Plenary Session

Tuesday, 19.08.2025, Room Großer Festsaal

Time	ID	Official Conference Opening
08:50		**Welcome Note** *Manuela Baccarini, Vice-Rector Research, University of Vienna;* *Alberta Bonanni, ÖPG President; Teresa Montaruli, SPS President;*
		Plenary Session I *Chair: Markus Aspelmeyer, Universität Wien*
09:00	31	**The Next 100 Years of Quantum Mechanics** *Caslav Brukner, Universität Wien* Over the past century, much of the foundational work in quantum mechanics was driven by attempts to resist its revolutionary message—seeking to restore classical notions of reality and test quantum theory against them. This journey culminated in the decisive, loophole-free Bell experiments of 2015, which confirmed the predictions of quantum mechanics and ruled out classical alternatives. Looking ahead, it is time to fully embrace quantum mechanics and explore its profound implications for a non-classical understanding of space-time, reference frames, and causal order. This talk will outline how these ideas set the stage for the next century of quantum science.
		Chair: Rachel Grange, ETH Zürich
09:45	32	**Spin Qubits in Semiconductors for Scalable Quantum Computers** *Daniel Loss, Department of Physics, University of Basel, CH-4056 Basel* Semiconductor spin qubits offer a unique opportunity for scalable quantum computation by leveraging classical transistor technology. This has triggered a worldwide effort to develop spin qubits, in particular, in Si and Ge based quantum dots, both for electrons and for holes. Due to strong spin orbit interaction, hole spin qubits benefit from ultrafast all-electrical qubit control and sweet spots to counteract charge and nuclear spin noise. In this talk I will present an overview of the state-of-the art in the field and focus, in particular, on recent developments on hole spin physics in Ge and Si nanowires, Si FinFETs, and Ge/SiGe heterostructures, as well as strategies for maximizing valley splitting crucial for scalability of electron spin qubits in Si and long-distance entanglement via magnetic domain walls in race tracks.
10:30		***Coffee Break***
11:00		***Award Ceremony***
		Chair: Hugo Zbinden, Université de Genève
12:00	33	**Quantum Threats and Opportunities for Secure Communication** *Nicolas Sangouard* *Institut de Physique Théorique, Orme des Merisiers, CEA Paris-Saclay, FR-91191 Gif-sur-Yvette Cedex* Algorithms that exploit quantum principles can efficiently solve mathematical problems that form the foundation of classical cryptographic systems. At the same time, these principles enable the development of cryptographic protocols with provable security guarantees. During this talk, I will present on-going efforts to precisely quantify the resources required to break widely used classical crypto-systems. I will also highlight recent results demonstrating that cryptographic keys can be distributed between remote locations with provable security guarantees — even in the extreme scenario where the quantum devices involved in the distribution are untrusted.

Time	ID	*Chair: Christian Teichert, Montanuniversität Leoben*
12:30	34	**AYPT: 27 Years, 17 Problems, 7 Challenges** *Paul Worm, Teamleiter AYPT* 27 years ago, the Austrian Young Physicists' Tournament (AYPT) was held for the first time. Since then, each year countless young physicists have had the opportunity to develop and present creative solutions to 17 open-ended physics problems as part of this competition. The range of topics spans questions such as "Under what conditions does hot water freeze faster than cold water?" to "How can one design the most effective arrestor bed to safely bring trucks to a stop?". At the competition, the solutions developed are presented in front of a jury and discussed in a scientific exchange format with students from other teams. This event offers 7 challenges, or as I prefer to call them, learning opportunities, for students: (1) working independently on open-ended topics, (2) collaborating effectively as a team (3) designing creative and practical experimental setups, (4) applying theoretical and computational physics, (5) presenting solutions to an audience, (6) engaging in live discussions about other teams' ideas, (7) and most importantly, having fun and connecting with fellow science enthusiasts, especially within this competitive setting. In this talk, I will share how I first had the chance to grow through AYPT as a student and later pass on that experience to new generations - as juror, team leader, and organizer. I can say with absolute confidence that this tournament has shaped me and fellow participants more deeply than we could have ever imagined. Today, I am both proud of our organizing teams and grateful for the recognition we have received as an organization for our efforts to popularize science in general, and physics in particular, among curious young students.
13:00		***Lunch***
14:00		***Topical Sessions***
18:00		***Transfer to ÖAW*** *Doktor-Ignaz-Seipel-Platz 2, 1010 Wien*

Tuesday, 19.08.2025, ÖAW Festsaal

Time	ID	**Public Lecture** *Chair: Christian Wüthrich, Université de Genève*
19:00	35	**Physical understanding in the times of AI. A philosophical analysis.** *Claus Beisbart, Institut für Philosophie, Universität Bern* These days, AI applications, particularly neural networks, are all the rage in physics and beyond. Undoubtedly, they can be powerful in classification and prediction tasks. However, can AI provide physicists with scientific understanding? Some authors have been skeptical and suggested that big-data-oriented science remains shallow because AI remains a black box to humans. Others, by contrast, have taken a more optimistic stance and pointed to examples in which AI has seemingly been instrumental to human understanding. This talk aims to reconcile these different views. I start with systematic reflections on understanding in physics. To account for the skeptical voices, I argue that AI can be trained with fairly little domain knowledge, and that tools that predict something to be the case are typically not known to contain explanatory information, which means that they are not suited for explanatory understanding. However, in some situations, there can be reasons to think that AI applications become sensitive to explanatory relevant variables, and a closer investigation of a network or a bunch of runs of a simulation program can often reveal explanatory information. Accordingly, the impact of AI tools on scientific understanding depends crucially on what people know and how they use AI. To show the power of AI for understanding, the talk systematically carves out inferences that lead to more understanding.
20:15		***END***

Wednesday, 20.08.2025, Room Großer Festsaal

Time	ID	Plenary Session II: Symposium "ERC Funding in Quantum Science"
08:30		***Opening remarks*** *Markus Aspelmeyer, Universität Wien* *Axel Cleeremans, President of the Association of ERC Grantees – AERG* *Silke Bühler-Paschen, TU Wien*
		Chair: Markus Aspelmeyer, Universität Wien
09:00	36	**When Crystals Flow: The Emergence of Supersolid Quantum States** *Francesca Ferlaino, Institut für Experimentalphysik, Universität Innsbruck, Austria* *IQOQI- Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, Innsbruck, Austria* The exploration of superfluidity has fascinated scientists for decades, spanning a wide range of systems—from solids and liquids to gases, and even light. Traditionally, the study of superfluid order has been confined to spatially homogeneous systems, where uniform conditions provide a simpler framework for understanding this extraordinary quantum state. But what happens when superfluidity arises in systems with periodic density modulations? Can the inherent localization of periodic structures coexist with the fluid-like properties of a superfluid? Could a solid, with its rigid crystalline structure, exhibit superfluid behavior? Or conversely, might a superfluid reveal a crystalline order? These questions have long intrigued the scientific community, pushing the boundaries of our understanding. Recent breakthroughs have provided compelling answers with the discovery of "supersolid" quantum states—phases that uniquely combine superfluid and crystalline properties. This talk will delve into the experimental realization of supersolidity in magnetic quantum gases, enabled by the momentum-dependent, long-range, and anisotropic dipole-dipole interactions. Key topics include the softening of roton excitations as a precursor to the supersolid phase transition, the dynamics of symmetry breakings, and the observation of quantized vortices in rotating supersolid states. These advancements open new avenues for understanding many-body quantum physics and the interplay of order and coherence in complex quantum systems.
09:45	37	**A mechanical qubit** *Yiwen Chu, ETH Zürich* Strong nonlinear interactions between quantized excitations are an important resource for quantum technologies based on bosonic oscillator modes. However, most electromagnetic and mechanical nonlinearities are far too weak to allow for nonlinear effects to be observed on the single-quantum level. This limitation has been overcome in electromagnetic resonators by coupling them to other strongly nonlinear quantum systems such as atoms and superconducting qubits. I will present the realization of the single-phonon nonlinear regime in a solid-state mechanical system. The single-phonon anharmonicity in our system exceeds the decoherence rate by a factor of 6.8, allowing us to use it as a mechanical qubit and demonstrate initialization, readout, and single qubit gates. Our approach provides a powerful quantum acoustics platform for quantum simulations, sensing, and information processing.
10:30		***Coffee Break***

Time	ID	*Chair: Silke Bühler-Paschen, TU Wien*
11:00	**38**	**Models and methods in the study of high-temperature superconductivity** *Jaksa Vucicevic, Institute of Physics Belgrade Pregrevica 118, 11080 Belgrade, Serbia* We will cover several lines of ongoing work aimed at improving our understanding of the cuprate superconductors. We focus on the mechanisms that determine the normal-phase transport properties and the magnitude of the superconducting critical temperature. The main difficulty in the theoretical description of the cuprates is that it requires a many-body treatment of an effectively strong interaction between the electrons; in addition, the details of the crystal structure also play a role, and one cannot account for material-specific properties by solving the simplest models. We will discuss the possible low-energy models and the ways to extract the corresponding model-parameters from ab initio results. Then, we will discuss recent advancements in methodology, in particular related to computing the dynamical response functions in interacting lattice models. Our results are pertinent to the hypothesis that the cuprate strange-metal regime is linked with quantum criticality.
11:30	**39**	**Non-equilibrium self-assembly in quantum materials: emergence of trapped quasiparticle noise.** *Dragan Mihailović, Yevhenii Vaskivskyi and Jaka Vodeb Jožef Stefan Institute, Jamova 39, 1000-Ljubljana, Slovenia, Faculty of Mathematics and Physics, University of Ljubljana, 1000-Ljubljana, Slovenia, & CENN Nanocenter, 1000-Ljubljana, Slovenia* The formation of defects and imperfections seems inevitable in any self-assembly process. This includes everything from crystal growth and device fabrication to biological self-assembly. Such processes are key to life and technology as well as fundamental physics of emergence in non-equilibrium systems. To understand the behaviour of such imperfections in quantum systems we experimentally focus on a model experimental system that exquisitely describes the salient features, particularly imperfections resulting from optically induced quench and ensuing self-assembly in the aftermath of a 1st order phase transition of a 2D charge-density-wave system. The chosen system allows us to perform real-time imaging of trapped quasiparticle motion by fast scanning tunnelling microscopy while spectrally and spatially analysing noise with atomic resolution. The experiments show that the electrons localised to topologically non-trivial defects form emergent states (qubits) exhibiting characteristic two-level system (TLS) behaviour including telegraph noise. The findings have direct implications for the physics of glasses and in the fabrication of superconducting Josephson-junction based devices used in quantum processors where topologically similar traps can lead to TLS noise interference.
12:00	**40**	**The Quantum Twisting Microscope: Visualizing Waves in Quantum Matter** *Shahal Ilani, Department of Condensed Matter Physics, Weizmann Institute of Science* Some of the most fascinating phenomena in nature arise when electrons behave as quantum mechanical waves that interact with one another. But how can we visualize these electronic waves in action? In this talk, I will introduce the Quantum Twisting Microscope (QTM), an innovative scanning probe microscope, developed within the ERC-Adv framework, designed to directly image electronic wavefunctions and energy bands within quantum materials. At its core lies a unique tip composed of an atomically thin van der Waals material, which functions as a quantum interferometer. Electrons tunnel from this tip into a sample at multiple locations at once, and the quantum interference between these tunneling paths enables the measurement of the phase evolution within electronic wavefunctions. These measurements allow the QTM to probe electrons in momentum space, much as a scanning tunneling microscope probes electrons in real space. I will present new experimental results on one of the most puzzling quantum systems - magic angle twisted bilayer graphene – revealing its interacting electronic bands and the intriguing interactions between its electrons and phonons.
12:30		***Lunch***

Time	ID	*Chair: Jörg Schmiedmayer, TU Wien*
14:00	**41**	**The laser in quantum science** *Serge Haroche, Collège de France, Paris* This year marks the 100th anniversary of quantum mechanics. Among all the inventions born of this physics, the laser occupies an important place, both for the lineage of discoveries that led to its birth, and for the role it plays today in fundamental and applied science. It has opened up fields in research that could not have been imagined at the time it was invented. We owe to it the cooling and trapping of atoms, the study of quantum gases of bosons and fermions, the discovery of gravitational waves and the manipulation of individual quantum particles which has led to current research into quantum simulation and quantum computing. The laser may also provide answers to fundamental questions about the link between quantum physics and gravitation, or about the nature of the hypothetical dark matter. The history of the laser in blue sky science illustrates the passion for precision and the essential link between basic research and technological advances that have driven modern science since its advent in the Age of Enlightenment.
14:45	**42**	***Panel Discussion:*** **From Blue Sky Research to Quantum Technologies** *Moderation: Silke Bühler-Paschen, TU Wien* PANELISTS: ***Serge Haroche*** (AERG Science & Society Seminar), ***Tom Henzinger*** (ERC Scientific Council), ***Ulrike Diebold*** (Vice President of the Austrian Academy of Sciences), ***Monika Ritsch-Marte*** (ERC ADG grantee, Medical University of Innsbruck), ***Johannes Fink*** (ERC POC grantee, ISTA).
15:45		***Exhibitor Presentation Session***
16:00		***Poster Session with Apéritif***
19:00		***END***

Thursday, 21.08.2025, Room Großer Festsaal

Time	ID	**PLENARY SESSION III** *Chair: Gernot Eichmann, Universität Graz*
09:00	**43**	**Status of the anomalous magnetic moment of the muon** *Martin Hoferichter, Universität Bern* The anomalous magnetic moment of the muon quantifies the deviation of the muon's g-factor from g = 2, as predicted by the Dirac equation. It can be measured very precisely in experiment and predicted at a comparable level, turning it into a prime precision observable with which to search for physics beyond the Standard Model. In the talk, I will discuss the current status of this precision test after the release of the final results from the Fermilab experiment, focusing on the role of theory to match the experimental precision in the Standard-Model prediction.
		Chair: Peter Korczak, ÖPG
09:45	**44**	**Trapped-ion quantum computing at Infineon** *Clemens Rössler, Infineon AG* The world is filled with computational problems that are far too complex for today's or even future classical supercomputers. These challenges span various critical domains such as life- and material science, finance and logistics and require new computational paradigms to be solved efficiently. Quantum computers, with their potential to process information in fundamentally different ways, promise to efficiently solve many of these intractable problems. However, for quantum computers to become practically useful, they must achieve the ability to control a large number of qubits with

		high precision, surpassing the state-of-the-art capabilities available today. Among the leading qubit modalities, trapped ions lead in key metrics such as the two-qubit fidelity, coherence time and connectivity between qubits. Furthermore, ion traps can be realized in an industrial semiconductor fabrication environment which offers precision and reproducibility. Infineon employs a dedicated team of developers to co-design, fabricate, and validate cutting-edge quantum processing units (QPUs) for both academic and commercial partners. Their work includes integrating advanced functionalities such as photonics for efficient light delivery and integrated electronics for the precise control of large-scale QPUs. I will introduce the basics of industrial ion trap fabrication, present recent developments in the field and provide an outlook to utility-scale quantum computing.
10:30		***Coffee Break***
		Chair: Michel Calame, Empa & Universität Basel
11:00	**45**	**Broadband integrated photonics with planarized terahertz quantum cascade lasers** *Urban Senica, Laboratory for Nanoscale Optics, John A. Paulson School of Engineering and Applied Sciences, Harvard University, USA; Quantum Optoelectronics Group, Institute for Quantum Electronics, Department of Physics, ETH Zurich, Switzerland* We developed an integrated photonics platform based on planarized waveguides, where terahertz quantum cascade laser (THz QCL) active waveguides (GaAs/AlGaAs quantum wells) are embedded in a low-loss polymer Benzocyclobutene (BCB), with an extended top metallization and placement of bonding wires over the passive area. Besides improved thermal, microwave, and dispersion properties, this also allows to co-integrate active and passive components on the same photonic chip, enabling the development of many novel integrated photonic devices. These include inverse-designed semiconductor laser cavities, field-enhancing structures for nonlinear photonics, and two fundamentally new types of frequency combs based on strong microwave modulation.
11:30	**46**	**Engineering Andreev band structures in multi-terminal Josephson junctions** *Marco Coraiola, IBM Research Zürich* Hybrid multi-terminal Josephson junctions, where three or more superconducting leads are coupled to a semiconducting region, offer a novel platform for engineering quantum states. In these systems, Andreev bound states form synthetic band structures controlled by multiple superconducting phases. I will present the experimental realization of Andreev band structures in three-terminal Josephson junctions. Using tunnelling spectroscopy, we probed the two-dimensional phase space, demonstrating the formation of hybridized Andreev molecules, as well as the emergence of spin-split energy levels and fermion parity transitions. These results open new opportunities for superconducting spin qubits and topological phases in higher-dimensional Andreev band structures.
		Chair: Gian Salis, IBM Rüschlikon
12:00	**47**	**Electrical and Optical Manifestation of Flat Bands in 2D Semiconductors** *Gabriele Pasquale, EPFL & Harvard University* This talk presents a series of experimental discoveries on how flat band physics emerges in the electrical and optical response of 2D semiconductors, with metal monochalcogenides as a case study. A new tunneling-based method is introduced to detect flat bands via the onset of out-of-plane current. This fast and reliable technique enables the observation of many-body excitonic interactions, chirality-sensitive tunneling in an originally achiral system, and the realization of a long-standing prediction: spin-polarized hole accumulation at the valence band edge. These findings establish new pathways to explore flat band phenomena and emergent effects across condensed matter systems.
12:30		***Lunch***
14:00		***Topical Sessions***

		Transfer to Dinner
19:00		***Conference Dinner***

Friday, 22.08.2025, Room Großer Festsaal

Time	ID	**Plenary Session IV** *Chair: Rainer Leitgeb, Med. Universität Wien*
09:00	**48**	**Using cellular phase transitions to understand cancer** *Roberto Cerbino, Universität Wien* Cells within tissues can undergo phase transitions—such as jamming and unjamming—that alter their collective behavior and mechanical properties. These transitions influence how tissues grow, move, and respond to their environment, and are increasingly recognized as important in both healthy development and disease. We explore how such transitions shape the organization and dynamics of epithelial cell assemblies. Our recent findings identify the small GTPase RAB5a as a key regulator of unjamming, enabling collective motion in both 2D monolayers and 3D spheroids. Alterations of its expression levels promote stronger mechanical interaction with the surrounding matrix and support invasive behavior through unjamming. Moreover, unjamming induces large density fluctuations that generate nuclear stress and lead to the release of DNA into the cytoplasm, potentially activating innate immune pathways. These insights highlight how mechanical state changes in tissues can contribute to cancer progression and offer new perspectives on the physical basis of disease.
		Chair: Ulrike Diebold, TU Wien
09:45	**49**	**Towards Quantum Computing with Spins on Surfaces** *Andreas Heinrich, Center for Quantum Nanoscience, Institute for Basic Science (IBS), and Department of Physics, Ewha Womans University, Seoul 03760, Republic of Korea.* There is a strong international research effort in the area of quantum information science. Here, the concepts of quantum coherence, superposition and entanglement of quantum states are exploited. Over the past two decades, many advances at studying such quantum coherence in solid-state and molecular architectures have evolved. In this talk we will focus on quantum-coherent experiments in Scanning Tunneling Microscopy (STM). STM enables the study of surfaces with atomic-scale spatial resolution and offers the ability to study individual atoms and molecules on surfaces. To study quantum spins with STM, we recently learned how to combine STM with electron spin resonance. Spin resonance gives us the means to quantum-coherently control an individual atomic or molecular spin on a surface. Using short pulses of microwave radiation further enables us to perform qubit rotations and learn about the quantum coherence times of our spins. Finally, we will demonstrate multi-qubit operations with spins on surfaces and discuss future research directions. Support from Institute for Basic Science (IBS-R027-D1) is gratefully acknowledged.
10:30		***Coffee Break***
		Chair: Teresa Montaruli, Université de Genève
11:00	**50**	**A matter of time, gravity and galaxies** *Sveva Castello, Université de Genève* Our understanding of the Universe relies on two pillars, gravity and dark matter. These are involved in compelling open questions: is the accelerated cosmic expansion due to gravity modifications? And does dark matter experience gravity in the same way as normal matter? I will discuss some insights about these issues that can be drawn from the observed distribution of galaxies. In particular, I will introduce you to the protagonist of my PhD thesis: the distortion of time, a novel observable that provides key information to disentangle gravity modifications from extended dark matter scenarios.

11:30	**51**	**Oscillating rings, IPT 2025** *Tamás Simon, Hannes Ischinger, ETH Zürich* We present the problem 'Oscillating rings' that won Switzerland first place at the IPT 2025. Take two ferromagnetic rings of different radii and tie them by a string. Connect another string to the larger ring at the same point. Now holding the whole construction by the second string, you can suspend it in the air by a magnet placed above. Being held only by these vertical strings, the rings are free to rotate around the vertical axis. We investigate their rotational motion based on the parameters of the system experimentally and compare these results with both theory and simulations.
		Chair: Sebastian Knauer, Universität Wien (ÖPG Young Minds)
12:00	**52**	**From Pen and Paper to Neural PDE Solvers:** **The Evolving Landscape of Computational Physics** *Claas Abert, TU Wien* This talk traces the evolution of computational physics from early hand-calculated climate models to modern high-performance simulations. Emphasis is placed on the numerical solution of partial differential equations (PDEs), highlighting how algorithmic strategies have adapted to increasingly parallel architectures. We conclude by exploring emerging approaches that integrate machine learning with physics-based modeling, such as physics-informed neural networks and neural operators, illustrating how these innovations are shaping the future of scientific computing.
12:30		***Poster Awards and Closing Ceremony***
12:45		***End; Lunch***
14:00		***Topical Sessions***
16:00		***CONFERENCE END***