SYDI 1: SKM Dissertation Prize 2009

Time: Monday 10:30–12:30 Location: BAR SCHÖ

SYDI 1.1 Mon 10:30 BAR SCHÖ

Relativistic Brownian motion and thermodynamics — •Jörn Dunkel — Rudolf Peierls Centre for Theoretical Physics, University of Oxford, UK

Over the past century Brownian motion theory has vastly contributed to our understanding of microscopic and mesoscopic phenomena. Originally proposed as a phenomenological paradigm of atomistic matter interactions, the original theory has since evolved into a vivid research area, with an ever increasing number of applications in biology, chemistry, finance, and physics. In this talk, I am going to discuss how Brownian motion concepts can be embedded into a relativistic framework. I will provide a brief historical survey, summarize applications, and compare different theoretical approaches and their respective implications. Finally, I intend to address closely related, basic questions in relativistic thermodynamics, such as the definition and the Lorentz transformation behavior of relativistic thermodynamic quantities.

SYDI 1.2 Mon 11:00 BAR SCHÖ

OLEDs Setting Out in New Directions – From Displays to Sensors — •Malte C. Gather — Department Chemie, Universität zu Köln, Germany

When organic light-emitting diodes (OLEDs) were developed some 20 years ago, the focus was on their implementation as light sources in flat-panel displays. Despite the great technical challenges faced at that time – especially with regard to their insufficient lifetime – displays consisting of hundreds of thousands of red, green and blue emitting OLEDs are now being commercialized. In close conjunction with the technologically driven development, the academic work on OLEDs and on aromatic hydrocarbons – the material class, on which these devices are based – grew into a very respectable field of research. And while much of the industrial work still focuses on the display market, the academic work greatly benefits from the tremendous progress achieved over the last few years, for example by borrowing the technology for new device configurations, which of course all pose interesting new scientific questions. My talk will reflect this exchange between (1) the very much display-oriented work on OLEDs, (2) the thorough characterisation, modelling and optimization of these devices, and (3) the transfer of the technology to novel applications, for example in metrology.

Defining lateral structure in organic semiconductors at micron resolution has turned out difficult but is essential for example to fabricate the red, green and blue emitting pixels of a full-colour display. An interesting approach to achieve this is to use so called “smart photoresists” which are electroluminescent and/or semi-conducting organic materials that can be structured by conventional photolithography in very much the same way as a photoresist. This is of special interest for high-resolution displays or microdisplays where the required resolution is not accessible with competing technologies such as ink-jet printing. I will describe the development of the smart photoresist process and present results on the first prototype of a full-color OLED display based thereon.[1]

Apart from the increasingly apparent commercial value of this new technique, the smart photoresist method is also a very useful tool for basic science: One can use the technique to define stacks consisting of an unlimited number of layers of different materials.[2,3] For example one can confine the emissive layer to a thin sheet with a thickness of a few nanometres and thus study thin-film interference effects in active devices. In combination with electromodulation spectroscopy, such devices can also be used to investigate the electric field distribution within OLEDs.[4]

Since the smart photoresist process enables defining virtually any micro or nano-structure in an organic semiconductor, completely new device concepts become feasible. One example are light sources for “lab-on-a-chip” systems: By sandwiching an electroluminescent material with a relatively high refractive index between to layers of hole and electron conducting materials of lower refractive index, a waveguide structure is formed. If electrodes are applied to the two outer layers this waveguide can be electrically pumped, with the generated radiation being guided in the core layer of the waveguide.[5] Because organic semiconductors can be more easily processed on glass or flexible substrates than their inorganic counterparts, this self-emissive waveguide structure might prove very useful as a light source on future lab-on-a-chip systems or highly integrated sensors.

[1] M. C. Gather, A. Köhnen, A. Falcou, H. Becker, K. Meerholz, *Adv Funct Mater* **2007**, *17*, 191.
[2] N. Rehmann, C. Ulbricht, A. Köhnen, P. Zacharias, M. C. Gather, D. Hertel, U. S. Schubert, K. Meerholz, *Adv Mater* **2008**, *20*, 129.
[3] P. Zacharias, M. C. Gather, M. Rojahn, O. Nuyken, K. Meerholz, *Angewandte Chemie* **2007**, *46*, 4388.
[4] M. C. Gather, R. Jin, J. C. deMello, D. D. C. Bradley, K. Meerholz, *Appl. Phys. B* **accepted**.
[5] M. C. Gather, F. Ventsch, K. Meerholz, *Adv Mater* **2008**, *20*, 1966.

SYDI 1.3 Mon 11:30 BAR SCHÖ

Model Systems of the Actin Cortex — •Oliver Lieleg — Lehrstuhl E27 für Zellbiophysik, Physik-Department, TU München, 85748 Garching, Germany — FAS Center for Systems Biology, Harvard University, Cambridge, USA

The cytoskeleton is constituted by networks of cross-linked and bundled biopolymers. While microtubuli serve as tracks for transport processes, the actin cortex mainly determines the mechanical properties of cells. However, due to the biological complexity of the cytoskeleton, it is difficult to unravel the microscopic principles which guide its viscoelastic response. Only in well-defined model systems the contribution of physical and biochemical parameters can be disentangled. In this talk I demonstrate that the microstructure of actin networks crucially depends on both the type and density of actin cross-linking proteins. This network microstructure sets the local deformation mode and with that the macroscopic elasticity of the network. Transient binding events between cross-linked actin filaments limit the stability of actin networks under mechanical load and dictate the viscoelastic network properties at low frequencies. Thus, the microscopic interaction potential between actin filaments and cross-linking proteins can be determined from the macroscopic frequency response of cross-linked actin networks. My results highlight how cells can harness a few generic physical principles in order to achieve enormous mechanical versatility.

SYDI 1.4 Mon 12:00 BAR SCHÖ

Dynamic patterns of biological systems — •Tobias Reichenbach — Laboratory of Sensory Neuroscience, The Rockefeller University, New York, USA

The formation of complex spatial patterns in biology enables differentiation, for example into separate functional parts, and therefore constitutes a necessity of life. Constantly working against entropy increase by active processes, living organisms operate, from a physical point of view, far from thermal equilibrium. The emerging patterns thereby exhibit a variety of special physical and mathematical characteristics, distinctly different from equilibrium patterns. In this talk, we present two examples of biological structure formation: molecular transport in eukaryotic cells and segregation of bacterial strains, enabling species diversity. We study these by employing generic models that provide insight into the respective mechanism of pattern formation, at the interplay of deterministic dynamics and unavoidable fluctuations.