Session II

(II.1)

Shradha Mishra
Syracuse University

Dynamic Renormalization Group Theory of the Nature of Orientation Fluctuations in a 2-dimensional Active Nematics

In an equilibrium nematic, there is no long range ordering (LRO) for space dimension d = 2, as a consequence of the Mermin-Wagner-Hohenberg theorem. For polar active systems, numerical and analytical studies in d = 2, give long-range-order (LRO). Using dynamic renormalization group theory we find that unlike in polar active systems, nonlinearities are marginally irrelevant. Therefore the nematic phase for an active systems in d = 2 has only QLRO.

(II.2)

Marc Neef
Universitat des Saarlandes

Instability and Polarity Sorting in Active Filament Bundles Attached to a Membrane

During the late states of cell division, animal cells are cleaved into two by a contractile ring. It consists of a bundle of actin filaments and molecular motors, where the actin filaments are connected to the plasma membrane. We study the effects of this coupling between filaments and the membrane on the dynamics of the bundle. In our model, we assume that filaments are anchored to the membrane by proteins that are bound to the filaments. We treat the membrane as a thin film of a viscous fluid and account for hydrodynamic interactions between the anchor proteins. These are included by application of the method of reflections. Using a discrete as well as a mean field version of this model, we calculate the stress in the membrane due to interactions between antiparallel filaments. Furthermore, we find polarity sorting within the bundle for sufficiently large interaction strengths.

(II.3)

Erika Rodriguez
Syracuse University and Syracuse Biomaterials Institute

Miscible Blends of Linear and Crosslinked Polymers for Shape Memory Assisted Self-Healing (SMASH)

We report on miscible blends of linear and crosslinked poly(ε-caprolactone) (*l*-PCL/*n*-PCL) exhibiting a combination of shape memory response and self-healing capacity. The crosslinked component, *n*-PCL with a network chain molecular weight (M_c) of 3,000 g/mol, affords reversible plasticity – a form of shape memory where apparently plastic deformation is fully recoverable upon heating above the blend melting temperature (T_m ~ 55 ºC). The linear component, *l*-PCL with a molecular weight of 65,000 g/mol, interpenetrates the shape memory n-PCL component, yet freely diffuses above T_m to yield a tacky surface capable of rebonding any cracks formed during damage. The *l*-PCL component incorporation was varied to include 0, 50, 60, and 70 percent, allowing quantification of the competition between network elasticity (*n*-PCL) and rebonding by *l*-PCL diffusion. Dynamic Mechanical Analysis (DMA) tests have revealed that all blends studied have the ability to be cold-drawn to 200 percent tensile strain at room temperature (T~25 °C) and this strain remains well "fixed" with time. The apparently plastic deformation can be recovered completely to its original shape by heating to a temperature $T > T_m$. For samples containing sufficient *l*-PCL, this heating event is accompanied by surface tackification and, for the case of pre-cracked samples, rebonding at the crack-surfaces, revealing shape memory assisted self-healing. We observe near-complete recovery of mechanical properties for damaged samples healed in this manner. We anticipate utilization of these new materials in coatings, adhesives, and films where long-term use facile repair are needed.

(II.4)

Kris Sadlej
Polish Academy of Sciences

Movement of Semi-flexible Nano-fibers in a Channel Flow

Movement simulations of long, semi-flexible polymers in low-Reynolds-number Pioseuille flow inside a microchannel made of two parallel walls is considered. To numerically model the fiber, the bead model is used. Each fiber strand is constructed out of N solid non-deformable spherical particles of diameter d which can move with respect to each other. Although there is no total external (non-hydrodynamic) force or torque applied to the fiber, each bead feels forces due to elastic and bending energies of the fiber. Hydrodynamic interactions between fiber segments and the walls are calculated using the accurate multipole method. The motion of fibers considered is generic and characterized by semi-periodic tumbling/flipping. Wall effects are in many aspects crucial, introducing subtle but important effects such as hindrance of tumbling near the wall or fiber migration, the direction and speed of which, depends on the distance from the walls as well as the flexibility and length of the fiber. These effects introduce ways of performing fiber (eq. DNA-strand) segregation in micro-fluidics but lead also to a better understanding of the mechanisms of swimming of micro-organisms. Experiments are under way to confirm the predictions of our simulations.

(II.5)

Tarun Saxena
Syracuse University and Syracuse Biomaterials Institute

Mesoindentation of Polyacrylamide: Effects of Sample Thickness, Tip Size, Tip Geometry, and Load on Young's Modulus.

The purpose of this study was to determine if polyacrylamide (pAA) is a suitable calibration material for microindenters used for indenting soft hydrated substrates (water content > 90%, Young's Modulus (E) < 100 kPa). Further, it was sought to determine the effect of tip geometry, tip size, sample thickness, and maximum applied load on the measured modulus of pAA in a load controlled test. Samples were indented using a custom built mesoindenter (2), operating in load control mode. To study the effects of tip size, tip geometry, and sample thickness, the maximum applied load was 8 µN. To study the effect of maximum applied load, the load was varied between 8 µN and 18 µN. The two tip geometries were spherical (radii 142 µm, 174 µm, and 325 µm) and flat cylindrical tips (radii 90 µm, 120 µm, and 345 µm). Polyacrylamide was shown to be a useful calibration material based on the invariability between samples and batches. Spherical tip based indentation showed little variation in modulus with load, contrary to cylindrical tip based indentation.

(II.6)

Volker Schaller
Technische Universität München

Self Organized Patterns in 2D Active Fluids

We present a minimal active system where highly concentrated actin filaments are propelled by molecular motors in the quasi two dimensional geometry of a motility assay. In the presence of ATP, we observe an astonishing variety of phenomena like the emergence of highly dynamic polar structures starting from a homogeneous apolar basic state. These self-organized structures are characterized by persistent density modulations yielding travelling wave structures and swirling motions. As all parameters are extremely well known and adjustable, this system furthermore may offer the possibility to verify theoretical model systems and predictions.

(II.7)

Eva-Maria Shoetz
Princeton University

Tissue Remodeling During Transverse Fission in Planaria

Planarians are flatworms with extraordinary regenerative capabilities: A worm cut into 100 pieces will give rise to 100 new worms. This regenerative potential is due to a large population of stem cells that are distributed throughout the worm's body. The stem cells allow the planarians to reproduce by transverse fission, analogously to the division of fission yeast or other lower organisms. In contrast to the latter however, flatworms possess a complicated internal structure with a central nervous system, a gut and excretory system, which raises a series of questions of how this dramatic body division works. What are the physical forces at play during fission? Is there a division hot spot? How is the remodeling of the internal structures coordinated on a cell and tissue level? What is the role of the stem cell population? We will try to answer some of these questions of this extraordinary reproduction and regeneration process.

(II.8)

Sumedha Sumedha
Brandeis University

Role of GTP remnants in microtubule dynamics

We have studied a model of microtubules with stochastic hydrolysis for bound tubulins. This allows for the presence of islands of GTP bound tubulins within the GDP tubulin region on microtubules. We find that these buried GTP provide an alternative rescue mechanism. Our results show that in the presence of GTP remnants within the microtubule, dynamics of microtubules can be regulated by changing the depolymerisation rate.

(II.9)

George Thurston
Rochester Institute of Technology

A Geometric Construction to Aid in Analysis of Non-monotonic Interaction Effects in Ternary Mixture Phase Separation

A combination of experiment, simulation and theory indicates that the phase-separation stability of eye lens alpha and gamma crystalline protein mixtures depends sensitively and non-monotonically on alpha/gamma interaction strength [1,2]. A geometric construction is presented that helps to analyze ternary stability analysis, and that suggests such non-monotonic effects may be common in concentrated mixtures. The non-monotonic effects are associated with conic sections in the space of the components of the Hessian of the free energy. We apply this analysis to generalized van der Waals models and to the Barboy-Tenne sticky mixture model.

[1] A. Stradner, G. Foffi, N. Dorsaz, G. M. Thurston, and P. Schurtenberger, Phys. Rev. Letts., 99 (19): Art. No. 198103 (2007).
[2] N. Dorsaz, G. M. Thurston, A. Stradner, P. Schurtenberger and G.Foffi, J. Phys. Chem. B, 113 (6), pp 1693–1709 (2009).

(II.10)

Alexander Veksler
Lehigh University

Generalized fractional Fokker-Planck equation for anomalous diffusion

The problem of anomalous diffusion is important for a variety of systems, such as fluids, glasses, polymers, proteins etc. It is characterized by a mean square displacement evolving in time as a power-law $langle x^2rangle = 2 D_0 t^{alpha}$. However, a Fokker-Planck-like equation which could describe a stationary Gaussian process with anomalous-diffusion behavior, such as the one described by the Generalized Langevin equation, is still missing. We propose a generalization for constant force to the fractional Fokker-Planck equation (fFP) [Metzler, R. and Klafter, J., Phys. Rep. 339 (2000), 1-77], based on a series expansion in spatial and fractional time derivatives and powers of the Fokker-Planck operator. The proposed equation, GfFP, recovers the generalized Einstein relation and leads to Gaussian distribution, in particular, for free particle diffusion. We apply GfFP to 1-D first passage time problem. The long-time asymptote of the probability distribution behaves like $exp(-t^alpha)$. This contrasts with the power-law behavior of the corresponding solutions of the fFP. We further propose to generalize GfFP for treating other outstanding problems, such as the transport in anomalously-diffusive media, generalization of the proposed equation to an harmonic potential and the Kramers` escape problem.

(II.11)

Fangfu Ye
University of Illinois, Urbana-Champagne

A Chiral Granular Gas

Inspired by rattleback toys, we created small chiral wires that rotate in a preferred direction on a vertically oscillating platform and quantified their motion with experiment and simulation. We demonstrate experimentally that angular momentum of rotation about particle centers of mass is converted to collective angular momentum of center-of-mass motion in a granular gas of these wires, and we introduce a continuum model that explains our observations.

(II.12)

Natsuhiko Yoshinaga
University of Tokyo

Thermophoresis and induced flow near surface under temperature gradient

Thermophoresis, also known as the Soret effect, is phenomenon that particles spontaneously move under temperature gradient. This attracts growing interest of manipulating and transporting particles to destinations in microfluidics. It has been discussed that the flow near a particle results in force acting on a particle in this phenomenon; this implies that surface properties play crucial roles. Despite of intensive past studies, microscopic pictures of correlation between surface properties and induced flow are still controversial. In this presentation, we will show Molecular Dynamics simulations of fluids between two walls under a gradient of temperature. We found that there is indeed flow near walls depending on interactions between solvents and walls, and both magnitude and direction of force acting on the walls are accordingly varying. Analyzing the results, we discuss the mechanism of thermophoresis and possible ways to control direction of motion.