Plenary Talk PLV I Mon 8:30 ZHG011
The Long Quantum Revolution — •Jürgen Renn — Max Planck Institute for Geoanthropologiy, Jena, Germany

The talk will review different phases of the quantum revolution with an emphasis on critical developments in the 1920s and the 1950s. On the basis of joint work in the context of the quantum project of the Max Planck Institute for the History of Science it will be shown how the exploration of the limits of classical physics yielded results that served as the scaffolding for the first quantum revolution of the 1920s. The talk will further argue that the second quantum revolution associated with the work of Clauser, Aspect, and Zeilinger goes back to the challenges to the Copenhagen interpretation by quantum dissidents like David Bohm.

Plenary Talk PLV II Mon 9:30 ZHG011
The Laser and fundamental quantum science — •Serge Haroche — Laboratoire Kastler Brossel, Collège de France, Paris, France

Among all the inventions born of quantum physics, the laser occupies an essential place, both for the rich history of discoveries that led to its birth, and for the role it plays today in fundamental and applied research. This history began at the time of the old quantum theory with Einstein's discovery of stimulated emission in 1916 and Stern's discovery of the spatial quantization of the atomic angular momentum in 1922. Nuclear magnetic resonance (1945), optical pumping (1952), atomic clocks and the maser (1954) followed, leading in 1960 to the invention of the laser.

This extraordinary light source plays an essential role in many modern technologies. It has also opened up fields of research in blue sky science that could not have been imagined at the time of its birth. 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 is a vivid illustration of the close link between fundamental research and technology

Plenary Talk PLV III Tue 8:30 ZHG011
The Quantum Roots of the Cosmos — •Gianfranco Bertone — University of Amsterdam, Amsterdam, 1098 XH, Netherlands

Quantum physics has far-reaching consequences beyond the microscopic: physicists tackling the greatest puzzles in cosmology - dark matter, dark energy and the Big Bang - routinely draw on their quantum field theory toolkit for answers. Gravitational-wave astronomy offers a new frontier to unlock these mysteries and forge a connection between the micro- and macrocosmos. As an example, I show how future interferometers will allow us to probe the matter surrounding black holes, opening up the possibility to discover new quantum fields, and to characterise the fundamental nature of dark matter.

Plenary Talk PLV IV Tue 9:30 ZHG011
Decoherence and Quantum Darwinism — •Wojciech Zurek — Los Alamos National Laboratory, USA

The measurement problem has been a central puzzle of quantum theory since its inception, and understanding how the classical world emerges from our fundamentally quantum Universe is key to its resolution. While the "Copenhagen" and "Many Worlds" interpretations have dominated discussion of this philosophically charged question, I will show how the physics of decoherence and the theory of Quantum Darwinism accounts for the emergence of classical reality.

Plenary Talk PLV V Tue 16:30 ZHG011
From Heisenberg in Göttingen to Quantum Information — •Anton Zeilinger — Austrian Academy of Sciences / University of Vienna, Austria

In the talk I will build a bridge from the early days of quantum mechanics to modern experiments. Heisenberg's role is particularly interesting as he also had very modern views of the interpretation which put knowledge of the observer in a central position. This can be seen in a modern way as putting information in the most central position.

Plenary Talk PLV VI Wed 8:30 ZHG011
The Higgs Boson and the Quantum Vacuum: Understanding Mass and Symmetry Breaking — •Beate Heinemann — DESY, Notkestr. 85, 22607 Hamburg, Germany

In 2012, the ATLAS and CMS collaborations at CERN announced the discovery of the Higgs boson * the quantum excitation of the scalar field responsible for electroweak symmetry breaking within the Standard Model of particle physics. This long-sought particle provides direct evidence for the Higgs mechanism, which explains how elementary particles acquire mass through their interaction with the Higgs field. The Higgs field constitutes an essential component of the quantum vacuum: its nonzero vacuum expectation value spontaneously breaks the electroweak symmetry, thereby endowing gauge bosons and fermions with mass.

In this talk, we will examine the theoretical framework of the Higgs mechanism and the role of the Higgs field in quantum field theory. We will discuss how spontaneous symmetry breaking shapes the structure of the Standard Model and consider the broader implications for our understanding of fundamental interactions and the vacuum structure of the universe. The presentation will also highlight the experimental challenges and milestones in the search for the Higgs boson, culminating in its discovery at the Large Hadron Collider. Particular emphasis will be placed on the key measurements, detector technologies, and the collaborative global effort that led to one of the most significant achievements in contemporary physics.

Plenary Talk PLV VII Wed 9:30 ZHG011
The Quantum Revolution in Metrology — •Klaus von Klitzing — Max Planck Institute for Solid State Research, Stuttgart, Germany

In celebration of the 2025 International Year of Quantum Science and Technology, this presentation will delve into the revolutionary impact of the quantum Hall effect on metrology. What began as fundamental research on silicon field-effect transistors culminated in the surprising discovery of the quantum Hall effect. This breakthrough ignited a paradigm shift in measurement science, paving the way for the worldwide implementation of an International System of Units (SI) based on constants of nature with e.g. a fixed value for the Planck constant to redefine the kilogram.

Plenary Talk PLV VIII Thu 8:30 ZHG011
Entanglement in quantum materials — •Silke Bühler-Paschen — Institute of Solid State Physics, TU Wien, Vienna, Austria

Entanglement is one of the most striking – and potentially most useful – phenomena in quantum physics. Over the past century, we've witnessed remarkable progress: from the discovery of the quantum nature of matter to the precise control and utilization of quantum states across a variety of platforms, with entanglement playing a pivotal role. Curiously, however, these advances have largely stalled at the doorstep of quantum materials – systems governed by the intricate interplay of multiple quantum degrees of freedom, and likely shaped in essential ways by their entanglement structure. In this talk, I will discuss recent developments in this field, focusing on the enigmatic "strange metal" state, which is uniquely suited to make progress.

Plenary Talk PLV IX Thu 9:30 ZHG011
Enabling optical quantum technologies with semiconductor quantum dots. — •Pascale Senellart — Université Paris-Saclay, Centre de Nanosciences et de Nanotechnologies, CNRS, 10 Boulevard Thomas Gobert, 91120, Palaiseau, France

Semiconductor quantum dots have emerged as excellent sources of single and entangled photons, opening new paths for light-based quantum technologies. We develop quantum light sources and spin-photon interfaces using InGaAs quantum dots embedded in microcavities. These devices generate highly indistinguishable single photons at high rates, and are now fiber pigtailed for plug-and-play operation. These sources are incorporated into early quantum computing prototypes together with integrated photonic chips and detectors. A software stack allows full control of the system and enables users to run small-scale quantum protocols.

To scale up the number of qubits and implement error correction, we are adopting measurement-based quantum computing protocols based on photonic graph states. By exploiting the spin degree of freedom of a charge trapped in a quantum dot, we can now generate various spin multi-photon entangled states. These results paves the way for hybrid quantum computing that leverage both spin and photonic qubits. As a first example, we analysed the resource requirements for implementing a logical qubit and showed that our hybrid approach can reduce the

number of components needed by six orders of magnitude compared to a fully photonic implementation.

Plenary Talk PLV X Fri 8:30 ZHG011

Quantum Simulation and Quantum Computing with Ultracold Atoms — •Immanuel Bloch — Ludwig Maximilians Universität, München, Germany — Max Planck Institute of Quantum Optics (MPQ), Garching, Germany

Quantum simulation has become a powerful interdisciplinary tool for probing quantum matter with microscopic resolution, both in and out of equilibrium. Platforms based on ultracold atoms in optical lattices and tweezers have played a crucial role in the development of the field, with applications ranging from strongly correlated electronic or spin systems to novel quantum optical light matter interfaces. These systems offer complementary insights to those obtained from advanced numerical methods. In particular, fermionic quantum simulators have begun to reveal new aspects of strongly interacting regimes that challenge conventional computational approaches. Alongside analog approaches, gate-based quantum computing offers broader universality, though it remains limited by scalability and error correction demands. Hybrid strategies combining both paradigms may offer a promising route to address complex quantum many-body problems in the near term.

This talk will survey recent progress, highlight key challenges, and discuss future directions at the interface of quantum simulation, computation, and many-body physics.

Plenary Talk PLV XI Fri 9:30 ZHG011

The hottest fluid on earth: characterizing deconfined quark-gluon matter at the Large Hadron Collider — •Anton Andronic — University of Münster, Germany

Deconfined quark-gluon matter, a state of matter which must have prevailed in our Universe in its first 10 microseconds of existence, is produced in collisions of nuclei at the Large Hadron Collider. I will discuss our knowledge and questions on the early thermalization of the hot and dense deconfined matter and focus on what we learned about its still-mysterious transition to hadrons with confined quarks and gluons.