BP 16: Poster IV

Active Matter (BP 14.1 – BP 14.19)

Time: Tuesday 14:00–16:00 Location: P2/EG

BP 16.1 Tue 14:00 P2/EG

Nanobars as a tunable stirrer for cell-like systems — •Mithun Thampi, Pierre-Yves Gires, and Matthias Weiss — Experimental Physics I, University of Bayreuth, Germany

Transport inside living systems or biofluid droplets is governed by diffusion and energy-dependent active transport. Speeding up these processes remains challenging: here we report on an easy way to gently stir biofluid droplets. We produce micrometer long magnetic stir bars (NBs) by aligning Fe_3O_4 nanoparticles and stabilizing them by a biocompatible silica coating. The successful production of these NBs is confirmed by scanning electron microscopy. The rotating magnetic field is achieved by using two pairs of Helmholtz-like coils with a custom build controller, which can tune both the frequency and the strength of the magnetic field. As the rotation frequency is increased, we observed the generation of superdiffusive transport in a NBs suspension of 200 nm fluorescent beads up to an optimum frequency. The range of frequencies we looked at is from 0.01 to 10 Hz and the magnetic field is around 10 mT. The frequency dependence of the transport property can be connected to the dynamics at the single NB level, which is also characterized in parallel experiments. We finally look at their stirring effects on the out of equilibrium self-organization of *Xenopus laevis* egg extract.

BP 16.2 Tue 14:00 P2/EG

Stability and noise of metachronal waves in cilia carpets — •Anton Solovev[1] and Benjamin M. Friedrich[1,2] — [1]Center for Advancing Electronics Dresden (cfaed), Germany — [2]Cluster of Excellence 'Physics of Life' (PoL), Dresden, Germany

Motile cilia on ciliated epithelia in mammalian airways, brain and oviduct display coordinated beating in the form of metachronal waves, presumably due to mutual hydrodynamic coupling. Metachronal coordination is important for efficient fluid transport.

How the shape of the cilia beat determines the direction and wavelength of metachronal waves is not fully understood, nor is robustness with respect to noise.

We developed a multi-scale modelling approach, where a cilia carpet is modeled as an array of noise phase oscillators, similar to a Kuramoto model with local coupling. Importantly, pair-wise hydrodynamic interactions between cilia are accurately computed from hydrodynamic simulations of the Stokes equation, using experimentally measured cilia beat patterns. We numerically determine the set of all possible synchronized states, as well as their linear stability.

Remarkably, while we find multiple metastable metachronal wave states, analysis of global dynamics reveals that only few of them have sizable basins of attraction. In the presence of noise, corresponding to active fluctuations of cilia beating, we observe stochastic transitions between different synchronized states. While strong noise reduces synchronization, weak noise biases the dynamics towards a single synchronized state of metachronal coordination.

BP 16.3 Tue 14:00 P2/EG

Synchronization of flagella at finite Reynolds numbers in viscoelastic fluids — •Chaojie Mo and Dmitry Fedosov — Institute of Complex Systems, Forschungszentrum Jülich, Jülich 52428, Germany

Recent experimental and numerical studies show that viscoelasticity can significantly promote clustering of sperm cells, implying its key role for the behavior of microswimmers. To better understand the effects of viscoelasticity, we conduct numerical simulations of the synchronization of two parallel 2-D flagella, where inertial effects, flagellum elasticity and fluid viscoelasticity are taken into account. We find that the characteristic time for synchronization due to inertia scales as $\tau^s \propto 1/(f\mathrm{Re})$. In addition, in-phase and anti-phase synchronization can be achieved through the competition between fluid inertial effects and other factors, such as flagellum elasticity, viscoelasticity and compressibility. The fluid viscoelasticity leads to very strong synchronization forces at large beating amplitudes and $\mathrm{De} \gg 1$. Viscoelasticity-induced synchronization generally requires a lower output energy and does not impede the swimming speed. Therefore, a viscoelasticity of suspending medium can promote synchronization by a significant enhancement of the synchronization forces. This can be an advantage for the synchronized sperm cells, as it facilitates their migration.

BP 16.4 Tue 14:00 P2/EG

Dynamic force measurements on actively beating flagella by means of micropipette force sensors — Thomas J. Böddeker, Stefan Karpitschka, Christian T. Kreis, Quentin Magdelaine, and •Oliver Bäumchen — Max Planck Institute for Dynamics and Self-Organization (MPIDS), Am Fassberg 17, 37077 Göttingen, Germany

Flagella and cilia are cellular appendages that mediate essential functions such as transport, motility and sensing of the environment. Using a novel experimental technique based on micropipette force sensors, we present the first direct measurement of the oscillatory forcing exerted by the beating flagella of the unicellular model organism *Chlamydomonas*. This method relies on partially aspiring a motile microbe at the tip of a micropipette cantilever. Through Fourier analysis of the deflection spectrum of the cantilever, we isolate the signal originating from the beating flagella from external noise, resulting in a force resolution of a few piconewtons. The method offers full optical access to the microbe at any time and high flexibility regarding varying experimental parameters. We demonstrate the versatility of this novel experimental approach by measuring the oscillatory forcing at varying distance of the beating flagella to a solid surface and identify the length over which hydrodynamic and steric flagella-surface interactions play a role (T.J. Böddeker et al., arXiv:1908.03602).

BP 16.5 Tue 14:00 P2/EG

Magnetic swimmers in confined, porous environments — •Omar Muñoz[1,2,3], Mohammad Charsooghi[4], Agnese Codutti[5,6], Vitali Telezki[1], Damien Faivre[4,7], and Stefan Klumpp[1] — [1]Faculty of Physics, Georg-August Universität Göttingen, Göttingen, Germany — [2]Department of Biology, Friedrich-Alexander Universität Erlangen-Nürnberg, Erlangen, Germany — [3]Max-Planck-Zentrum für Physik und Medizin, Erlangen, Germany — [4]Department of Biomaterials, Max Planck Institute of Colloids and Interfaces, Postdam, Germany — [5]Department of Theory and Biosystems, Max Planck Institute of Colloids and Interfaces, Postdam, Germany — [6]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [7]Aix-Marseille University, CNRS, CEA, BIAM, Saint Paul lez Durance, France

Magnetic swimmers are a class of microswimmers, which can be steered and/or propelled by a magnetic field. We proposed a minimal model for independent magnetic swimmers in porous environments, whose orientation aligns passively with an external magnetic field. The porous environment is implemented via coarse-grained interactions with confining walls and circular obstacles. By numerical integration of the respective Langevin equations, we studied the interactions of the swimmers with the environment, as well as their global behavior in a large, confined environment with a magnetic field present. For the specific case of magnetotactic bacteria swimming in sediment-like environments we present a first comparison with experimental data from *Magnetospirillum gryphiswaldense* swimming in a quasi-2D channel.

BP 16.6 Tue 14:00 P2/EG

Absorption Induced Geometry Change in Porous Media — •Carl Becker[1] and Karen Alim[1,2] — [1]Max Planck Institute for Dynamics and Self-Organization — [2]Technical University of Munich

Solute transport through natural porous media is often strongly incoherent throughout the medium due to random pore-sizes and connections. This can be improved either by creating artificial porous media layer by layer or by actively changing the network geometry in a random porous medium. One method to change the geometry in a random porous medium with little effort is by flushing a solute through the medium which is absorbed at the pore-walls and thereby changes the pore-size (e.g.~an acid etching away the pore-walls). It would be highly time- and energy-efficient if this method could be used to optimise the transport properties of porous media. Recently, it has been shown that porous media with low porosity can be approximated by tubular networks with varying radii. Here, we use this approximation to analytically investigate the solute dynamics in single pores with absorbing walls. This is used to predict the impact of small solute concentration peaks travelling through the network which get absorbed at the walls and change the pore-sizes. We show a first numerical example where absorption induced geometry change is used to improve the transport properties of a toy-model of a porous medium.

BP 16.7 Tue 14:00 P2/EG

Gliding motility and self-organization of *Chlamydomonas* populations on surfaces — •Sebastian Till, Alexandros Fragkopoulos, and Oliver Bäumchen — Max Planck Institute for Dynamics and Self-Organization (MPIDS), 37077 Göttingen, Germany

Green microalgae are photoactive microorganisms that inhabit porous environments, e.g. wet soils and the interstitial space of rocks, where they constantly interact with surfaces. *Chlamydomonas reinhardtii*, a unicellular biflagellated microbe, can adhere and colonize essentially any surface under exposure to blue light. In this surface-adhered state, the flagella are attached in a widespread configuration and the cooperative effort of molecular motors translocates the cell parallel to them. This type of motion is known as gliding motility. We find that for a sufficiently high density of adhered cells, a motility-induced self-organization effect may be observed leading to areas of locally increased cell densities.

In order to understand this clustering, we quantify the surface-based gliding motility of single cells as well as the spatio-temporal evolution of the surface-associated microbial population. The dynamics of single cells is characterized by rapid movements, followed by states of prolonged inactivity. Due to the predominant directionality induced by the initial flagella configuration, the motility can't be described as a run-and-tumble process, as in their free-swimming state, but rather as a slow rotational diffusion.

BP 16.8 Tue 14:00 P2/EG

Chiral symmetry breaking in viscous environments — •Jonas Neipel[1], Stephan W. Grill[2,3], and Frank Jülicher[1] — [1]Max-Planck-Institute for the Physics of Complex Systems, Dresden, Germany — [2]Max-Planck-Institute for Molecular Cell Biology and Genetics, Dresden, Germany — [3]Biotechnology Center, Technical University Dresden, Dresden, Germany

The body plan and organs of most animal species show a consistent handedness. During the development of these organisms and structures, chiral flows of molecules and cells in thin fluid films are often observed. These flows suggest the presence of torques. In particular, chiral flows in the acto-myosin cortex of the *Caenorhabditis elegans* embryo have been linked to active torque generation by the acto-myosin system. Due to angular momentum conservation, a torque in such an active surface has to be balanced by an opposing torque somewhere in the surrounding. Hence, the material properties of the environment and its interaction with the active surface are of crucial importance. Here, we study ensembles of torque dipoles in viscous environments. We demonstrate that the resulting flow fields in the active surface show striking differences to torque generation on a rigid substrate. We also study the dynamics of torque dipoles in the presence of active isotropic and nematic stresses. We observe that the presence of even weak torque dipoles can bias chiral symmetry breaking in active nematics. We then ask the question, whether the mutual action of nematic stress and torque dipoles can account for the appearance of chiral flows in avian embryos in the absence of cilia.

BP 16.9 Tue 14:00 P2/EG

Simulations of polymers in crowded environments — •Niklas Butkevich, Ali Malek, and Stefan Klumpp — Georg-August-Universität Göttingen, Institut für Dynamik komplexer Systeme, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

Biopolymers, such as DNA, RNA and proteins, are essential components in all living organisms. In cells, these polymers are subject to a crowded environment as well as to active processes. In the present work, molecular dynamics simulations in 3D are performed to study static and dynamical properties of flexible polymer chains in a bath of passive and active crowders. The model is based on the Rouse model with additional repulsive interactions. The active bath has a pronounced effect on the configurational dynamics of the polymer: by increasing the density of the passive crowders, the squared end-to-end distance decreases, the motion of the center of mass slows down and the chain relaxation is delayed. The model is extended to self-propelled active particles that drive the system out of equilibrium.

BP 16.10 Tue 14:00 P2/EG

Turbulence in a suspension of active rods — •Osamah Sufyan, Josua Grawitter, and Holger Stark — Technische Universität Berlin, Institut für Theoretische Physik, Hardenbergstraße 36, 10623 Berlin, Germany

Self-organizing active systems can exhibit non-equilibrium phase transitions, e.g., from ordered collective motion to spatio-temporal chaos as in motility assays of biofilaments and bacterial suspensions. An interesting phenomenon in such systems is the emergence of active turbulence at small Reynolds numbers [1].

Here, we investigate the collective dynamics of a dilute suspension of active rods in a viscous fluid using the incompressible Navier-Stokes equation coupled to the dynamic equation for the local tensorial order parameter, which quantifies the liquid-crystal nematic order of the active rods [2,3]. We numerically solve the model equations. With increasing activity, we identify a transition from an isotropic to a turbulent phase. We characterize this phase by the scaling law of the local nematic order parameter, the power spectrum of the flow-field fluctuations, as well as the dynamics and statistics of the topological defects in the nematic director field.

[1] L. Giomi, Phys. Rev. X **5**, 03100 (2015).
[2] S. Ramaswamy, Annu. Rev. Condens. Matter Phys. **1**, 323 (2010).
[3] E. L. C. VI M. Plan, S. Musacchio, and D. Vincenzi, Phys. Rev. E **96**, 053108 (2017).

BP 16.11 Tue 14:00 P2/EG

Can the Motility of Magnetotactic Bacteria be Measured by Means of Magnetization Curves? — Sophia Nagelstrasser[1], Frank Mickoleit[2], Dirk Schüler[2], Ingo Rehberg[1], and •Reinhard Richter[1] — [1]Experimentalphysik 5, Universität Bayreuth, 95447 Bayreuth, Germany — [2]Mikrobiologie, Universität Bayreuth, 95447 Bayreuth, Germany

The magnetization of a paramagnetic gas, like oxygen, increases with the applied magnetic field H and saturates if all magnetic moments m are aligned. This curve is described by $M(H) = \Phi L(\xi)$, where Φ denotes the volume fraction of the molecules, $L(\xi)$ the Langevin function, and $\xi = mH/(k_{\mathrm{B}}T)$ the ratio of magnetic and thermal energy. This function should also apply to a dispersion of magnetotactic bacteria, like the model organism *Magnetospirillum gryphiswaldense.* However, whereas the molecules have identical magnetic moments, those bacteria biomineralize a variing number of magnetite crystals (so called magnetosomes), with 20-60 particles per cell [1]. Moreover, in contrast to the molecules, which are passively kicked by $k_{\mathrm{B}}T$, the bacteria are *actively* swimming in their environment. In a series of measurements we are elucidating, whether the $M(H)$-curves of this active suspensions can still be described by a superposition of Langevin functions [2], capturing their motility by an enhanced effective temperature.

[1] R. Uebe and D. Schüler, *Nat. Rev. Microbiol.*, 14 (2016) 621.
[2] I. Rehberg, R. Richter, S. Hartung, N. Lucht, B. Hankiewitz, T. Friedrich, *Phys. Rev. B*, 100 (2016) 134425.

BP 16.12 Tue 14:00 P2/EG

Quantifying the flexural rigidity of filamentous cyanobacteria — •Mixon Faluweki and Lucas Goehring — Nottingham Trent University, Nottingham, UK

The structural and mechanical properties of biofilms contribute to their successes in a wide variety of ecological niches; filamentous cyanobacteria show an increase in complexity from single cells towards multicellular structures. We study how the microscopic activity of these organisms gives rise to the macroscopic properties of their colonies, including biofilms and biomats. One of the most important mechanical properties is the flexural rigidity, also known as the bending modulus. Direct measurement of the flexural rigidity of filamentous cyanobacteria is a challenging task due to their small size. Here, we quantify the flexural rigidity of three cyanobacteria species via bending tests in a microfluidic flow device, where single cyanobacteria filaments are introduced into the microfluidic channel and deflected by fluid flow. This measurement is confirmed separately by measuring the Young*s modulus and cell wall thickness using atomic force microscopy and scanning electron microscopy, respectively. These mechanical properties will control how individual filaments of cyanobacteria bend or curve when they interact with each other, or their environment, for example in their alignment into bundles, or with flows or physical boundaries.

BP 16.13 Tue 14:00 P2/EG

Anisotropic exclusion effect between photocatalytic Ag/AgCl

Janus particles and passive beads in a dense colloidal matrix — •Tao Huang[1,2], Xu Wang[2], Vyacheslav Misko[3,4], Franco Nori[3], Jürgen Fassbender[2], Denys Makarov[2], Gianaurelio Cuniberti[1], and Larysa Baraban[1,2] — [1]TU Dresden, Dresden, Germany — [2]Helmholtz-Zentrum Dresden-Rossendorf e.V. — [3]RIKEN Cluster for Pioneering Research, Saitama, Japan — [4]Vrije Universiteit Brussel, Brussels, Belgium

Synthetic nano- and micromotors interact with each other and their surroundings in a complex manner. Here, we report on the anisotropy of the active-passive particles interaction in a soft matter system containing an immobile yet photochemical Ag/AgCl-based Janus particle embedded in a dense matrix of passive beads in pure water. The asymmetry in the chemical gradient around the Janus particle, triggered upon visible light illumination, distorts the isotropy of the surrounding electric potential and results in the repulsion of adjacent passive beads to a certain distance away from the Janus particle. This exclusion effect is found to be anisotropic with larger distances to passive beads in front of the Ag/AgCl cap of the Janus particle. We provide an insight into this phenomenon by performing the angular analysis of the radii of exclusion and track their time evolution at the level of a single bead.[1,2] 1. X. Wang. et al., Small,1803613 (2018). 2. X. Wang. et al., Small,1802537 (2018).

BP 16.14 Tue 14:00 P2/EG

Imaging protein-based artificial molecular motors — •Ivan Unksov[1], Pradheebha Surendiran[1], Chapin Korosec[2], Peter Jönsson[3], Roman Lyttleton[1], Damiano Verardo[1], Roberta Davies[4], Till Böcking[5], Nancy Forde[2], Paul Curmi[4], and Heiner Linke[1] — [1]Solid State Physics and NanoLund, Lund University, Lund, Sweden — [2]Department of Physics, Simon Fraser University, Burnaby, British Columbia, Canada — [3]Department of Chemistry, Lund University, Lund, Sweden — [4]School of Physics, University of New South Wales, Sydney, Australia — [5]Single Molecule Science and ARC Centre of Excellence in Advanced Molecular Imaging, University of New South Wales, Sydney, Australia

We are working on two concepts of artificial molecular motors: the Tumbleweed, a protein motor built from DNA-binding protein repressors (Bromley et al. HFSP J 2009), and the Lawnmower, a motor based on a microbead decorated with trypsin protease (Kovacic et al. IEEE Trans Nanobioscience 2015). The Tumbleweed is designed to make steps as small as 10 nm along a DNA upon switching of buffers which enable ligand-specific binding of motor to DNA. We show the binding using silica beads with attached multiple DNA tracks: we add motors with fluorescent labels and track the changes in the intensity and radius of fluorescence patterns; with this approach, we aim at seeing motor motion with sub-diffraction precision. For the Lawnmower, using fluorogenic peptides as the surface-bound substrate, we demonstrate the substrate cleavage by trypsin, which is expected to allow for the motion of motor based on rectified diffusion.

BP 16.15 Tue 14:00 P2/EG

Emergent activity of motile phytoplankton in nutrient landscapes — •Francesco Danza and Anupam Sengupta — Physics of Living Matter Group, University of Luxembourg, Luxembourg

Phytoplankton, microscale photosynthetic organisms that constitute base of most of the aquatic food webs, inhabit dynamic environments where nutrients, alongside light and fluid flow, mediate phytoplankton activity, fitness and succession. Nutrient availability has long been associated with plankton physiology, which due to the shifting environmental trends, is undergoing a major makeover. Currently we lack a biophysical framework that could link nutrient availability to phytoplankton behavior, and crucially, predict if motile species could thrive in shifting nutrient conditions. Using a combination of micro-scale imaging, microbiology and fluid dynamic models, we investigate how nutrient availability regulates single-cell physiology and motility, and scale it up to uncover emergent collective behavior of phytoplankton populations. By quantifying the biophysical traits over ecologically relevant nutrient levels, we extract the time-scales over which phytoplankton actively regulate swimming and morphological characteristics, thus shedding light on the finely tuned biophysical mechanisms that equip them to tackle spatial and temporal heterogeneity of nutrient landscapes. Beyond the ecological context, our results propose local nutrient levels as a handle to control the activity of motile phytoplankton species, promising an exciting model of motile active matter where spontaneous changes in motility and morphology trigger a rich phase space over different cell concentrations.

BP 16.16 Tue 14:00 P2/EG

Shape-shifting intelligent active swimmers — •Arkajyoti Ghoshal and Anupam Sengupta — Physics of Living Matter Group, University of Luxembourg, Luxembourg City, Luxembourg

Shape, a key phenotypic trait in living systems, underpins crucial functions across different biological taxonomies. The ability of microbes (e.g., bacteria or algae) to dynamically shape-shift enables them to respond to external cues, optimize resources, and ultimately enhance fitness. Recent studies on microplankton have revealed exquisite mechanisms that allow cells to rapidly tune their shape and modulate motility under environmental perturbations [1]. Such adaptive traits play out over seconds to minutes timescales, offering biophysical insights that could be harnessed to engineer intelligent active swimmers. Combining single and population scale imaging, automation and tracking techniques, we catalogue active behavioral response of microbial species exposed to hydrodynamic cues over respective life cycles. Our results indicate that, for individual level, shape is a fundamental determinant of motility over cell lifecycle. At a population scale, variabilities in shape lead to intrinsic heterogeneity in motility traits, leading to an activity landscape that elicit a rich collective behavior over different flow regimes. These results provide quantitative insights which can be harnessed, on the one hand to elucidate niche composition in aquatic ecosystems, and on the other hand, tailor intelligent active matter based on adaptive biomechanics across scales. [1] A. Sengupta et al., Nature 543, 555, 2017. [2] Dynamic shape-motility coupling in active biological swimmers: A. Ghoshal & A. Sengupta (in prep).

BP 16.17 Tue 14:00 P2/EG

Reinforcement Learning with Artificial Microswimmers — Frank Cichos[1], Viktor Holubec[2], and •Ravi Pradip[1] — [1]Molecular Nanophotonics, Peter Debye Institute for Soft Matter Physics, Leipzig, Germany — [2]Charles University in Prague, Faculty of Mathematics and Physics

Artifical microswimmers are designed to mimic the motion of living microorganisms. The adaptive behavior of the latter is based on the experience they gain through the interactions with the environment. They are also subjected to Brownian motion at these length scales which randomizes their position and propulsion direction making it a key feature in the adaptation process. However, artificial systems are limited on their ability to adapt to such noise and environmental stimuli. A novel solution to this problem has already been demonstrated by incorporating machine learning algorithms: self thermophoretic artificial microswimmers are employed in a real-world environment controlled by a real-time microscopy system to introduce reinforcement learning. It has also been shown that the learning process in these noisy environments contributes to a decline in learning rate and varied optimal behavior. In addition, as a consequence of non zero delay between sensing and responding to external stimuli in such an environment an optimal velocity emerges for these microparticles which ensure the expected behavior. Therefore an effort to lower the current delay is made which will enable the particles to exploit the learned knowledge for a wider range of velocities.

BP 16.18 Tue 14:00 P2/EG

Environmental applications of high-motility visible light-driven Ag/AgCl Janus microswimmers — •xu wang[1], tao huang[2], larysa baraban[2], vyacheslav r misko[3,4], franco nori[3], gianaurelio cuniberti[2], jurgen fassbender[1], and denys makarov[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf — [2]Technische Universität Dresden — [3]RIKEN Cluster for Pioneering Research — [4]Vrije Universiteit Brussel

Active photochemically-driven microswimmers show a great potential for the applications of environment remediations, such as the dyesolution degradation.[1] Previous reports focus on the favourable stimuli of visible light for driving microswimmers only show limited propulsion ability.[1] Here, we demonstrate Ag/AgCl-based spherical Janus microswimmers that reveal an efficient propulsion under visible light illumination.[2,3] They can boost the MSD to a remarkable value of 800 um2 (over 8 s) in pure H2O when activated by blue light (λ = 450-490 nm). We also demonstrates the potential of using visible light-driven plasmonic Ag/AgCl-based Janus micromotors in human saliva, phosphate-buffered saline solution, the most common isotonic buffer that mimics the environment of human body fluids, and Rhodamine B solution.

1. Simmchen, J., et al., ChemNanoMat 2017, 3, 65. 2. Wang, X., et al., Small 2018, 14, 1803613. 3. Wang, X., et al., Small 2018, 14,

1802537.

BP 16.19 Tue 14:00 P2/EG

Self-assembly of magnetic cubic nanomotors — •Martin Kaiser[1], Sofia Kantorovich[1,3], Yeimy Martinez[2], and Annette Schmidt[2] — [1]Faculty of Physics, University of Vienna, Boltzmanngasse 5, 1090 Vienna, Austria — [2]Chemistry Department, University of Cologne, D-50939 Cologne, Germany — [3]Ural Federal University, Lenin Av. 51, Ekaterinburg 620000, Russian Federation

Microscopic active particles, including self-propelled cells, microorganisms and artificial swimming colloids, have gained a lot of attention due to their relevance in such important fields as biology, biomedicine, nanoscience and nanotechnology. The term ”active” is usually used in order to underline the ability of particles or units to gain the kinetic energy and move by converting the energy from their environment.

In this study, we use active matter to create a new type of nanomotor, based on active particle propulsion, that can be oriented by an applied magnetic field. Such a nanomotor consists of two units: one is a magnetic cube that can be directed due to its interaction with a magnetic field, whereas a second non-magnetic active particle with a propulsion force directed into the cubes centre of mass.

In the present contribution, we discuss the self-assembly of the aforementioned magnetic nanomotors, employing the combination of Molecular Dynamics Simulations and experiments. Due to competing propulsion and magnetic forces we observe striking differences in cluster size distribution and topology if compared to the self-assembly of non-active magnetic cubes.