SYES 1: Spain as Guest of Honor I

Time: Thursday 9:30–12:15 Location: HSZ 02

Invited Talk SYES 1.1 Thu 9:30 HSZ 02
Understanding the physical variables driving mechanosensing — •Pere Roca-Cusachs — Institute for Bioengineering of Catalonia (IBEC), the Barcelona Institute of Technology (BIST), 08028 Barcelona, Spain

Cell response to force regulates essential processes in health and disease. However, the fundamental mechanical variables that cells sense and respond to remain largely unknown. During this talk, I will discuss how this process of mechanosensing can be understood in physical terms, and used to predict cell response to both external force application, and passive mechanical properties such as Extracellular Matrix (ECM) rigidity.

Invited Talk SYES 1.2 Thu 10:00 HSZ 02
Mechanics of life: Cellular forces and mechanics far from thermodynamic equilibrium — •Timo Betz — Institute of Cell Biology, University Münster, Germany

Living organisms are dauntingly complex structures that operate with high robustness on the micrometer scale. Inherently, cells and tissues are dealing with both thermal but also active noise, which is generated by random uncorrelated internal forces driving the system far away from thermodynamic equilibrium. From a research perspective these characteristics are one reason why biological systems are so challenging to measure and to perform reproducible experiments on. The complexity also challenges theoretical models, as these aim at simplification. Here we focus on the mechanical aspects and force generation in single cells and tissue by exploring their non-equilibrium nature. We discuss recent experimental and theoretical approaches which reveal new insights in the underlying physics used in biological systems to perform their individual functions.

Invited Talk SYES 1.3 Thu 10:30 HSZ 02
A hydrodynamic approach to collective cell migration in epithelial tissues — •Jaume Casademunt — University of Barcelona, Barcelona, Spain

Collective migration of cohesive groups of cells is a hallmark of the tissue remodeling events that underlie embryonic morphogenesis, wound repair and cancer invasion. In this collective migration, supra-cellular properties such as collective polarization or force generation emerge and eventually control large- scale tissue organization. This suggests that a coarse-grained approach based on a hydrodynamic description of tissues as continuous active materials may shed some light into our understanding of tissue dynamics. Specifically, an appealing open question is to what extent the complex biological regulation at play can be encoded in a series of material parameters within a purely mechanical description. Here we present an overview of hydrodynamic modeling of cell tissues as active polar fluids, and discuss some examples where this approach has been instrumental to elucidate physical mechanisms behind collective cell behavior in epithelia: the occurrence of elastic-like waves, the wetting-dewetting transition in spreading monolayers, and the understanding of morphological instabilities of tissues.

Coffee Break

Invited Talk SYES 1.4 Thu 11:15 HSZ 02
The spindle is a composite of two permeating polar gels — David Oriola[1,2], Benjamin Dalton[1,2], Franziska Decker[1,2], Frank Julicher[1], and •Jan Brugues[1] — [1]MPI PKS; PoL; CSBD; Dresden, Germany — [2]MPI CBG, Dresden, Germany

During cell division, correct segregation of chromosomes depends on the ability of microtubules to self-organize into a bipolar spindle. Spindle assembly is based on the interplay between spatial microtubule nucleation and microtubule transport. It has been recently shown that branching nucleation is the main mechanism driving microtubule nucleation in spindles. However, microtubule branching leads to explosive waves of microtubule nucleation that rapidly travel away from initially created microtubules much faster than the microtubule flux velocity. This behavior should normally result in spindles with inverted polarity, yet spindles manage to robustly assemble bipolar spindles despite slow microtubule flux. Here, we used experiment and theory to study how spindles acquire the proper microtubule organization despite the slow microtubule transport and branching nucleation. We found that microtubules self-organize into two mechanically distinct microtubule networks that undergo a gelation transition. This gelation allows the propagation of long-range extensile stress from the center of the spindle that push these two gels apart. This process globally transports microtubules independently of their local polarity environment, and explains how microtubules can be sorted out into the proper bipolar structure in the presence of branching nucleation despite the slow microtubule transport.

Invited Talk SYES 1.5 Thu 11:45 HSZ 02
Adding magnetic properties to epitaxial graphene — •Rodolfo Miranda — IMDEA Nanociencia, Madrid, Spain — Dept. Condensed Matter Physics, Universidad Autónoma Madrid

The intrinsic magnetic properties of pristine graphene are negligible, but we show that, by either adsorption of suitable molecules or intercalation of heavy metal atoms, one can create long range magnetic order in hybrid graphene systems, introduce a giant spin-orbit coupling into the π bands of graphene or produce chiral domain walls protected by graphene at 300 K.

A monolayer of TCNQ molecules on graphene grown on Ru(0001) acquire charge and a magnetic moment. The TCNQ monolayer develops spatially extended, spin-split, electronic bands and a magnetically ordered ground-state as visualized by spin-polarized STS. The long range magnetic order is due to direct exchange interaction mediated by overlapping frontier orbitals of the molecules.

Pb-intercalated Graphene grown on Ir(111)develops a giant (70-100 meV) spin-orbit coupling in the π bands of graphene, as detected by spin-ARPES, which is a suitable candidate for the observation of Spin Hall Effect in graphene

Finally, epitaxial graphene/Co(111)/Pt(111) stacks grown on MgO(111) crystals exhibit enhanced Perpendicular Magnetic Anisotropy for Co layers up to 4 nm thick and generate left-handed Néel-type chiral Domain Walls stabilized by interfacial DMI interaction. The magnetic texture is protected by graphene, stable at 300 K in air, and amenable to transport measurements.