SYSD 1: SKM Dissertation Prize

Time: Monday 12:00–13:40 Location: EW 201

Invited Talk SYSD 1.1 Mon 12:00 EW 201

Allan variance analysis and fast camera detection schemes for optical tweezers — •Fabian Czerwinski[1,2] and Lene Oddershede[1] — [1]Niels Bohr Institute, University of Copenhagen, Denmark — [2]Lewis-Sigler Institute, Princeton University, USA

In soft-matter and biological physics, optical tweezers are among the most versatile force-microscopy techniques. Optical tweezers allow for non-invasive and localized sample control under physiological conditions. Within a tightly focused laser beam, an optical handle fluctuates. Its positions can be thought of as a thermal, stochastic sampling that is elegantly used to calibrate the trap. Previous protocols emphasize only the high-frequency spectrum (>400Hz), handling unavoidable low-frequency effects with unsatisfying arguments.

To rigorously quantify these low-frequency effects, we pioneered the usage of Allan variance analysis in addtion to existing calibration protocols. It measures an experimental accuracy map and is essentially assumption-free. It allows one to quantify the optimal calibration interval and determine the force sensitivity. It became one of the keystones to calibrate new tweezers setups. At the same time, Allan variance analysis was implemented for other biophysical techniques, including FRET, magnetic tweezers, and ionic currents through nanopores.

In a second project, we built a camera detection scheme to directly visualize fast biological processes. It acquired and stored optical tweezers data up to 40kHz. The scientific community and nanotech companies have been utilizing our hardware and open-source software solutions.

Invited Talk SYSD 1.2 Mon 12:20 EW 201

Pulsed communication in neocortical neuronal networks — •Moritz Deger — Bernstein Center Freiburg, University of Freiburg, Freiburg im Breisgau, Germany

Neurons communicate via action potentials, also called spikes. The times of neuronal spike emission define a sequence of point-like events, the spike train. Firstly, I will introduce stochastic point processes that allow to define concise models of spike trains of single neurons. A neuron in a neocortical network typically receives spike trains from thousands of cells as input. This input signal can be modelled as a superposition of point processes. As we found, the effective refractory period of the component spike trains dominates the superposition's statistics. This result suggests superpositions of Poisson process with dead-time as a minimal and analytically tractable model of pooled neuronal input. Secondly, I will discuss the stochastic dynamics of the membrane potential of neurons driven by fluctuating inputs. Our extension of the theory of the integrate-and-fire neuron allows for pulsed inputs instead of diffusive noise and reveals the neuron's non-linear, instantaneous response to perturbations. Finally, the statistics of a neuronal spike train can be described as a function of the statistics of the input. Assuming consistency of neuronal and input (network) activity, these methods enable to understand the spike train statistics of neurons in generic neocortical networks.

Invited Talk SYSD 1.3 Mon 12:40 EW 201

Si(100) in hydrogen ambient - new physics of an old suspect — •Henning Döscher — Helmholtz-Zentrum Berlin für Materialien und Energie, Germany — Technische Universität Ilmenau, Germany

III-V heteroepitaxy on Si(100) substrates is strongly desired for micro- and optoelectronics, in particular for terrestrial concentrator photovoltaics. One major challenge is preparing single-domain Si(100) surfaces to prevent the formation of anti-phase disorder during III-V nucleation. Numerous theoretical and experimental studies explore the generation of energetically favorable B-type double-layer steps in ultra-high vacuum (UHV). Atomic hydrogen exposure suppresses their formation, but optoelectronics are usually manufactured by (metalorganic) vapor phase epitaxy (VPE) in hydrogen ambient.

We investigate VPE processing of Si(100) by optical in situ spectroscopy and surface science techniques accessible by contamination-free sample transfer to UHV. Cooling under hydrogen flow went along with strong interaction between process gas and Si(100) surface, formation of a monohydride termination, and a rate-dependent imbalance of the (2x1)/(1x2) reconstruction domains. High pressure and slow cooling promotes dimer rows parallel to the step edges equivalent to a preference for A-type double layer steps thought to be energetically unfavorable. We explain the anomalous Si(100) step structure by a kinetic model based on vacancy generation, diffusion, and annihilation as evidenced by vacancy island nucleation and monolayer oscillations in our in situ signals. Anti-phase disorder-free GaP films grown on single-domain Si(100) serve as template for device integration.

Invited Talk SYSD 1.4 Mon 13:00 EW 201

All-electrical preparation and detection of excited many-particle states in self-assembled quantum dots — •Bastian Marquardt — Faculty of Physics and CeNIDE, University of Duisburg-Essen, Germany — Cavendish Laboratory, University of Cambridge, United Kingdom

Self-assembled quantum dots (QDs) with their strong confinement are promising candidates for qubit operations above liquid helium temperatures. The ambitious realization of qubits by using artificial atoms requires the preparation and control of excited charge or spin states. Here, I introduce an all-electrical preparation and read-out scheme for (excited) charge/spin states in self-assembled InAs QDs at 4 K [1]. A two-dimensional electron gas placed nearby to the dots acts as a non-invasive charge detector [2,3]. Using a novel time-resolved transport spectroscopy allows us to generate and to detect excited many-particle states with a defined number of charge carriers. The excitation spectra of the first three "QD elements" with their non-equilibrium charge/spin configurations are resolved, i. e. the spectrum of single-charged (QD-Hydrogen), double-charged (QD-Helium) and triple-charged QDs (QD-Lithium). Comparison with many-particle calculations make it possible to identify the different configurations and in particular to verify the detection of the first excited triplet state in QD-Helium, which could serve as a spin qubit at B=0.

[1] Marquardt et al., Nature Commun. 2, 209 (2011); [2] Marquardt et al., Appl. Phys. Lett 95, 022113 (2009); [3] Marquardt et al., Appl. Phys. Lett 99, 223510 (2011)

Invited Talk SYSD 1.5 Mon 13:20 EW 201

Structuring of colloidal dispersions in slit-pore confinement — •Yan Zeng — Stranski-Laboratorium, Department of Chemistry,Technical University Berlin,Germany

The structuring of colloidal particles under confinement draws more and more attention from researches nowadays due to their numerous practical applications, such as the transport of particles in channels (e.g. microfluidic devices) and stability of particles in thin films (e.g. painting). The advanced colloidal-probe atomic force microscope was used in this work which directly provides the structuring information about colloidal nanoparticles (e.g. silica nanoparticles and surfactant micelles).

This work quantitatively investigated the scaling laws of the characteristic lengths of the structuring of colloidal dispersions and tested the generality of these laws, which explained and resolved some long-lasting contradictions in literature.

It also revealed the effect of confinement on the structuring, separated from specific properties of the confining interfaces. In addition, it resolved the influence of roughness and charge of the confining interfaces on the structuring and as well provided a method to measure the effect of surface deformability on colloidal structuring.

The surface charge and rigidity of the colloids were investigated in this work. The difference of the scaling law between charged and uncharged particles under confinement shed some light on the possible influence of electrostatic repulsive force on the extend of compression.