BP 6: Bacterial Mechanics

Time: Monday 15:00–17:15 Location: BAR 0106

BP 6.1 Mon 15:00 BAR 0106

Antigenic variation modulates attractive forces between bacteria and affects antibiotic tolerance — •Isabelle Wielert[1,3], Sebastian Kraus-Römer[1,3], Paul Higgins[2,3], and Berenike Maier[1,3] — [1]Institute for Biological Physics, University of Cologne, Germany — [2]Institute for Medical Microbiology, Immunology and Hygiene, University of Cologne, Germany — [3]Center for Molecular Medicine Cologne

Type 4 pili (T4P) are multifunctional surface exposed polymers involved in adhesion, force generation, surface motility, aggregation and act as major antigens. During antigenic variation, the human pathogen Neisseria gonorrhoeae varies the primary structure of the pilin, the major subunit of the T4P fibre, to escape from immune surveillance. But it is unclear how pilin antigenic variation impacts other T4P functions. We addressed this question by replacing the pilin of a laboratory strain by pilins from various clinical isolates. By performing dual laser trap experiments, we found that the pilin variant strains clustered into two groups with different attractive forces. Variants with interaction forces exceeding 40 pN formed colonies while weakly interacting bacteria retained a planktonic lifestyle. All pilin variants supported surface motility, yet the planktonic variants moved faster. Previous studies indicated that bacterial aggregation results in higher tolerance against antibiotic treatment. To test whether pilin antigenic variation affects tolerance, we carried out bacterial survival assays and showed that indeed colony-forming variants are more tolerant. We conclude that pilin variation enhances bacterial fitness beyond immune escape.

BP 6.2 Mon 15:15 BAR 0106

Stress anisotropy in confined populations of growing rods — Jonas Isensee[1,2], Lukas Hupe[1,2], Ramin Golestanian[1,2,3], and •Philip Bittihn[1,2] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [2]Institute for the Dynamics of Complex Systems, Göttingen University — [3]Rudolf Peierls Centre for Theoretical Physics, University of Oxford, UK

A central feature of living matter is its ability to grow and multiply. The mechanical activity associated with growth produces both macroscopic flows shaped by confinement, and striking self-organization phenomena, such as orientational order and alignment, which are particularly prominent in populations of rod-shaped bacteria due to their nematic properties. However, how active stresses, passive mechanical interactions and flow-induced effects interact to give rise to global alignment patterns remains elusive. Here, we study in silico colonies of growing rod-shaped particles confined in channel-like geometries. A spatially resolved analysis of the stress tensor reveals a strong relationship between near-perfect alignment and an inversion of stress anisotropy for particles with large length-to-width ratios. In quantitative agreement with an asymptotic theory, strong alignment can lead to a decoupling of active and passive stresses parallel and perpendicular to the growth axis, respectively. We demonstrate the robustness of these effects to perturbations and for weaker confinement. Our results illustrate the complexity arising from the inherent coupling between nematic order and active stresses in growing active matter, modulated by geometric and configurational constraints due to confinement.

BP 6.3 Mon 15:30 BAR 0106

Magnetic fields help magnetotactic bacteria navigate complex environments — Agnese Codutti[1,2], Mohammad Charsooghi[1], Konrad Marx[3], Elisa Cerda-Donate[1], Omar Munoz[3], Paul Zaslansky[1], Vitali Telezki[3], Tom Robinson[1], Damien Faivre[1,4], and •Stefan Klumpp[3] — [1]MPI of Colloids and Interfaces, Potsdam — [2]TU Munich — [3]University of Göttingen — [4]Aix-Marseille Université, CEA, CNRS, BIAM, Saint Paul lez Durance, France

To study swimming of magnetotactic bacteria in a near-realistic sediment environment resembling those in their natural habitat, we produced microfluidic channels that contained sediment-mimicking obstacles. These obstacle channels were produced based on microCT reconstructions of sediment samples. We characterized the swimming of magnetotactic bacteria through these channels and found that swimming throughput was highest for intermediate magnetic fields. This observation was confirmed by extensive computer simulations using an active Brownian particle model, parameterized based on experimental trajectories. The simulations indicate that swimming at strong field is impeded by the trapping of bacteria in corners that require transient swimming against the magnetic field for escape. At weak fields, the direction of swimming is almost random, making the process inefficient as well. We confirmed the trapping effect in our experiments and showed that lowering the field strength allows the bacteria to escape.

BP 6.4 Mon 15:45 BAR 0106

Mechanical strain sensing and growth of rod-shaped Escherichia coli independent of cell wall synthesis — •Lars Renner[1], Felix Wong[2], Ariel Amir[2], Yuki Kitahara[3], and Sven van Teeffelen[3] — [1]Leibniz Institute of Polymer Research, Dresden — [2]Harvard University, Cambridge, USA — [3]Universite de Montreal, Canada

One of the central questions in bacterial cell biology is how specific shapes evolved and are maintained. It is remarkable how bacteria can precisely control the cellular processes regulating cell shape. However, many of the underlying biophysical cues are largely unknown. We set out to understand how mechanical stress affects rod-shape maintenance. Specifically, we combine microfabrication tools and mathematical modelling to identify a stress-based mechanism that regulates shape in rods. We then examined the influence of the biomolecular machinery that builds the cell wall and found that rod-shaped cells retain the ability to expand their envelopes differentially in response to locally varying mechanical forces. Thus, cell-wall cleaving enzymes appear to represent an alternative pathway for coupling cell envelope growth to mechanical forces that is distinct from cell wall insertion.

15 min. break

Invited Talk BP 6.5 Mon 16:15 BAR 0106

Mechanical and electrical properties of bacterial biofilms modulate antibiotic tolerance — •Berenike Maier — Institute for Biological Physics and Center for Molecular Medicine Cologne, University of Cologne

Aggregation into colonies and biofilms can enhance bacterial survivability under antibiotic treatment. Yet, the transition between the life as an individual cell and life within a biofilm is poorly understood. We investigate this transition using the human pathogen *Neisseria gonorrhoeae* (gonococcus). Within minutes, these bacteria self-assemble into spherical colonies comprising thousands of cells. We show that freshly assembled colonies are reminiscent of liquid droplets whose viscosity can be tuned by the pilus-mediated attractive force between bacterial cells. The viscosity correlates with antibiotic tolerance. Next to mechanical properties, we investigate the electrical properties of gonococcal colonies. We show that once the colonies have reached a critical size, the membrane polarization transitions from uncorrelated to collective dynamics. The spatial polarization pattern correlates with patterns of distict growth rates and antibiotic tolerance. In summary, both mechanical and electrical properties of bacterial colonies affect survivability under external stresses.

BP 6.6 Mon 16:45 BAR 0106

Acclimatization of filamentous cyanobacteria to light and pH - from individual to colony-scale — •Franziska Papenfuss, Sarah Haeger, Maximilian Kurjahn, Antaran Deka, and Stefan Karpitschka — MPI for Dynamics and Self-Organization, Göttingen, Germany

Photoautotrophic cyanobacteria contribute about 10 % to the net primary production of earth‘s biosphere. Acclimatization to fluctuating environmental conditions supported their sustained existence over a few billion years, but the underlying mechanisms remain elusive. Here, we investigate three species of filamentous cyanobacteria, cultivated for three weeks at different light-intensities (0.25-8 μE) and pH buffered to specific values between 6.8-8.4 or unbuffered. During cultivation, micro-scale parameters like the abundance of photopigments and the velocity of single filaments as well as macro-scale parameters like growth rate, pH and colony morphology were tracked. In unbuffered cultures, pH varies between 6.5-10, depending on light driven photosynthesis. Filaments start to aggregate at high densities but mainly independent of illumination and pH. Neither is the growth rate influenced by pH, however it is positively correlated to illumination. Nevertheless, in some species, pH seems to influence the filament gliding velocity and photopigmentation. Thus, our investigations show that pH is not only a consequence of the photosynthetic activity, but also influences the acclimatization of the cyanobacteria in a regulating feedback mechanism.

BP 6.7 Mon 17:00 BAR 0106

Molecular Dynamics Simulation of the Polymer Layering on the Surface Layer Proteins of Methanosarcina acetivorans — •Jonathan Hungerland[1], Aitolkyn S. Uali[2], Po-Heng Lee[3], and Ilia A. Solov'yov[1] — [1]Dept of Physics, University of Oldenburg — [2]Dept of Chemistry, Gumilyov Eurasian National University — [3]Dept of Civil and Environmental Engineering, Imperial College London

The archaea of the type Methanosarcina can produce Methane in an efficient, anaerobic, symbiotic process with Geobacter metallireducens. Their symbiosis is a so-called direct interspecies electron transfer (DIET), which is not limited by diffusion and has potential application in prospective energetically net-positive, anaerobic waste-water treatment. However, the mechanisms underlying DIET are yet unclear. The Methanosarcina species that coat themselves in layers of Methanochondroitin polymers were found to be capable of DIET. Therefore, the polymers might be crucial for the DIET of Methanosarcina species. The performed molecular dynamics simulations generate an atomistic picture of the Methanochondroitin layers accounting for the porous surface layer proteins aiming to suggest potential charge-transfer mechanisms into the cell and might reveal the role of the surface layer pores.