Symposium SKM Dissertation Prize 2023 (SYSD)

jointly organised by
the divisions of the Condensed Matter Section (SKM)

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The divisions belonging to the Condensed Matter Section (SKM) of the DPG annually award the SKM Dissertation Prize. The prize acknowledges outstanding research during the PhD work in the research areas of SKM completed in 2021 or 2022, and its excellent oral presentation. Based on nominations, a jury consisting of the chairpersons of all SKM divisions has selected five finalists for the award to present their work in this symposium. The winner will be selected after the symposium and publicly announced Tuesday, March 28th in the afternoon during the ceremonial session.

Overview of Invited Talks and Sessions

(Lecture hall HSZ 04)

Invited Talks

SYSD 1.1	Mon	9:30–10:00	HSZ 04	**Diffusion of antibodies in solution: from individual proteins to phase separation domains** — •Anita Girelli
SYSD 1.2	Mon	10:00–10:30	HSZ 04	**Intermediate Filament Mechanics Across Scales** — •Anna V. Schepers
SYSD 1.3	Mon	10:30–11:00	HSZ 04	**Ultrafast Probing and Coherent Vibrational Control of a Surface Structural Phase Transition** — •Jan Gerrit Horstmann
SYSD 1.4	Mon	11:00–11:30	HSZ 04	**Electro-active metasurfaces employing metal-to-insulator phase transitions** — •Julian Karst
SYSD 1.5	Mon	11:30–12:00	HSZ 04	**The role of unconventional symmetries in the dynamics of many-body systems** — •Pablo Sala

Sessions

SYSD 1.1–1.5	Mon	9:30–12:00	HSZ 04	**SKM Dissertation Prize**

SYSD 1: SKM Dissertation Prize

Time: Monday 9:30–12:00 Location: HSZ 04

Invited Talk SYSD 1.1 Mon 9:30 HSZ 04

Diffusion of antibodies in solution: from individual proteins to phase separation domains — •Anita Girelli — Universität Tübingen, Tübingen, Germany — Stockholm University, Stockholm, Sweden

We investigated the diffusion of a model system for liquid-liquid phase separation (LLPS), which is a biological mechanism for the formation of intracellular organelles. The solution of γ-globulin and PEG spontaneously separates and reaches a gel state due to the high concentration of the more concentrated of the two phases. The hierarchy of motions requires to probe the sample from nanometers to micrometers and time scales from picoseconds to hundreds of seconds. We achieved this by combining light, neutron, and X-ray scattering. At LLPS domains length scale, X-ray photon correlation spectroscopy (XPCS) reveals correlation functions which show typical characteristics of ballistic motion as seen for colloidal gels [1]. The experimental results are compared with simulated data based on the Cahn-Hilliard equation. Qualitative comparability is obtained by adding a strong dependence of the protein mobility on protein concentration. The validity of this assumption is confirmed by probing the diffusion on the protein length scale and below with neutron quasi-elastic scattering and XPCS [2,3]. The combination of Neutron Spin Echo and XPCS allows to access the diffusion at protein length scale over 10 orders of magnitude.

[1] Girelli et al., PRL 126 (13), 2021. [2] Girelli et al., Mol. Pharm. 18 (11), 2021.[3] Reiser et al., Nat. Comm., 13,2022.

Invited Talk SYSD 1.2 Mon 10:00 HSZ 04

Intermediate Filament Mechanics Across Scales — •Anna V. Schepers — Rosalind Franklin Institute and University of Oxford, UK — Georg-August University Göttingen, DE

The mechanical properties of cells are largely determined by the cytoskeleton, an intricate and complex structure formed by protein filaments, motor proteins, and crosslinkers. The three main types of protein filaments are microtubules, actin filaments, and intermediate filaments (IFs). Whereas microtubules and actin filaments are exceptionally conserved, the family of IFs is diverse. The variety of IF proteins is potentially linked to the various mechanics of different cell types. We combined studies of IF mechanics on different time scales and in systems of increasing complexity, from single filaments to networks in cells. This multiscale approach allows us to interpret observations from simplified system while adding increasing physiological context in subsequent experiments. We focussed on the tunability of IF mechanics by environmental cues. In a series of experiments, including single filament stretching measurements and filament-filament interaction measurements with optical tweezers, microrheology, and cell stretching, we characterised how electrostatic and hydrophobic interactions provide mechanisms by which the IF cytoskeleton can be tuned. The studies revealed how small changes influence IF mechanics on multiple scales. In combination with simulations, we characterised how charge shifts alter single filament mechanics. Such insights provide a deeper understanding of the mechanisms by which cells can maintain their integrity and mechanically adapt to their environment.

Invited Talk SYSD 1.3 Mon 10:30 HSZ 04

Ultrafast Probing and Coherent Vibrational Control of a Surface Structural Phase Transition — •Jan Gerrit Horstmann — Max Planck Institute for Multidisciplinary Sciences, Göttingen, Germany — Dept. of Materials, ETH Zürich, Zürich, Switzerland

The desire to exert active optical control over matter is a unifying theme across multiple scientific fields. In femtochemistry, multi-pulse optical excitation schemes exploit coherences in decisive electronic and vibrational degrees of freedom of molecules to influence the efficiencies of chemical reactions. The application of this concept to solid-state systems is, however, complicated by, e.g., the high electronic and vibrational density of states, or couplings to an external heat bath. In this respect, low-dimensional and strongly correlated systems represent a promising intermediate between molecules and bulk solids, with phase transitions assuming the role of a ‘reaction’.

In this talk, I report on the coherent vibrational control of a metal-insulator structural phase transition in a quasi-one-dimensional surface system, namely, atomic indium wires on the (111) surface of silicon. By analogy with repeatedly pushing a child on a swing, we use timed sequences of femtosecond light pulses to manipulate the amplitudes of key phonon modes connecting the insulating and metallic phases, thereby steering the system across the transition state. Our results confirm the applicability of coherent control tactics from femtochemistry to solids, creating not only strong conceptual links between the two fields, but also providing a new handle to switch the chemical and physical functionalities of materials on ultrafast time scales.

Invited Talk SYSD 1.4 Mon 11:00 HSZ 04

Electro-active metasurfaces employing metal-to-insulator phase transitions — •Julian Karst — 4th Physics Institute and Research Center SCoPE, University of Stuttgart, Germany

Functional and active plasmonic nanostructures and metasurfaces are at the heart of emerging and novel optical technologies as they allow to confine and actively manipulate light on very small length scales. Ultimately, they will contribute to the miniaturization of existing and novel optical devices necessary in a great variety of different fields. They include but are not limited to new display and projection technologies for augmented and virtual reality, dynamic 3D holography devices or miniaturized LiDAR (Light Detection and Ranging) approaches. I will introduce and give an in-depth analysis of our novel approaches for such functional and active plasmonic systems and metasurfaces, utilizing metal-to-insulator phase change materials. In particular, I will highlight nanoantennas and metasurfaces from metallic polymers which can be electrically switched in the infrared spectral range via CMOS-compatible voltages. This concept is based on an electrically driven metal-to-insulator phase transition and allows me to demonstrate, on the one hand, metasurfaces for ultra-high-contrast active beam switching. On the other hand, I realize an electro-active metaobjective comprising metalenses-on-demand. By using gel electrolytes, the presented metadevices can even be integrated into state-of-the-art on-chip electro-optic components.

Invited Talk SYSD 1.5 Mon 11:30 HSZ 04

The role of unconventional symmetries in the dynamics of many-body systems — •Pablo Sala — California Institute of Technology (Caltech), Pasadena, United States

Symmetries are essential to classify equilibrium phases of matter and to explain how thermal equilibrium is attained. In this talk, we explore the role that certain unconventional symmetries play in the dynamics of many-body systems.

To begin with, we show that the conservation of a charge and its associated dipole moment leads to a provable fragmentation of the Hilbert space into exponentially many disconnected sectors. In turn, this can translate into non-vanishing bulk correlators and the existence of localized among other unexpected phenomena. In general, we find that this conservation leads to novel universal hydrodynamic behavior, which can coexist with initial states that avoid thermalization, hence providing examples of weak ergodicity breaking.

We then show that dipole-conserving models become good approximations of strongly-tilted interacting systems. In fact, the high level of control of current experimental platforms makes these phenomena accessible to present-day experiments. We use our previous insights to analyze experimental results obtained via ultracold atoms, where the system is observed to remain localized at accessible times.

We conclude by revisiting the notion of symmetry from a broader perspective. In particular, we inquire about what spatially-modulated symmetries a system can have, providing a novel approach to realize some of them.