DY 53: Anomalous Diffusion in Complex Environments (joint session BP/CPP/DY)

Time: Thursday 15:00–17:45 Location: H15

Invited Talk DY 53.1 Thu 15:00 H15

Phenomenology of Collective Chemotaxis in Artificial and Living Active Matter — •Ramin Golestanian — University of Oxford

The non-equilibrium dynamics of active particles that send and receive chemical signals could lead to enhanced and/or anomalous diffusion, as well as spontaneous formation of interesting structures and patterns due to the long-range nature of the interactions. We examine theoretically the consequences of this interaction, and present some results that exemplify the type of emergent properties that could result from them, including: spontaneous formation of small stable clusters or "molecules" that can exhibit functionality that depends on geometry, collective chemotaxis in a solution of catalytically active colloids that could lead to cluster formation, aster condensation, and spontaneous oscillations, swarming - in the form of a comet - of light-induced thermally active colloids with negative Soret coefficient due to a shadowing interaction, and collective behaviour of a colony of cells that divide and interact chemotactically.

Invited Talk DY 53.2 Thu 15:30 H15

First-passage times of Markovian and non Markovian random walks in confinement — •raphael Voituriez — CNRS/ Université Pierre et Marie Curie, Paris, France

The first-passage time is a key quantity for evaluating the kinetics of various processes, and in particular chemical reactions involving "small" numbers of particles. A striking example is given by gene transcription, where specific proteins search for target sequences on DNA. I will present asymptotic results which enable the evaluation of the distribution of the first-passage time to a target site for a wide range of random processes in confined domains, and show how these results can be extended to non Markovian processes.

Invited Talk DY 53.3 Thu 16:00 H15

Cytoskeleton organization as an optimized, spatially inhomogeneous intermittent search strategy — •Heiko Rieger, Yannick Schröder, and Karsten Schwarz — Theoretical Physics, Saarland University, 66123 Saarbrücken, Germany

The efficiency of intracellular transport of cargo from specific source to target locations is strongly dependent upon molecular motor assisted motion along cytoskeleton filaments, microtubules and actin. Radial transport along microtubules and lateral transport along the filaments of the actin cortex underneath the cell membrane are characteristic for cells with a centrosome. Here we show that this specific filament organization for ballistic transport in conjunction with intermittent diffusion realizes a spatially inhomogeneous intermittent search strategy that is in general optimal for small thicknesses oft he actin cortex. We prove optimality in terms of mean first passage times for three different, frequently encountered intracellular transport tasks: 1) the narrow escape problem (e.g. transport of cargo to a synapse or other specific region of the cell membrane), 2) reaction kinetics enhancement (e.g. binding of two mobile reaction partners within the cell), 3) the reaction-escape problem (e.g. release of cargo at a synapse after intracellular vesicle pairing). Since homogeneous search strategies could only be realized by completely filling the search volume with randomly oriented cytoskeleton filaments, our results indicate that living cells realize optimal search strategies for various intracellular transport problems *economically* through a spatial cytoskeleton organization that involves only small amounts of randomly oriented actin filaments.

15 min break

Invited Talk DY 53.4 Thu 16:45 H15

Ergodicity violation and ageing in living biological cells — •Ralf Metzler — Institute of Physics and Astronomy, University of Potsdam, 14476 Potsdam-Golm, Germany

In 1905 Einstein formulated the laws of diffusion, and in 1908 Perrin published his Nobel-prize winning studies determining Avogadro's number from diffusion measurements. With similar, more refined techniques the diffusion behaviour in complex systems such as the motion of tracer particles in living biological cells is nowadays measured with high precision. Often the diffusion turns out to deviate from Einstein's laws.

This talk will discuss the basic mechanisms leading to anomalous diffusion as well as point out the physical and biological consequences, for instance, in gene regulation or cargo transport in cells. In particular the unconventional behaviour of non-ergodic, ageing systems will be discussed. Concrete examples include the motion of submicron and nanoprobes in biological cells, uncrowded and crowded lipid membranes, as well as interacting many particle systems.

Invited Talk DY 53.5 Thu 17:15 H15

Anomalous diffusion within cells — Sarah Klein[1,2], •Cecile Appert-Rolland[1], and Ludger Santen[2] — [1]Laboratory of Theoretical Physics, CNRS, Univ. Paris-Sud, Bat 210, 91405 Orsay, France — [2]Fachrichtung Theoretische Physik, Univ. des Saarlandes D-66123 Saarbrücken, Germany

Within cells, various objects (vesicles, organelles,...) need to be transported. Some processive molecular motors get attached to these objects (or cargos) to form a complex that will have a stochastic motion along a network of microtubules. Intriguingly, there is some evidence that this motion results from a tug-of-war between teams of motors that pull in opposite directions.

A stochastic model for cargo-motors complex allows us to study the properties of the resulting motion along a single microtubule. We find some anomalous diffusion, both subdiffusive or superdiffusive depending on the timescale. Interestingly, such anomalous diffusion has indeed been observed experimentally. I will discuss the importance of fluctuations in the dynamics, and present some hypotheses why nature chose such a transport process to carry cargos through the crowded interior of cells.

[Klein, Appert-Rolland, Santen, EPL 107 (2014) 18004,
Eur. Phys. J. Special Topics 223 (2014) 3215,
EPL 111 (2015) 68005]