proved impactful within the context of fundamental physics and discuss future directions including differentiable and probabilistic programming, foundation models and fast simulation.

Prize Talk PV XV Thu 12:30 HSZ/AUDI
Direct dark matter detection: What if there's no WIMP? — •Belina von Krosigk — Karlsruhe Institute of Technology, Institute for Astroparticle Physics, Eggenstein-Leopoldshafen, Germany — Laureate of the Hertha-Sponer-Prize 2023

More than a century has passed since the first hint of the existence of dark matter in the Universe. This hint has since been corroborated by a plethora of further astronomical observations revealing that even most of the matter in the Universe is dark. Observing the respective dark matter particles, and elucidating their nature, became one of the most tantalizing endeavors of modern physics, with the Weakly Interacting Massive Particle (WIMP) being a prime suspect. Tremendous experimental efforts and successes have allowed a large portion of the WIMP parameter space to be explored in recent decades, with optimized experiments for direct dark matter detection taking the lead in these searches. But no WIMP in sight thus far. Today, a new generation of highly sensitive, large-scale direct detection experiments is at the ready to observe WIMPs, and their successors are already being planned. But what if there's no WIMP? This talk will discuss the diversity of the worldwide direct dark matter search program beyond the traditional WIMP and provide a glimpse of where the near future will take us in this effort to directly observe dark matter in the laboratory.

Evening Talk PV XVI Thu 20:00 HSZ/AUDI
Von Sachsen ins Universum — •Christian Stegmann — Deutsches Elektronen-Synchrotron DESY, Zeuthen

Forschende teilen Wissenschaft in Disziplinen auf, die Natur tut das nicht. Astronomie, Astrophysik, Astroteilchenphysik und Kern- und Teilchenphysik haben in den vergangenen Jahren neue Fenster in unser Universum geöffnet. Von den kleinsten bis zu den größten Abständen, von den Anfängen des Universums bis heute, haben sie unser Verständnis der Welt geprägt. Neue Observatorien werden uns noch tiefer in unser Universum blicken lassen. Sie bieten die Chance, Perspektiven zu verbinden und Antworten auf Fragen nach dem Ursprung und der Entwicklung des Universums zu liefern – mit viel „irdischem" Potenzial.

Im September vergangenen Jahres haben die Bundesrepublik Deutschland und der Freistaat Sachsen als Ergebnis des größten offenen Wissenschaftswettbewerbs in der Geschichte Deutschlands entschieden, in der Lausitz das Deutsche Zentrum für Astrophysik zu errichten. Eine Investition in dieser Größenordnung in Grundlagenwissenschaft – das ist bemerkenswert. Sie zeigt nicht nur die große Faszination, die Astronomie und Astrophysik ausüben, sondern auch, dass sie ganz konkret wichtige technologische und innovative Impulse setzen können und einen nachhaltigen Strukturwandel in der Lausitz, einer Region im Zentrum Europas, ermöglichen.

Der Vortrag nimmt Sie mit in die Weiten unseres Universums, in die Vergangenheit bis zum Tag, der kein Gestern hatte und eine Zukunft mit großen Chancen für Innovationen in Technologie und Digitalisierung.

Plenary Talk PV XVII Fri 9:00 HSZ/AUDI
The Einstein Telescope — •Harald Lück — Institut für Gravitationsphysik, Leibniz Universität Hannover und Max-Planck Institut, Hannover

The detections of gravitational waves with the current gravitational wave detectors enabled us to eavesdrop on hidden processes in the universe and obtain information about processes that we cannot see with other methods. They marked the beginning of gravitational astronomy. But we are only at the beginning of this new era. We know how to build new instruments with even better sensitivity that will allow us to listen out into the early times of the universe and constantly register the quiver of spacetime caused by a vast number of sources. With the Einstein Telescope, we want to build such an instrument in Europe. Bigger than before, more sensitive, underground and definitely cool. I will report on the plans and the current state of developments.

Plenary Talk PV XVIII Fri 9:45 HSZ/AUDI
The LHC legacy and prospects — •Markus Klute — KIT, Karlsruhe, Germany

The Large Hadron Collider (LHC) at CERN has had two successful and highly productive runs (2009-2013 and 2015-2018), colliding protons and heavy ions with center-of-mass energies of up to 13 TeV and collecting an unprecedented amount of data. Its highlight, the Higgs Boson discovery in 2012, completed the Standard Model of fundamental particle interactions. The particle physics world has changed dramatically in the last decade. While the impact of the collected data has been tremendous, many open questions in the world of elementary particle physics remain. I will review the main conclusions from the LHC to date and present the prospects of the LHC program and beyond.

Prize Talk PV XIX Fri 13:00 HSZ/AUDI
The science and technology of DUNE and its future as an international neutrino observatory — •Stefan Söldner-Rembold — University of Manchester, United Kingdom — Laureate of the Max-Born-Prize 2023

The preponderance of matter over antimatter in the early universe, the dynamics of the supernovae that produced the heavy elements necessary for life, the search for physics beyond the standard model – these mysteries at the forefront of particle physics and astrophysics are key to understanding the evolution of our universe. DUNE is an international neutrino experiment dedicated to addressing these questions as it searches for leptonic charge-parity symmetry violation, stands ready to capture supernova neutrino bursts, test the three-flavour paradigm and search for new physics. To achieve its science goals, it will employ the technology of liquid-argon time projection chambers at an unprecedented scale and precision. DUNE will comprise a far detector located at the SURF laboratory in South Dakota and a near detector close to the neutrino beam source at Fermilab near to Chicago. The presentation will introduce the science and technology of DUNE and discuss the status of the international project.