Plenary Talk PLV I Mon 8:30 H1

Intrinsic Josephson junctions in $Bi_2Sr_2CaCu_2O_8$: Generation of Terahertz radiation and beyond — •Reinhold Kleiner — Physikalisches Institut, Center for Quantum Science (CQ) and LISA$^+$, Universität Tübingen

The layered superconductor $Bi_2Sr_2CaCu_2O_8$(BSCCO) is known to intrinsically form a stack of Josephson tunnel junctions (IJJs). Each junction is formed by adjacent superconducting CuO_2 layers and the insulating BiO and SrO layers in between. Due to the fact that the BiO layers are coupled by van der Waals forces, stacks of consisting of only a few IJJs up to several thousands of IJJs can be created by using exfoliation methods combined with lithography. After an initial phase of investigations on small-sized stacks, in recent years the focus was on the generation of terahertz (THz) radiation, making use of stacks consisting of a large number of IJJs. The stacks mainly radiate in the frequency range between 0.5 THz and 2 THz, which inside the so-called THz gap. Beyond THz generation BSCCO received attention in the context of 2D materials and it was also shown recently that IJJ stacks can host electromagnetic modes acting as a discrete classical space-time crystal, developing periodic order both in space and time. In the talk, after some introduction, I will present the recent status on the field of THz generation. I will then turn to the possible realization of a discrete space-time crystal based on BSCCO IJJ stacks.

Plenary Talk PLV II Mon 14:00 H1

Topology and Chirality — •Claudia Felser — Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — Laureate of the Max-Born-Prize 2022

Topology, a well-established concept in mathematics, has nowadays become essential to describe condensed matter. At its core are chiral electron states on the bulk, surfaces and edges of the condensed matter systems, in which spin and momentum of the electrons are locked parallel or anti-parallel to each other. Magnetic and non-magnetic Weyl semimetals, for example, exhibit chiral bulk states that have enabled the realization of predictions from high energy and astrophysics involving the chiral quantum number, such as the chiral anomaly, the mixed axial-gravitational anomaly and axions. The potential for connecting chirality as a quantum number to other chiral phenomena across different areas of science, including the asymmetry of matter and antimatter and the homochirality of life, brings topological materials to the fore.

Plenary Talk PLV III Mon 14:00 H2

Controlling and exploiting defects in diamond for Quantum Technologies — •Mark Newton, Ben Green, Chloe Newsom, Imogen Gullick, and Gloria Zhao — Department of Physics, University of Warwick, Coventry UK

Point defects in diamond have great potential for use in a range of quantum technologies. For example as single photon sources and quantum bits that can be exploited in quantum information processing and as the heart of sensors that will transform the way we do analytical science and medical imaging. The negatively charged nitrogen-vacancy centre is an amazing defect in diamond that possesses properties highly suited to many of these applications. However, it does have some challenging weaknesses and full exploitation of the optical and spin properties of this and other defects necessitates that we control their position, orientation and environment to optimise all of the desirable properties simultaneously, especially near the surface of the diamond. I will review our understanding of the production of intrinsic defects and present new data on the creation of defect complexes by doping, electron irradiation, short pulse laser irradiation, ion implantation and annealing. The success and failure of different combinations of processing steps to control and optimise the local defect environment will be discussed and the ongoing search for alternate colour centres with comparable spin properties and superior optical properties will be reviewed.

Plenary Talk PLV IV Tue 8:30 H1

Insights from Atomic-Scale Studies on Surfaces — •Ulrike Diebold — Institute of Applied Physics, TU Wien, Vienna, Austria

The arrangement of the top layer of atoms on a solid and the resulting electronic and chemical properties affect and sometimes even dominate its functionality. In the talk, I will showcase how we can use basic physical phenomena – tunneling, diffraction, and change in resonance frequencies – to measure surface properties in an atom-by-atom fashion. Such experiments can be interlinked tightly with theoretical computations by investigating well-defined samples in a controlled environment. Examples include assessing the acidity of individual surface atoms, pushing the size of catalytically-active nanoclusters to their physical limit, and extending ultrahigh-vacuum experiments to the liquid phase.

Plenary Talk PLV V Wed 8:30 H1

Towards useful quantum computing with superconducting qubits — •Rami Barends — Institute for Functional Quantum Systems (PGI-13), Forschungszentrum Jülich

One of the outstanding scientific challenges of this decade is the construction of an architecture and development of a methodology that can enable useful quantum computing. Superconducting quantum circuits have demonstrated unparalleled performance, by outperforming the world's most powerful supercomputers on a specific sampling task. Yet, applying quantum computing to real-world problems has remained elusive. The performance of current systems is limited, and the development of algorithms that make efficient use of present-day hardware is only starting. I will discuss the challenges in going from the current exploratory phase towards one where addressing real-world problems could be accomplished.

Plenary Talk PLV VI Wed 14:00 H1

Disordered Solids — •Annette Zippelius — Institut für Theoretische Physik, Universität Göttingen, 37077, Germany — Laureate of the Max-Planck-Medal 2022

We discuss a phase of matter which is characterized by 1) random localization of the atoms or molecules and 2) a finite restoring force for static shear deformations. The following questions will be addressed: What is an appropriate order parameter for the amorphous solid state? How can we characterize its random structure? How do long range elastic correlations develop at the glass transition? These questions will be discussed by means of a statistical mechanical theory of disordered system as well as generalized hydrodynamics.

Plenary Talk PLV VII Wed 14:00 H2

Topological insulator lasers — •Mordechai Segev — Technion - Israel Institute of Technology

Topological Insulator Lasers are arrays of semiconductor lasers arranged on a photonic chip in a way that endows them with topological features. We utilize the topological features of robustness and nonzero group velocity, both associated with the topological edge states, to force injection locking of tens of semiconductor lasers, eventually giving rise to many lasers working together as a single high order radiation source. The concepts of topological insulator lasers will be reviewed, while current challenges and recent progress will be described.

Plenary Talk PLV VIII Thu 8:30 H1

Physics of Structure Formation in Living Systems — •Stephan Grill — MPI-CBG, Dresden

One of the most remarkable examples of self-organized structure formation is the development of a complex organism from a single fertilized egg. With the identification of many molecules that participate in this process of morphogenesis, attention has now turned to capturing the physical principles that govern the emergence of biological form. What are the physical laws that govern the dynamics and the formation of structure in living matter? Much of the force generation that drives morphogenesis stems from the actomyosin cortical layer inside cells, which endows the surface of the cell with the ability to generate active forces and stresses that can drive reshaping. We combine theory and experiment and investigate how the actomyosin cell cortex self contracts, reshapes and deforms, and how these physical activities couple to regulatory biochemical pathways to give rise to the emergence of shape in living systems.

Plenary Talk PLV IX Thu 14:00 H1

Evolutionary transitions: universality, complexity and predictability — •Ricard Sole — Universitat Pompeu Fabra, Barcelona, Spain — Santa Fe Institute, Santa Fe, USA

The evolution of life in our biosphere has been marked by several major innovations. Such major complexity shifts include the origin of cells, genetic codes or multicellularity to the emergence of language, cognition or even consciousness. Understanding the nature and conditions for evolutionary innovation is a major challenge for evolutionary biology. Along with data analysis, phylogenetic studies and dedicated experimental work, theoretical and computational studies are an essential part of this exploration. With the rise of synthetic biology,

evolutionary robotics, artificial life and advanced simulations, novel perspectives to these problems have led to an emerging new synthesis, where evolutionary innovations can be understood in terms of phase transitions, as defined in physics. Such mapping (if correct) would help in defining a general framework to establish a theory of evolutionary change and the role played by chance and constraints in shaping living complexity.

Plenary Talk PLV X Thu 14:00 H2

Semiconductor quantum optics: from artificial atoms to atomically thin materials — •Jonathan Finley — Walter Schottky Institut, Am Coulombwall 4, 85748 Garching, Germany

Optically active confined spins in solids such as III-V semiconductor quantum dots (QDs), colour centres in diamond and atomic-scale defects in 2D-semiconductors are of interest for a wide range of applications in quantum science and technology. For example, in the context of photon-based quantum communication and computation electron and hole spins localized in single QDs can be used for the high rate ($\sim GHz$) on-demand generation of single photons with excellent Hong-Ou-Mandel (HOM) quantum indistinguishability, as well as entangled multi-photon cluster states. We will explore the factors currently limiting the performance of QD based non-classical light sources and discuss how methods derived from the quantum optical toolbox, such as incoherent spin pumping and coherent quantum state preparation can be used to both suppress unwanted re-excitation processes, that lead to multi-photon errors, while precisely timed stimulation pulses reduce the timing jitter of emitted photons, leading to much improved HOM indistinguishability. For few-spin systems hosted by electrically tunable QD-molecules, we will show how selective optical-charge generation can be used to suppress coupling of S-T spin states to electric and magnetic field fluctuations. Finally, we will explore how spin states in 2D-semiconductors are highly sensitive to lattice and macroscopic vibrational modes, providing interesting perspectives in quantum sensing and metrology.

Plenary Talk PLV XI Fri 8:30 H1

Spinwaves as experimental probes — •Christian Back — Physik-Department, TU München, Garching, Germany

Spin waves - the dynamic eigenmodes of magnetically ordered systems - are suitable as potential information carriers in future nanoscale microwave devices with frequencies ranging from a few GHz to several THz. It has been shown that their frequency, amplitude and phase can be relatively easily controlled. In this talk, I will revisit some of the fundamental properties of spin waves in thin magnetic films, show how we can image them with high resolution, and give examples of how they can also be used to detect fundamental properties such as spin-orbit fields.