BP 35: Focus Session: 75 Years Division Polymer Physics: From Curiosity to Smart Materials (joint session CPP/BP)

Polymer materials are ubiquitous in modern society. In recent years, the focus has been on the development of functional, tunable or responsive materials, oftentimes inspired by biological materials. At this, a number of fundamental problems arise, e.g. regarding the interaction of polymers with water, biomolecules or inorganic nanoparticles and the resulting self-assembled morphologies as well as the underlying dynamics and the kinetics of morphological changes upon a stimulus. These problems are nowadays addressed in an interdisciplinary way by experimental methods, computer simulations and theory, often in close collaboration with polymer chemists. In five talks by renowned speakers, the focus session aims at highlighting few of these aspects that are currently under investigation worldwide. The fact that the Polymer Physics Division of the German Physical Society was founded in 1951 and hence, 2026 is the 75th anniversary, seems to be a good occasion to bring modern polymer physics into the focus.

Organized by Christine M. Papadakis, Christian Holm, Tayebeh Ameri and Kristian Franze.

Time: Thursday 15:15–17:45 Location: ZEU/LICH

Topical Talk BP 35.1 Thu 15:15 ZEU/LICH
The Loops of Life — Brian Chan and •Michael Rubinstein — Duke University, Durham, NC, USA

In mammalian cells, the cohesin protein complex is believed to regulate chromatin during interphase through active loop extrusion, in which dynamic loops are formed by cohesin translocating along chromatin. We developed a theoretical model that quantifies how key parameters, including cohesin residence time on chromatin, extrusion velocity, and the number density of chromatin-bound cohesins, regulate genomic contacts. The model describes chromatin contact probabilities and predicts that loop formation probability is a nonmonotonic function of loop length. Our theory demonstrates that active loop extrusion causes the apparent fractal dimension of chromatin to cross over between two and four at contour lengths on the order of 30 kilobase pairs. This work provides a theoretical basis for the compact organization of interphase chromatin, explaining the physical reason for the segregation of topologically associated domains and suppression of chromatin entanglements by up to a factor of 50, which contributes to efficient gene regulation by distal elements such as enhancers or silencers.

Topical Talk BP 35.2 Thu 15:45 ZEU/LICH
Polyelectrolytes and Biological Systems: A Charged Relationship — •Matthias Ballauff — Chemie und Biochemie, Freie Universitaet Berlin

If charges are appended to linear or crosslinked polymers, a polyelectrolyte results. Polyelectrolytes are ubiquitous and play a major role in biophysics. Important natural polyelectrolytes as e.g. DNA or Heparin are central in biology, and a thorough understanding of these systems and of charge-charge interaction is one of the main tasks of biophysics. In my lecture, I will discuss our recent research done on -Interaction of linear polyelectrolytes with proteins. This problem is also relevant for the formation of biocondensates by the interaction of cationic and anionic proteins; -Charged polymer networks and their interaction with proteins; -Role of polyelectrolytes in virus infections. In all cases, a quantitative understanding of the systems in terms of analytical models can be achieved, which may pave the way for future pharmaceutical applications.

Topical Talk BP 35.3 Thu 16:15 ZEU/LICH
From block copolymer morphologies to functional polymer membranes — •Volker Abetz — Helmholtz-Zentrum Hereon, Institute of Membrane Research, Max-Planck-Str. 1, 21502 Geesthacht, Germany — University of Hamburg, Institute of Physical Chemistry, Martin-Luther-King-Platz 6, 20146 Hamburg, Germany

Depending on solvent selectivity and the time of evaporation different structures can be obtained in cast block copolymers, showing that there is an interplay between kinetics and thermodynamic driving forces during the self-assembly before the sample is dry. When preparing membranes from block copolymer solutions, besides molecular weight, composition of the block copolymer and its concentration, also the choice of solvent, and the casting conditions play an important influence on the obtained morphology of the finally obtained membrane. This is especially important when membranes are prepared via the so-called non-solvent induced phase separation process after initial self-assembly by partial evaporation of solvent. The obtained membranes, when prepared successfully, display a rather isoporous top layer and can be subsequently post functionalized, in order to tune pore size and pore surface property. Different examples of the separation properties will be shown and also the potential use as a membrane reactor will be discussed.

Topical Talk BP 35.4 Thu 16:45 ZEU/LICH
Molecular electronic materials and devices for solar energy conversion — •Jenny Nelson — Imperial College London

To maximize the potential of solar power, new materials will be needed to harvest and convert solar energy alongside existing photovoltaic technologies. Molecular electronic materials, such as conjugated polymers and molecules, can achieve photovoltaic conversion through a process of photon absorption, charge separation at a heterojunction, and charge collection. Through a remarkable series of advances in materials design, the efficiency of photovoltaic energy conversion in molecular materials has risen from 1% to over 20% within two decades. We will discuss the factors that control the function of molecular solar cells including the nature of the charge separating heterojunction, and the impact of chemical and physical structure on phase behaviour, energy and charge transport, light harvesting, and loss pathways, comparing experimental measurements with a computational model of the generation and evolution of excited states and charges in such systems. We identify key molecular parameters that are likely to assist charge generation and consider the extent to which these parameters are optimised in the best performing materials. Finally, we will address the limits to conversion efficiency in such systems.

Topical Talk BP 35.5 Thu 17:15 ZEU/LICH
Control of cell and tissue stiffness by biopolymer networks and particle inclusions — •Paul Janmey — University of Pennsylvania, Philadelphia, PA, USA

Filamentous networks of semiflexible polymers are ubiquitous in biology. Collagen fibers form much of the extracellular matrix, the cytoskeleton controls cell mechanics, and chromatin fibers span the volume of the nucleus. The mechanical properties of the biopolymer fibers, the way in which the fibers link into networks, and the types of cells within the network all affect the way in which tissues respond to mechanical stress.