Plenary Talk PLV I Mon 8:30 HSZ/AUDI
Cavity-altered superconductivity — •Dmitri Basov — Columbia University, New York, USA

Is it feasible to alter the ground state properties of a material by engineering its electromagnetic environment? Inspired by theoretical predictions, experimental realizations of such cavity-controlled properties without optical excitation are beginning to emerge. A grand aspiration of cavity quantum materials research is to uncover fundamentally new routes for controlling properties of matter by judiciously tailoring the quantum electromagnetic environment. We devised and implemented a novel platform to realize cavity-altered materials. Single crystals of hyperbolic van der Waals (vdW) compounds provide a resonant electromagnetic environment with enhanced density of photonic states and prominent mode confinement. We interfaced hexagonal boron nitride (hBN) with the molecular superconductor κ-(BEDT-TTF)2Cu[N(CN)2]Br (κ-ET). Meissner effect measurements demonstrate a strongly altered superfluid density at the hBN/κ-ET interface. Our work highlights the potential of dark cavities devoid of external photons for engineering electronic ground state properties of complex quantum materials. To appear in Nature in 2026.

Plenary Talk PLV II Mon 14:00 HSZ/AUDI
Towards Intelligent Matter: Energy-Efficient In-Materio Computing — •Karin Everschor-Sitte — Faculty of Physics and Center for Nanointegration Duisburg-Essen, University of Duisburg-Essen, Duisburg, Germany

The rapid expansion of artificial intelligence has driven computational demands to unprecedented levels, making power consumption a central bottleneck for state-of-the-art hardware architectures. This presentation addresses how functional materials, including magnetic, ferroelectric, optical, and plasmonic systems, offer a path beyond this limitation by leveraging their intrinsic physical properties to compute and process information directly within matter. Our research centers on magnetic materials, whose nonlinear, complex hysteretic responses make them particularly well-suited for low-energy, efficient unconventional computing paradigms like reservoir computing. Advances in harnessing magnetic and ferroelectric textures for in-materio computation will be presented. These developments outline how coordinated integration of material properties, algorithmic design, and device engineering can enable high-performance, energy-efficient computing technologies and ultimately pave the way toward intelligent matter.

Plenary Talk PLV III Mon 14:00 HSZ/0002
Simulating the Hubbard model with moiré semiconductors — •Jie Shan — Max Planck Institute for the Structure and Dynamics of Matter — Cornell University

The Hubbard model is a simple theoretical model of interacting quantum particles in a lattice. It is believed to capture the essential physics of many strongly correlated phenomena, such as high-temperature superconductivity, magnetism, and metal-insulator transitions, but has proved difficult to solve accurately except in one dimension. Physical realizations of the Hubbard model therefore have a vital role to play in the study of correlation physics. Moiré materials, formed by overlaying two van der Waals materials of slightly different orientations or lattice constants, have recently emerged as a promising Hubbard model simulator. In this talk, I will review the recent experimental progress on the realization of both the triangular and honeycomb lattice Hubbard models, and how the electronic phase diagram evolves with the U/W ratio (where U and W denote the onsite Coulomb repulsion and the moiré bandwidth, respectively).

Plenary Talk PLV IV Tue 8:30 HSZ/AUDI
Spins in Quantum Dots: The Quiet Revolution — •Dorian Gangloff — Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom

Solid-state spins in semiconductors provide a natural interface between stationary qubits and single photons, forming key building blocks for future quantum communication networks. Historically, semiconductor quantum dots (QDs) were considered too noisy for spin physics: strong hyperfine interactions within a mesoscopic system, materials inhomogeneity, and limited control tools once cast doubt on their suitability as coherent spin qubits. In recent years this perception has shifted dramatically. Advances in growth, device engineering, coherent control, and nuclear-spin cooling have ushered in a quiet revolution in III-V QDs. They now exhibit excellent optical coherence, near-unity photon collection when integrated with photonic structures, and spin degrees of freedom with long coherence times.

In this talk I will present three developments that illustrate this transformation: (1) High-fidelity electron-spin control, (2) Quantum memories from nuclear spins, and (3) Deterministic design of QD properties prior to growth.

Together, these advances reveal how the long-standing "noise problem" in III-V quantum dots is being turned into a resource, and underline their emergence as a platform for quantum communication and quantum information processing.

Plenary Talk PLV V Wed 8:30 HSZ/AUDI
Reimagining Physics Education for a Planet in Transformation — •Giulia Tasquier — Department of Physics and Astronomy, ALMA MATER STUDIRUM - University of Bologna, Bologna, Italy

The accelerating climate crisis intensifies the need to interpret complex evidence and act upon it. While physics and climate science offer foundations for understanding global warming, scientific knowledge alone does not suffice to support informed action. This plenary examines how physics education can help bridge this gap. Drawing on research in climate change education, I discuss how modelling, causal reasoning, and the epistemology of complex systems can strengthen students' understanding of climate phenomena and uncertainty in scientific prediction. Insights from futures studies highlight the importance of anticipating alternative scenarios and moving beyond deterministic expectations. Integrating these perspectives supports what we define as agency: a capacity connecting scientific understanding with ethical reflection and imaginative anticipation. Empirical work shows that students engaging with complexity-based explanations expand their imaginative horizons and begin to position themselves as agents within complex climate futures. Activities such as exploring branching scenarios or reframing narratives of the climate crisis help them see the future not as fixed, but as a space of plurality, contingency, and imagination. The talk outlines a three-dimensional framework on agency to integrate these elements into physics education, reimagining it as a practice of freedom that turns complexity into a resource for imagination and solidarity.

Plenary Talk PLV VI Wed 14:00 HSZ/AUDI
Materials selection methods: a compass in the jungle — •Yves Bréchet — Monash University, Materials Science Department, Clayton Campus, Melbourne, Australia

Materials use and development have undergone a profound transformation in the last decades: the "book of specifications" is more and more demanding, more and more multifunctional, and additional requests such as sustainability have progressively strengthened conflicting requirements. At the same time, the variety of materials available to engineers has expanded in such a way that materials selection and materials design is a must for efficient use of materials. To meet this new request, materials and process databases, and materials selection tools have been developed in the last 20 years, allowing both for a better use of materials, and for a guidance of "materials by design". The case of materials associated with a prescribed geometry, so-called "architectured materials", are a striking example of this evolution from "materials by chance", via "materials in competition", to "materials by design". Recent developments in AI to generate new materials open new opportunities and raise new challenges for this general trend toward materials by design.

Plenary Talk PLV VII Wed 14:00 HSZ/0002
Stronger yet weaker: Long-range orientational order in 2D active matter — •Hugues Chaté — CEA - Saclay, France

The Mermin-Wagner-Hohenberg theorem tells us that, in a 2D system in equilibrium, the spontaneous breaking of a continuous symmetry cannot lead to true long-range order. Out of equilibrium, and in particular in active matter systems, it is now well known that 2D true long-range orientational order is possible.

I will first give an updated view of our knowledge of polarly ordered phases in 2D active matter systems. I will then proceed to show that many of these phases are metastable to the nucleation of droplets which, opposite to the Peierls argument at play in equilibrium, grow and eventually destroy order. Order is thus both stronger (truly long-range) and weaker (metastable) in 2D active systems.

Plenary Talk PLV VIII Thu 8:30 HSZ/AUDI
Insights into aqueous solution oxide interfaces from ab initio neural network potential molecular dynamics — •Annabella Selloni — Princeton University, Department of Chemistry, Princeton, NJ, United States

Aqueous solution-oxide interfaces play a critical role in many environmental, biological, and energy-relevant processes. Molecular dynamics (MD) simulations employing ab initio based deep neural network potentials (DPs) have recently emerged as a valuable approach to complement experimental observations and obtain detailed molecular scale insights. In this talk, I shall discuss recent applications of DP-MD to understand the structure and properties of aqueous solution-oxide interfaces. Focusing on titanium dioxide, a prototypical metal oxide with a prominent role in energy applications, specific topics will include characterization of the electrified TiO2-electrolyte interface, and the effects of organic compounds such as formic acid and methanol on the structure and chemistry of water at the interface.

Plenary Talk PLV IX Thu 14:00 HSZ/AUDI

On the sunny side - polymer-based organic solar cells — •Peter Müller-Buschbaum — TUM School of Natural Sciences, Chair for Functional Materials, Garching, Germany

Polymer-based organic solar cells open up new fields of application compared to conventional silicon-based solar cells, as they are flexible, lightweight, color-adjustable, and potentially very cost-effective. In addition, they also function in low-light conditions and have a high power density, which makes them very attractive for space applications, in addition to their classic terrestrial applications. Since 2025, single-junction organic solar cells have surpassed the magic 20% efficiency rate. Moreover, organic solar cells are also successfully combined with other solar technologies in tandem devices as recently demonstrated with an efficient near-infrared harvesting in perovskite-organic tandem solar cells [1]. Current research questions focus on the aging mechanisms of organic solar cells and the feasibility of converting solar cell production to highly scalable manufacturing methods. The Müller-Buschbaum Group is investigating both issues using advanced X-ray and neutron scattering methods in situ and operando during production [2] and solar cell operation [3]. In addition, the Müller-Buschbaum Group has conducted pioneering work in investigating organic solar cells in space, demonstrating that organic solar cells function equally well in space as they do in the laboratory [4]. [1] Nature 643, 104-110 (2025); [2] Adv. Energy Mater. 15, 2404724 (2025); [3] Nano Energy 140, 111043 (2025); [4] Joule 4, 1880-1892 (2020)

Plenary Talk PLV X Thu 14:00 HSZ/0002

Towards a Science of Cities: A Complex Systems Approach — •Marta Gonzalez — UC Berkeley, USA

Cities are complex systems whose dynamics emerge from the interactions of millions of individuals, institutions, and infrastructures. In this talk, I present a framework that applies the principles of complex systems science to urban environments, aiming to uncover unifying patterns and mechanisms that govern urban behavior. Drawing on large-scale mobility, traffic, emissions, and financial transaction data, I show how cities can be studied as living laboratories of collective behavior. First, I examine the macroscopic dynamics of urban traffic, identifying critical thresholds that mark the onset and collapse of mobility systems across different cities, and framing these collapses as nonequilibrium phase transitions. I then explore the environmental consequences of these dynamics, introducing a scalable model that links real-world mobility patterns to vehicular CO* emissions, highlighting the pivotal role of vehicle kilometers traveled. Shifting focus to spatial structure, I illustrate how mobility data reveals the transformation of urban form in response to disruptive events, such as pandemics, and offer novel metrics to quantify home-based travel and structural shifts. Finally, I demonstrate how behavioral regularities in credit card transaction sequences encode individual lifestyles and social structures, showing how economic activity reflects deeper patterns of urban life. Together, these studies underscore the value of a data-driven, systems-oriented approach to understanding and shaping the future of cities.

Plenary Talk PLV XI Fri 8:30 HSZ/AUDI

Phase separation in Cell Physiology and Disease — •Anthony Hyman — Pfotenhauerstraße 108

Cells organize many of their biochemical reactions by formation and dissolution of non-membrane-bound compartments. Recent experiments show that a common mechanism for such biochemical organization is phase separation of unstructured proteins to form liquid-like compartments. These liquid-like compartments can be described by principles elucidated from condensed-matter physics and are therefore termed biomolecular condensates. I will discuss the relationship between the formation of liquid like compartments, quality control mechanisms that preserve the liquid-like state, and the onset of aggregated-protein pathology that is commonly observed in neurodegenerative diseases.