Prize Talk PRV I Mon 13:15 H1

Ultrafast topological switching of magnetic skyrmions — •Felix Büttner — Helmholtz-Zentrum Berlin, Berlin, Germany — Laureate of the Walter-Schottky-Prize 2022

Magnetic skyrmions are non-collinear arrangements of spins, characterized by a defining non-trivial topology and a quasi-particle character. Skyrmions can be of nanometer-scale size, even at room temperature and - upon suitable stimulation - they can move coherently within their hosting material. Both, the stability and the emergent quasi-particle dynamics of skyrmions, can be linked to their topology, and these exotic properties have widely inspired research in fundamental and applied physics alike. In this talk, I will first give an overview of the field of skyrmionics before discussing one particularly fascinating aspect in greater depth: the possibility to switch, i.e., nucleate or annihilate, magnetic skyrmions despite their topological protection. I will show that the topological nucleation energy barrier of skyrmions, which can be understood from a simple product of magnetic exchange energy and film thickness, can surprisingly be lifted by heating the system into a newly discovered fluctuation state. This allows the simultaneous nucleation of an extended array of skyrmions, even on a picosecond time scale, as we could evidence by direct experimental observation. I will discuss this mechanism in the context of topological phase transitions and conclude with a perspective on technological applications.

Prize Talk PRV II Tue 13:15 H1

Water flows in carbon nanochannels: from quantum friction to carbon memories — •Lydéric Bocquet — Laboratoire de Physique, Ecole Normale Supérieure and CNRS, Paris — Laureate of the Gentner-Kastler-Prize 2022

In this talk, I will discuss various experimental and theoretical results that we obtained recently on the transport of water and ions in ultra-confinement. I will in particular focus on the odd properties of the water-carbon couple, which highlights a variety of strange transport properties. I will first discuss the ultra-fast, and radius dependent, flows of water in carbon nano-structures [1]. We demonstrate that this phenomenon is a consequence of an unconventional quantum friction at the water-carbon interface, taking its root in the coupling between water collective modes with electronic excitations [2]. I will then explore far from equilibrium transport of ions across quasi two-dimensional slits. We predict that under an electric field, ions assemble into elongated clusters - as a consequence of a 2D Wien effect -, whose slow dynamics results in the emergence of long-term memory [3]. This phenomenon, known as the memristor effect, can be harnessed to build an elementary neuron. Experimental demonstrations of this effect in the 2D nanochannels allow for the development of elementary ion-based computing, with basic forms of Hebbian learning [4].

References [1] E. Secchi, et al. , Nature 537 210 (2016) [2] N. Kavokine, M.-L. Bocquet and L. Bocquet, Nature, 602, 84-90 (2022) [3] P. Robin, N. Kavokine, and L. Bocquet, Science, 373, 687-691 (2021) [4] P. Robin, et al., submitted (2022).

Prize Talk PRV III Wed 13:15 H1

Learning the stochastic dynamics of living systems across scales: from single cells to tissues — •David Brückner — Institute of Science and Technology, Am Campus 1, 3400 Klosterneuburg, Austria — Laureate of the Gustav-Hertz-Prize 2022

Many biological phenomena, including embryo development, immune response, and cancer, rely on the coordinated movement of cells in complex environments. In all these processes, cells face a dual physical challenge: they navigate confining extra-cellular environments, in which they squeeze through thin constrictions; and they communicate with close-by cells to organize their collective behaviour. The motion of cells is powered by a complex machinery whose molecular basis is increasingly well understood. However, a quantitative understanding of the functional cell behaviours that emerge at the cellular scale remains elusive. This raises a central question: are there simple dynamical 'laws' that describe the dynamics of confined cell migration and cell-cell interactions? In this talk, I will discuss how we can use stochastic inference methods to learn the dynamics of migrating cells directly from observed experimental trajectories. I will show how these approaches give insight into the non-linear dynamics governing confined single cell migration, the pair-wise collisions of cancerous and healthy cell types, as well as collective cell migration at the tissue level.