Plenary Talk PV I Mon 9:00 Paulussaal
From quantum foundations to quantum communication technologies and back — •Nicolas Gisin — Group of Applied Physics, University of Geneva, Rue de l'Ecole de Médecine 20, 1205 Geneva, Switzerland — Constructor University, Geneva, Switzerland

Quantum information science emerged from studies on the foundations of quantum physics. I'll illustrate this, starting from Bell inequalities all the way to commercial Quantum Key Distribution and Quantum Random Number Generator chips. But the story doesn't stop here. Quantum information science, in turn, feeds back into the foundations, asking questions like, e.g., "how does non-locality manifest in quantum networks" and "how should one describe joint quantum measurements (especially when paying attention to energy conservation)".

Plenary Talk PV II Mon 9:45 Paulussaal
Frequency Combs and Dual-Comb Interferometry — •Nathalie Picqué — Max-Born Institute for Nonlinear Optics and Short Pulse Spectroscopy, Berlin, Germany — Max-Planck Institute of Quantum Optics, Garching, Germany — Humboldt University of Berlin, Germany

Optical frequency combs have revolutionized time and frequency metrology by providing rulers in frequency space that measure large optical frequency differences and/or straightforwardly link microwave and optical frequencies. Such combs enable precision laser spectroscopy, tests of fundamental physics and provide the long-missing clockwork mechanism for optical clocks.

One of the most successful applications of frequency combs beyond their original purpose has been dual-comb interferometry. An interferometer can be formed using two frequency combs of slightly different line spacing. Dual-comb interferometers without moving parts are fundamentally different from any other type of interferometers for broadband light sources: they perform direct frequency measurements, without geometric limitations to resolution. They outperform state-of-the-art devices in an increasing number of fields including spectroscopy and three-dimensional imaging, offering a unique host of features such as frequency measurements, accuracy, precision, speed.

This talk will provide an introduction to dual-comb interferometry and will survey its latest exciting developments.

Plenary Talk PV III Tue 9:00 Paulussaal
Roller coaster with cold molecules — •Ed Narevicius — TU Dortmund

Quantum effects play a central role in low temperature collisions. Particularly important is the formation of metastable scattering resonances that lead to temporary trapping of the colliding particles. Observation of such states has long been limited to laser cooled species, leaving chemically relevant molecules such as hydrogen out of reach. I will present our method that uses high magnetic field gradients to merge two molecular beams circumventing the laser cooling step. It allows us to perform collisions with molecular hydrogen at energies reaching 0.001 K. I will show the fingerprints of quantum resonances on observable properties and also highlight the astounding effect of the internal molecular structure and symmetry. Finally, I will discuss how a moving magnetic trap decelerator can serve as stepping stone towards the direct laser cooling of diatomic radicals.

Plenary Talk PV IV Tue 9:45 Paulussaal
Highly Charged Ion Optical Clocks to Test Fundamental Physics — •Piet O. Schmidt — Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — Leibniz Universität Hannover, Hannover, Germany

The extreme electronic properties of highly charged ions (HCI) make them highly sensitive probes for testing fundamental physical theories while reducing systematic frequency shifts, making HCI excellent optical clock candidates. The technical challenges that hindered the development of such clocks have now all been overcome, starting with their extraction from a hot plasma and sympathetic cooling in a linear Paul trap, readout of their internal state via quantum logic spectroscopy, and finally the preparation of the HCI in the ground state of motion of the trap. Here, we present the first operation of an atomic clock based on an HCI (Ar^{13+} in our case) and a full evaluation of systematic frequency shifts. The achieved uncertainty is almost eight orders of magnitude lower than any previous frequency measurements using HCI and comparable to other optical clocks. By comparing the isotope shift between $^{36}Ar^{13+}$ and $^{40}Ar^{13+}$ the theoretically predicted QED nuclear recoil effect could be confirmed. Finally, first results on the search for a 5^{th} force based on isotope shift spectroscopy of Ca^{+}/Ca^{14+} isotopes will be presented. This demonstrates the suitability of HCI as references for high-accuracy optical clocks and to probe for physics beyond the standard model.

Plenary Talk PV V Wed 9:00 Paulussaal
Is physics timeless ? — •Jan Michael Rost — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

Time has always fascinated and puzzled humanity and plays a role in very different contexts, from society, to individual living beings, to fundamental laws of nature. In quantum mechanics, time has the peculiar property that it is a parameter and not an operator. In this talk we will try to understand time and this quantum property by arguing that time is not fundamental but emerges upon separation of systems. More specifically, we will derive from the heavily entangled eigenstate of a global Hamiltonian comprising the system and its environment the time-dependent Schroedinger equation for the system under interaction of system and environment. Tanking this relational time approach one step further, thermodynamics for the system can also be derived with complex relational time as emergent from a structureless, global energy eigenstate.

Plenary Talk PV VI Wed 9:45 Paulussaal
Investigating the atomic and nuclear structure of the heaviest elements — •Michael Block — GSI Helmholtzzentrum für Schwerionenforschung, 64291 Darmstadt — Helmholtz-Institut Mainz, 55099 Mainz — Johannes Gutenberg-Universität Mainz, 55099 Mainz

The study of heavy and superheavy elements is a multi-faceted field of science. The heaviest of the 118 presently known chemical elements show pronounced features of relativistic effects impacting their atomic level structure and their chemical properties. With $Z\alpha \approx 1$ also quantum electrodynamics effects also become important. Moreover, superheavy nuclei are in the focus of nuclear physics with distinct features different from lighter nuclei. Their existence is thanks to nuclear shell effects that stabilise them against the disintegration by spontaneous fission due to the strong Coulomb repulsion. This is predicted to eventually result in a central depression of the nuclear charge distribution for even to give rise to specific shapes such as bubble nuclei. The experimental study of the heaviest elements is challenging as they can only be produced artificially in nuclear reactions at accelerator facilities in atom-at-a-time quantities and are often short-lived. In recent years, we have established tailored experimental methods allowing us to extend the reach of Penning-trap mass spectrometry and resonant ionisation laser spectroscopy to heavy elements well beyond uranium. In my talk I will present the latest results on mean-square charge radii of fermium and nobelium isotopes as well as mass measurements of nuclides up to dubnium isotopes.

Plenary Talk PV VII Thu 9:00 Paulussaal
Electronic molecular movies at FLASH — •Markus Gühr — Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, 22607 Hamburg — Institute of Physical Chemistry, University of Hamburg, Grindelallee 117, 20146 Hamburg

The conversion of light energy into molecular energy forms, such as bond formation, charge transfer, and heat, results from a concerted and ultrafast motion of electrons and nuclei. This phenomenon frequently occurs under the breakdown of the Born-Oppenheimer approximation. This presentation focuses on ultrafast experiments conducted at the free-electron laser FLASH aimed at resolving the underlying electronic molecular dynamics with soft X-ray probe pulses. Utilizing the element and site specificity of soft X-rays, we extract details about valence electron dynamics on a femtosecond time scale, achieving atomic spatial resolution. Furthermore, we will present a complementary perspective on changes in nuclear geometry, providing a comprehensive understanding of the interconnected electron-nuclear dynamics in molecular photoenergy conversion.

The presentation will also provide an overview of the atomic and molecular science program at FLASH, highlighting new opportunities arising from increased coherence resulting from externally seeded operations at high repetition rates.

Plenary Talk PV VIII Thu 9:45 Paulussaal
Continuous Frontiers for Quantum Measurements — •Birgitta Whaley — University of California, Berkeley

Quantum measurements are an essential component of quantum information science and technology but are often presented only within discrete formulations. Continuous weak measurements provide a versatile framework for monitoring quantum systems that can be integrated with feedback onto both unitary and dissipative measurement controls, allowing for a broad range of applications to key quantum information tasks. I shall describe examples of such control to superconducting qubit platforms where this enables high fidelity generation of large-scale entangled states, continuous quantum error correction, implementation of quantum gates and quantum state steering ('dragging') by continuously implemented quantum Zeno dynamics and realizing controlled non-Hermitian quantum dynamics.

Evening Talk PV IX Thu 20:00 Paulussaal

Von der Sonne lernen - Ein Stern als Physiklabor — •Oskar von der Lühe — Leibniz-Institut für Sonnenphysik, Freiburg i. Br.

Die Sonne ist der uns nächste Stern und zeigt die auf und in Sternen vorkommenden physikalischen Phänomene in einem Detail, welches die anderen Sterne aufgrund ihrer großen Entfernung nicht vermögen. Viele fundamentale physikalische Prozesse wurden zuerst auf der Sonne entdeckt, bevor sie bei anderen Sternen nachgewiesen werden konnten. Dazu benutzen die Forscher seit 150 Jahren Teleskope, welche speziell für die Sonnenbeobachtung entworfen wurden. Dieser Vortrag führt durch die Geschichte der Sonnenteleskope und erläutert die damit gewonnenen physikalischen Erkenntnisse. Eine besondere Rolle spielt der Beitrag der Sonnenforschung in Freiburg.

Plenary Talk PV X Fri 9:00 Paulussaal

Search as (quantum) selforganized process — •Giovanna Morigi — Theoretical Physics, Saarland University

Efficient retrieval of information is a core operation in the world wide web, is essential for the sustainance of living organisms, and is a paradigm for optimization algorithms. Inspired by the food search of living organisms, we model a search mechanism on a graph with multiple constraints where the dynamics is a selforganized process resulting from the interplay of coherent dynamics and noise. We show that noise can be beneficial leading to a significantly faster convergence to the optimal solution. We then analyse adiabatic quantum searches that are assisted by stochastic dynamics and discuss when their efficiency can outperform the one of the coherent counterparts.

Plenary Talk PV XI Fri 9:45 Paulussaal

Listening to, and learning from, ultrafast few-body quantum dynamics in intense laser fields — •Thomas Pfeifer — Max-Planck-Institut für Kernphysik

Interactions of electrons govern everything we touch and see around us. While manifesting on human timescales ($>$ milliseconds (10^{-3} s)), the electronic timescale within atoms ticks in attoseconds (10^{-18} s). Their fast "heartbeat" makes these lightest charged fundamental particles respond quickly even to the electric fields of light, with their optical-cycle periods of femtoseconds (10^{-15} s). Coulomb forces bind electrons to nuclei in atoms, i.e. Angstrom-sized electron traps with internal quantum states observed by resonant driving with light, also giving objects their color. *But what happens when the light becomes so intense that electrons are pushed far outside their "comfort zone"?*

This question fascinates physicists since the invention of the laser. Its constant evolution now allows concentrating light in spacetime to (by far) exceed the Coulomb binding forces. Control over the coherent fields of light renders the steering of electrons in matter a reality—requiring "only" our understanding of *intense-light*–matter interaction on a fundamental level, involving the motion of at least two coupled electrons (the quantum few-body problem).

This talk will explain our ongoing quest of ultrafast quantum control of two or more bound electrons, show examples of what has been understood already, and shine light into the widely open future, where e.g. laser-programmed atoms may one day perform (quantum-)computational tasks at Terahertz (or faster) clock speeds.