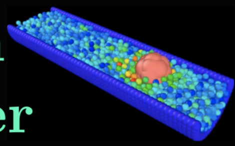


Current and Future Themes in Soft & Biological Active Matter

Week 1 Programme

Monday 25th July

1015–1030	INFORMAL PRE-TALK MEET & COFFEE
1030–1130	**Anton Souslov** *Topology not in biology*
1130–1200	**Jack Binysh** *Active elasticity*

Tuesday 26th July

1015–1030	INFORMAL PRE-TALK MEET & COFFEE
1030–1130	**Arnold Mathijssen** *Transport and delivery by living materials*
1130–1200	**Kiran Raj Melayil** *Soft matter biomicrofluidics – from mimicking blood flows to cancer drug screening*

Wednesday 27th July

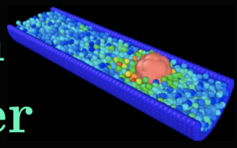
1015–1030	INFORMAL PRE-TALK MEET & COFFEE
1030–1130	**Andela Šarić** *One becomes two: non-equilibrium assemblies that split cells across evolution*
1130–1200	**Kristian Olsen** *Collective states of active matter with stochastic reversals and non-instantaneous alignment*
1900	PROGRAM DINNER

Thursday 28th July

1015–1030	INFORMAL PRE-TALK MEET & COFFEE
1030–1130	**Thomas Speck** *Stress and forces in scalar active fluids*
1130–1200	**Edgardo Rosas** *Rectification of self-propelled translational bacterial motors.*
1530–1600	INFORMAL MEET & COFFEE

Friday 29th July

1015–1030	INFORMAL PRE-TALK MEET & COFFEE
1030–1130	**Joakim Stenhammar** *Collective (hydro)dynamics of bacterial suspensions*
1130–1200	**Nirvana Caballero** *Interfaces as a probe for interactions in biological systems*
1530–1600	INFORMAL MEET & COFFEE



Week 2 Programme

Monday 1st August

1015–1030	INFORMAL PRE-TALK MEET & COFFEE
1030–1130	**Paul Dommersnes** *Transient dynamics in active matter*
1130–1200	**Jérémy Vachier** *Premelting controlled active matter in ice*
1530–1600	INFORMAL MEET & COFFEE

Tuesday 2nd August

1015–1030	INFORMAL PRE-TALK MEET & COFFEE
1030–1130	**Giovanni Volpe** *Interplay between active particles and their environment*
1130–1200	**Jan Rozman** *Villi formation due to junctional activity in vertex model of epithelial shells and sheets*
1530–1600	INFORMAL MEET & COFFEE

Wednesday 3rd August

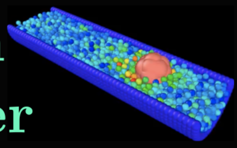
1015–1030	INFORMAL PRE-TALK MEET & COFFEE
1030–1130	**Anupam Sengupta** *Geometry, order and topology in microbial active matter*
1130–1200	**Sami Al-Izzi** *Covariant Hydrodynamics of Membranes and Nematic Surfaces*
1530–1600	INFORMAL MEET & COFFEE
1900	PROGRAM DINNER

Thursday 4th August

1015–1030	INFORMAL PRE-TALK MEET & COFFEE
1030–1130	**Ignacio Pagonabarraga** *Activity-induced interactions and emergent patterns in active suspensions*
1130–1200	**Amin Doostmohammadi** *Symmetries and mechanical imprints in cellular assemblies*
1530–1600	INFORMAL MEET & COFFEE

Friday 5th August

1015–1030	INFORMAL PRE-TALK MEET & COFFEE
1030–1130	**Kristian Thijssen** *Control of Active Nematics*
1130–1200	**Julia Yeomans** *Modelling the Dynamics of Confluent Cell Layers*
1530–1600	INFORMAL MEET & COFFEE



Week 3 Programme

Monday 8th August

1015–1030	INFORMAL PRE-TALK MEET & COFFEE
1030–1130	**Teresa Lopez-Leon** *Geometrical confinement: a powerful tool to choreograph the dance of active nematic defects*
1130–1200	**Luiza Anghuleta** *Dynamics of topological defects in active nematic films*
1530–1600	INFORMAL MEET & COFFEE

Tuesday 9th August

1015–1030	INFORMAL PRE-TALK MEET & COFFEE
1030–1130	**Gerhard Gompper** *Computational Physics of Active Filaments, Membranes, and Cells*
1130–1200	**Chantal Valeriani** *The role played by interactions in the assembly of active colloids: discovering dynamic laws from observations*
1530–1600	INFORMAL MEET & COFFEE

Wednesday 10th August

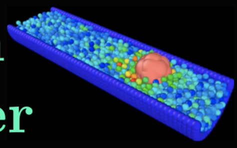
1015–1030	INFORMAL PRE-TALK MEET & COFFEE
1030–1130	**Corinna Maaß** *Self-propelling droplets*
1130–1200	**Sumesh Thampi** *Channel confined microswimmers*
1530–1600	INFORMAL MEET & COFFEE
2000	PROGRAM DINNER

Thursday 11th August

1015–1030	INFORMAL PRE-TALK MEET & COFFEE
1030–1130	**Patrick Charbonneau** *Recent Advances on the Glass Problem*
1130–1200	**Žiga Kos** *Defect dynamics and coarsening in three-dimensional active nematics*
1530–1600	INFORMAL MEET & COFFEE

Friday 12th August

1015–1030	INFORMAL PRE-TALK MEET & COFFEE
1030–1130	**Angelo Cacciuto** *Designing reconfigurable structures and squeezing through narrow openings*
1130–1200	**Sankalp Nambiar** *Hydrodynamics of slender swimmers near deformable interfaces*
1530–1600	INFORMAL MEET & COFFEE



Week 4 Programme

Monday 15th August

1015–1030	INFORMAL PRE-TALK MEET & COFFEE
1030–1130	**Mike Cates** *Biased Ensembles + Optimal Control in Active Particle Systems: Large Deviation Theory for Active Work*
1130–1200	**Cesare Nardini** *Capillary waves in active phase separation*
1500–1530	FIKA

Tuesday 16th August

1015–1030	INFORMAL PRE-TALK MEET & COFFEE
1030–1130	**Mogens Høgh-Jensen** *DNA repair, Droplet Formation and Chaos in Cells*
1130–1200	**Dhrubaditya Mitra** *Entropy and active elasticity*
1500–1530	INFORMAL MEET & COFFEE

Wednesday 17th August

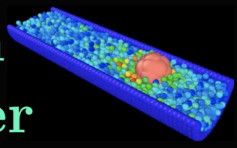
1015–1030	INFORMAL PRE-TALK MEET & COFFEE
1030–1130	**Jörn Dunkel** *Towards programmable living materials and quantitative models of active matter*
1130–1200	**Zhouyang (Anthony) Ge** *Dynamics of periodically sheared shakers*
1500–1530	FIKA
1930	PROGRAM DINNER

Thursday 18th August

1015–1030	INFORMAL PRE-TALK MEET & COFFEE
1030–1130	**Sriram Ramaswamy** *Chiral active matter*
1130–1200	**Farzan Vafa** *Diffusive growth sourced by topological defects*
1500–1530	INFORMAL MEET & COFFEE

Friday 19th August

0845–0900	INFORMAL PRE-TALK MEET & COFFEE
0900–1000	**Tyler Shendruk** *Mesoscopic models for active nematic fluids*
1000–1030	**Aboutaleb Amiri** *Emergent chirality in active rotation of pancreas organoids*
1100–1130	FIKA & PROGRAM CLOSE



Monday 25th July

1030–1130

Speaker **Anton Souslov**

Title *Topology not in biology*

Abstract

In this talk, I will focus on applications of topology to artificial metamaterials, in which functionality is programmed in through structure on length scales much larger than the atom. In addition to this large-scale structure, topological phenomena can be designed using active components such as motors. These topological metamaterials have a wealth of phenomena inaccessible in naturally occurring systems. I will provide three examples of how topological band structures can inform metamaterials design. In the first example, I will show how a 3D printed topological mechanical insulator can be softer on one side than the other due to a vector topological invariant in its bulk [1]. In the second example, topology informs the design for the cross-section for an optical fibre. As a result, light is conducted in a topological state over large distances and protected by the topological invariant [2]. Finally, I will talk about a topological active fluid designed to conduct sound only on its surface and in a chiral manner. I will discuss the unique features of this fluid band structure and how topological can be exploited to design complete acoustic absorption [3].

[1] Achilles Bergne, Guido Baardink, Evripides G Loukaides, Anton Souslov. Scalable 3D printing for topological mechanical metamaterials (2022) arXiv:2206.11837
[2] Nathan Roberts, Guido Baardink, Josh Nunn, Peter J. Mosley, Anton Souslov. Topological supermodes in photonic crystal fibre (2022) arXiv:2201.10584
[3] Guido Baardink, Gino Cassella, Luke Neville, Paul A. Milewski, Anton Souslov. Complete absorption of topologically protected waves. Physical Review E 104, 014603 (2021)

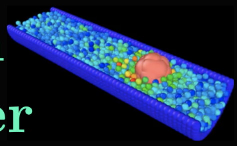
1130–1200

Speaker **Jack Binysh**

Title *Active elasticity*

Abstract

Active solids consume energy to allow for actuation and shape change not possible in equilibrium. In this talk, I will discuss our recent work on active elastic solids, focusing on the interplay between non-equilibrium surface stresses and bulk elasticity in soft materials. I will first introduce a continuum theory and microscopic simulations that describe a 3D soft solid whose boundary experiences active surface stresses. The competition between active boundary and elastic bulk yields a broad range of previously unexplored phenomena, which are demonstrations of so-called active elastocapillarity. I will then discuss how elasticity modifies a surface-stress-driven phenomenon we are all familiar with - the Leidenfrost effect. When a hydrogel sphere is lowered onto a hot plate, its bottom begins to vaporize. The resulting vapor flow couples tightly to elastic deformations within the sphere, giving either spontaneous bouncing or steady-state floating. Despite experimental evidence, a fundamental theory of these phenomena remains a challenge. Here, I will provide a theory of elastic Leidenfrost floating. As weight increases, a rigid solid sits closer to the hot surface. By contrast, I will describe a counter-intuitive Hertzian regime, in which the heavier the solid, the higher it floats. These results provide theoretical underpinning for recent experiments, and point to the design of novel soft machines.



Tuesday 26th July

1030–1130

Speaker: **Arnold Mathijssen**

Title: *Transport and delivery by living materials*

Abstract:

One of the major challenges in robotics is controlling transport and micromanipulation by active and adaptive materials. Existing delivery technologies often suffer from limited navigation control, low speeds, and proneness to environmental disturbances. Biology often solves these problems by collectively organizing actuation at the microscale. For example, pathogens are removed from our lungs by an active carpet of cilia. Inside these cilia, in turn, microtubules form highways for molecular motors. In this talk, I will present developments in the microfabrication of "artificial cilia" and "artificial microtubules". We designed amphibious cilia that can transport both liquids and dry objects. These carpets can sort particles by size and by shape using a crowd-surfing effect. We also designed magnetic microtubules, structured microfibers that rapidly guide particles through flow networks such as the cardiovascular system. These works offer unique strategies for robust microscale delivery, but equally shed light on non-equilibrium effects in biological transport processes.

1130–1200

Speaker: **Kiran Raj Melayil**

Title: *Soft matter biomicrofluidics – from mimicking blood flows to cancer drug screening*

Abstract:

Over the past few decades, microfluidics has emerged as an extensive and multidisciplinary area of research within the domain of fluid dynamics. The rise in technological advancements especially in the field of electronics and instrumentation has resulted in the development of microfluidics based biomedical devices and techniques for diagnosis, vital monitoring, support systems, and therapeutic screening. Microfluidics comes handy due to its inherent advantages in sensing, sample requirements, time of detection and the affordability to the masses. In the light of these developments in the field of microfluidics with potential applications in areas ranging from soft matter physics to global healthcare, my research was focused on experimental and theoretical aspects of fluid flows in deformable microchannels that mimic the human vasculature. The experimental results, corroborated with theoretical analysis have demonstrated the intricate relationship of the channel deformation and the pressure drop across a deformable microchannel. Later, it was extended to time varying flows and flows of red blood cells in hydrogel based deformable microchannels. Another aspect that would be emphasized is the wetting of droplets with microparticles and bacteria on highly repellent (superhydrophobic) surfaces. Further in the fight against cancer, commonly followed microfluidics-based approaches for cancer drug screening are complicated and expensive, including fabrication and instrumentations steps requiring high-end equipment. We propose a low-cost drug screening and viability testing platform with minimal technical sophistication. A novel way of spheroid generation inside a microfluidics environment is introduced that exploits pure hydrodynamic and interfacial effects with the aid of droplet microfluidics for drug screening of cancer cells with chemotherapy drugs.

Wednesday 27th July

1030–1130

Speaker	**Andela Šarić**
Title	*One becomes two: non-equilibrium assemblies that split cells across evolution*

The molecular machinery of life is largely created via self-organisation of individual molecules into functional larger-scaled assemblies. Such processes are multi-scale in nature and constantly driven far from thermodynamic equilibrium. Our group develops minimal coarse-grained models to investigate how driven macromolecular assemblies result in living machines, and how such processes can fail, leading to diseases.

Abstract

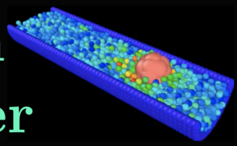
Today I will present our research on computational modelling of active elastic filaments that dynamically reshape and cut cells. I will present the comparison of our simulation results to live cell data on reshaping processes across evolution — from cellular trafficking to cell division. I will finish with our recent efforts in computationally evolving assemblies that perform a desired function. Beyond their biological context, our models can help guide the design of artificial structures that are able to mimic life at the nanoscale.

1130–1200

Speaker	**Kristian Olsen**
Title	*Collective states of active matter with stochastic reversals and non-instantaneous alignment*

Abstract

Biological and synthetic active matter systems portray a wide range of complex behavioral patterns at the single-particle level. Here we will discuss some aspects of how different microscopic dynamics affects collective behavior. In the mean-field limit, the order-disorder transition takes place at a critical alignment timescale, which for a wide class of systems is shown to satisfy a simple relation to the persistence time of the underlying dynamics. The case of particles undergoing stochastic reversals of their direction of motion is considered in more detail, displaying collective behaviours including emergent chiral states and macroscopic flow reversals.



Thursday 28th July

1030–1130

Speaker **Thomas Speck**

Title *Stress and forces in scalar active fluids*

Abstract

Understanding and predicting the forces generated in fluids due to the presence of interfaces and surfaces are of interest for a wide range of applications including the interfacial tension between different phases and depletion forces acting on immersed bodies. I will discuss recent advances for scalar active fluids in which the non-aligning constituents are self-propelled, and how the stress can be used to predict phase equilibrium as well as forces on non-symmetric bodies and symmetric bodies under confinement. Finally, I will sketch the thermodynamics of extracting work from active fluids.

1130–1200

Speaker **Edgardo Rosas**

Title *Rectification of self-propelled translational bacterial motors*

Abstract

We generate translational bacterial motors by confining a high density suspension of self-propelled Escherichia Coli bacteria inside a droplet immersed in oil. The collective motion generated by the interaction of individual swimmers makes the droplet move when it is posed over a substrate. Past studies have shown that the droplet exhibits a persistent movement at short times, but zero mean displacement at long times, behaving in a diffusive fashion when it is posed over an isotropic substrate (Ramos2020). Due to the dominance of viscous forces at the microscale, the extraction of useful work from these motors requires a non-reciprocal motion. We designed and fabricated ratchet type substrates and studied how translational bacterial motors behave when posed over it, showing it is possible to rectify the motion of translational bacterial motors.

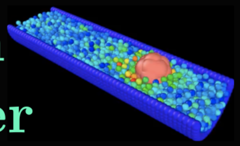
Friday 29th July

1030–1130

Speaker	**Joakim Stenhammar**
Title	*Collective (hydro)dynamics of bacterial suspensions*
Abstract	Due to their nonequilibrium character, the collective dynamics of swimming microorganisms systems is often dictated by long-ranged hydrodynamic interactions. One example is the collective motion of swimming, rear-actuated ("pusher") bacteria that interact through their long-ranged dipolar flow fields to create a state of so-called "active turbulence" with chaotic, collective swimming with long-ranged correlations. This behavior is in contrast to the behaviour of front- actuated ("puller") organisms such as certain algae, that do not exhibit any collective motion in 3 dimensions. In this talk, I will summarize results from analytical theory and large-scale, particle resolved simulations of model microswimmer suspensions that provide new information about the transition to active turbulence in both unbounded and confined systems. Our results reveal a qualitatively different behaviour of microswimmers in quasi-2D confinement compared to the unbounded case, where the long-ranged instability leading to active turbulence in 3D is instead rendered short-ranged. Additionally, we find a previously uncharted density instability of confined puller microswimmers, which has no counterpart in unbounded systems. Our results thus highlight that the details of the experimental geometry is crucial for collective phenomena in active matter dominated by hydrodynamic interactions.

1130–1200

Speaker	**Nirvana Caballero**
Title	*Interfaces as a probe for interactions in biological systems*
Abstract	Control over cells, either individually or as a proliferating cell front, remains elusive because the plethora of interactions at widely varying length scales present in these systems leads to highly complex dynamical and geometrical properties. Interfaces separating different regions of heterogeneous composition (domains) can encode information about the underlying physics of a system. I will show how physical theories describing interfaces can be used to capture the microscopic interactions dominating a system. I will give examples at different scales from cell membranes [1], where the heterogeneous domain composition is key to biological function, to migrating colonies of cells, where interfaces reveal the main interactions present in a colony [2]. [1] NC, K. Kruse, T. Giamarchi. Phase separation on surfaces in presence of matter exchange. ArXiv:2205.03306. https://arxiv.org/abs/2205.03306 [2] G. Rapin⋆, NC⋆, I. Gaponenko, B. Ziegler, A. Rawleight, E. Moriggi, T. Giamarchi, S. A. Brown, and P. Pruch. Roughness and dynamics of proliferating cell fronts as a probe of cell-cell interactions. Sci. Rep. 11, 8869 (2021). https://www.nature.com/articles/s41598-021-86684-3



Monday 1st August

1030–1130

Speaker **Paul Dommersnes**

Title *Transient dynamics in active matter*

Abstract

Part1: An active system can go from one state (or phase) to another as some parameter is changed. Whereas the steady-state dynamics of a given state is usually well understood, there is somewhat less knowledge about the transient dynamics, i.e. how one goes from one state to another. I will present some experiments on swarms of granular Quincke rollers where individual particles can be tracked and the transition from an initially turbulent flow to a lamellar flow state can be monitored. Depending on the experimental parameters, the system exhibit either vortical flow dynamics or ordered XY type polar flow with topological defects. The energy spectrum is power-law distributed throughout the transition, and the characteristic vortex scale grows approximately diffusively in time. Using a minimal particle model, we show that structure and dynamics can be understood by a combination of long-rangle hydrodynamic dipolar interactions coupled with self-orientation in flows.
Part 2: I will attempt to discuss theoretically some general aspects of the dynamics of active systems as they go from one phase to another.

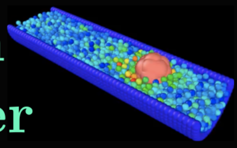
1130–1200

Speaker **Jérémy Vachier**

Title *Premelting controlled active matter in ice*

Abstract

Self-propelled particles can undergo complex dynamics due to a range of bulk and surface interactions. In the case of a foreign particle inside a subfreezing solid, such as a particle in ice, a premelted film can form around it allowing the particle to migrate under the influence of an external temperature gradient, which is a phenomenon called thermal regelation. It has recently been shown that the migration of particles of a biological origin can accelerate melting in a column of ice and thereby migrate faster. We have previously shown that the effect of regelation plays a major role in the migration of inert particles and impurities inside ice, with important environmental implications. In particular, the question of how the activity affects a particle's position over time is essential for paleoclimate dating methods in ice cores. We re-cast this class of regelation phenomena in the stochastic framework of active Ornstein-Uhlenbeck dynamics and make predictions relevant to this and related problems of interest in geophysical and biological problems.



Tuesday 2nd August

1030–1130

Speaker **Giovanni Volpe**

Title *Interplay between active particles and their environment*

Abstract

In this seminar, I will present some examples of how the behaviour of active particles can be influenced by their environment. In particular, I'll show the formation of active molecules and active droploids from passive colloidal building blocks; the emergence of non-Boltzmann statistics and active-depletion forces between plates in an active bath; and the environment topography alters the way to multicellularity in the bacterium Myxococcus xanthus.

1130–1200

Speaker **Jan Rozman**

Title *Villi formation due to junctional activity in vertex model of epithelial shells and sheets*

Abstract

The study of organoids, artificially grown cell aggregates with the functionality and small-scale anatomy of real organs, is one of the most active areas of research in biology and biophysics, yet the basic physical origins of their different morphologies remain poorly understood. Using a 3D surface tension-based vertex model of epithelial shells [1], we reproduce the characteristic shapes from branched and budded to invaginated structures. Importantly, we find that the formation of branched morphologies relies strongly on junctional activity, resulting in aggregations of topological defects in cell packing. We then compare these results to morphologies that emerge in a more general model tissue: A strained unsupported epithelial monolayers subject to active junctional noise due to stochastic binding and unbinding of myosin [2]. We find that while uniaxial, biaxial, and isotropic in-plane compressive strains do lead to the formation of longitudinal, herringbone pattern, and labyrinthine folds, respectively, the villi morphology again appears only if junctional tension fluctuations are strong enough to fluidize the tissue. Moreover, the fluidized epithelium features villi even in absence of compressive strain. Together, this work provides a generic interpretation of many observed epithelial tissue shapes, highlighting the role of physical factors such as differential surface tension, cell rearrangements, compression, and tissue growth.

[1] J. Rozman, M. Krajnc, and P. Ziherl, Collective cell mechanics of epithelial shells with organoid-like morphologies, Nat. Commun. 11, 3805 (2020).
[2] J. Rozman, M. Krajnc, and P. Ziherl, Morphologies of compressed active epithelial monolayers, Eur. Phys. J. E 44, 99 (2021).

Wednesday 3rd August

1030–1130

Speaker **Anupam Sengupta**

Title *Geometry, order and topology in microbial active matter*

Abstract

Topology transcends boundaries that conventionally delineate physical, biological, and engineering sciences. Our ability to mathematically describe topology, combined with recent access to precision tracking and manipulation approaches, has triggered a fresh appreciation of topological ramifications in biological systems. Microbial ecosystems, a classic example of living matter, offer a rich test bed for exploring the role of topological defects in shaping community compositions, structure, and functions spanning orders in length and time scales. Microbial activity—characteristic of such structured, out-of-equilibrium systems—triggers emergent processes that endow evolutionary and ecological benefits to microbial communities. The interplay of geometry, order, and topology elicit novel, if not unexpected dynamics that are at the heart of active and emergent processes in such living systems. This talk, based on a recent works in my team [1,2,3], will summarize key advances that highlight the interface of active liquid crystal physics and the physical ecology of microbes; and present results we have obtained during our adventures with sessile bacteria and motile phytoplankton. Topology and its functional manifestations—a crucial and well-timed topic—offer a rich opportunity for both experimentalists and theoreticians willing to take up an exciting journey across scales and disciplines.

[1] Microbial Active Matter: A Topological Framework: A. Sengupta, Frontiers in Physics 8, 184, 2020.
[2] Self-regulation of phenotypic noise synchronizes emergent organization and active transport in confluent microbial environments: J. Dhar, A.L.P.Thai, A. Ghoshal, L. Giomi A. Sengupta, Nature Physics 2022 (in press)
[3] Active reconfiguration of cytoplasmic lipid droplets governs migration of nutrient-limited phytoplankton: A. Sengupta, J. Dhar, F. Danza, A. Ghoshal, S. Müller; N. Kakavand (under review), bioRxiv https://www.biorxiv.org/content/10.1101/2021.10.17.463831v1.full

1130–1200

Speaker **Sami Al-Izzi**

Title *Covariant Hydrodynamics of Membranes and Nematic Surfaces*

Abstract

Firstly, I will review some concepts in the mechanics of fluid membranes (such as lipid membrane making up cell bilayers). I will then discuss how hydrodynamical equations governing the membrane dynamics can be derived before focussing on a specific example of a lipid membrane tube under azimuthal shear. Hear we find that shear forces drive helical instabilities in the tube shape which are eventually stabilised by the underlying advection, these dynamics do however lead to a novel non-equilibrium steady-state in the shape fluctuations of the membrane tube. We discuss the possible role of this shear driven fluctuation amplification in the process of dynamin mediated tube scission. Secondly, I will discuss some theoretical work I have done extending the notions of active hydrodynamics to deformable surfaces with nematic ordering. We derive fully covariant hydrodynamical equations in the large deformation limit for active liquid crystal surfaces and characterise such equations in terms of typical dimensionless numbers. I will present some simple examples of instabilities and morphology generation from the coupling between ordering, flows and shape and their relevance to morphogenetic processes, such as Hydra morphogenesis.

Thursday 4th August

1030–1130

Speaker **Ignacio Pagonabarraga**

Title *Activity-induced interactions and emergent patterns in active suspensions*

Abstract

Active matter systems are intrinsically out of equilibrium in the absence of any external driving. Their collective behavior emerges from a balance between direct interactions and indirect couplings through the medium they move in, and a self-consistent dynamical approach is required to analyze their evolution. The mechanical balance that determines their collective behavior makes these systems very versatile. An understanding on the basic principles underlying the emergence and self-assembly on active systems poses fundamental challenges. I will consider simple models to address the fundamental properties of active systems, which require a consistent dynamic treatment, and will discuss the generic implications that self-propulsion has in the emergence of structures in suspensions of model self-propelled particles. I will analyze the role that the medium in which active colloids displace has in generating dynamic correlations. Specifically, I will consider swimming and heterogeneous catalysis, which lead to spontaneous self-organization in the absence of external driving for a variety of active suspensions. Such a comparison will help to discern between specific ingredients and general features determining the emergent properties of active systems.

1130–1200

Speaker **Amin Doostmohammadi**

Title *Symmetries and mechanical imprints in cellular assemblies*

Abstract

Dynamics of cell organization within tissues present a fascinating ground for studying physics of active materials: not only cells generate active stresses through interactions with the substrate or extracellular matrix, but also different forms of stresses through cell-cell adhesion lead to active interaction forces. Additionally, the self-propulsion, stress generation, and arrangement of cells within tissues present complex cross-talk between polar, nematic, and hexatic symmetries. I will first discuss criticality of a counter-intuitive glass to fluid transition in 3D cell layers upon increasing cell-cell adhesion. I will then present results of recent 3D cell-based simulations on the competition between cell-cell and cell-substrate interactions to switch between nematic disclinations and hexatic dislocations as local mechanical hotspots within the tissue. I will then turn to a continuum model to show unexpected impact of fluctuations on the flow and stress patterns around disclinations and present a unifying picture of competition between polar and nematic symmetries.

Friday 5th August

1030–1130

Speaker	**Kristian Thijssen**
Title	*Control of Active Nematics*
Abstract	Coupling between flows and material properties imbues rheological matter with its wide-ranging applicability, hence the excitement for harnessing the rheology of active fluids for which internal structure and continuous energy injection lead to spontaneous flows and complex, out-of-equilibrium dynamics. In this talk, I will discuss work investigating different ways to control active nematic films, a class of active matter that displays collective active motion, orientational order and topological singularities, by altering substrate properties and boundaries. The effect of isotropic and anisotropic friction is discussed on the active nematic film's general flow and topological structure. I will demonstrate convenient, highly tuneable methods for controlling flow, topology and composition within active nematic films due to either direct introduction of boundaries or with the indirect presence of fully submersed micropatterned structures within a thin, underlying oil layer, which introduce virtual boundaries. These control methods of active films present pathways for engineering active microfluidic systems.

1130–1200

Speaker	**Julia Yeomans**
Title	*Modelling the Dynamics of Confluent Cell Layers*
Abstract	A lot is understood about the ways in which single cells move over a surface, but the motion of confluent layers of epithelial cells, where the cells are coupled through strong intercellular junctions, remains puzzling. The cells in epithelial layers can be jammed in a glass-like state, they can flock, or they can show active turbulent-like motility with chaotic flows, high vorticity and motile topological defects. Active turbulence characterises active nematics, and we have been trying to understand why cells that are, on average, isotropic can show nematic properties. Moreover, it is surprising that single cells are contractile, whereas the direction of movement of active defects in many confluent cell layers suggests that they are behaving as an extensile material. We are addressing these questions using analytical arguments, phase field simulations and continuum theories.

Monday 8th August

1030–1130

Speaker **Teresa Lopez-Leon**

Title *Geometrical confinement: a powerful tool to choreograph the dance of active nematic defects*

Abstract

Active nematics are biomimetic liquid crystals in which a 2D network of microtubule filaments is set in motion by the action of molecular motors (1, 2). In its steady state, this system usually exhibits chaotic dynamics controlled by the motion of a large number of self-propelled topological defects (3). In this talk, I will show how the chaotic motion of topological defects can be turned into an organized choreography using confinement and geometry (4, 5). Directional motion arises spontaneously when the active nematic is confined to thin open channels, due to the interaction of the defects with the walls. Complex active flow networks can be built by connecting these channels together, imposing global topological constraints on the system that enable, for example, logical operations to be implemented. Finally, I will show that remarkable dynamic states arise when the active nematic is confined to the surface of a micro-sized, ellipsoidal, smectic droplet. We observe two distinct dynamic states with quadrupolar and a bipolar symmetry respectively, where the system regularly oscillates between a rotational and a translational regime. We use numerical simulations to investigate the origin of this intriguing dynamics, finding interesting interplay between curvature, viscous anisotropy and hydrodynamics.

(1) D. Needleman and Z. Dogic, Nature Reviews Materials 2, 17048 (2017)
(2) T. Sanchez et al., Nature 491, 431 (2012).
(3) L. Giomi et al., Phys. Rev. Lett. 110, 228101 (2013)
(4) J. M Hardouin et al Communications Physics 2, 121 (2019)
(5) J.M Hardouin et al, Soft Matter 16, 9230 (2020)

1130–1200

Speaker **Luiza Anghuleta**

Title *Dynamics of topological defects in active nematic films*

Abstract

Active nematics is a minimal theoretical approach that captures some of the complex behavior of biological systems from sub- to multicellular scales where orientational order emerges. Intrinsic activity in such systems builds mechanical stresses that distort nematic order and generate spontaneous active flows. The interplay between active flows and order leads to the formation of topological defects that acquire an activity-induced motility, also termed as self-propulsion, and sustain chaotic flows. In this talk, I will present some theoretical considerations on the defect dynamics induced by the active stress competing with viscous dissipation and frictional drag with a substrate. Pressure gradients for incompressible flows have an important contribution to the self-propulsion speed. Recent studies have also shown that the defect dynamics can be guided by spatial heterogeneities in activity. I will discuss some of our theoretical results on the effect of spatially varying activity on the defect self-propulsion.

Tuesday 9th August

1030–1130

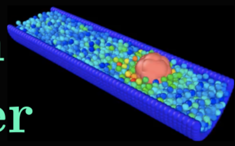
Speaker **Gerhard Gompper**

Title *Computational Physics of Active Filaments, Membranes, and Cells*

Abstract

Active matter exhibits a wealth of emergent non-equilibrium behaviors [1,2]. A paradigmatic example is the interior of cells, where active components, such as the cytoskeleton, are responsible for its structural organization and the dynamics of the various components. Of particular interest are the properties of active polymers and filaments [3]. The intimate coupling of active forces, thermal noise, hydrodynamic interactions, and polymer connectivity implies the emergence of novel structural and dynamical features. Different propulsion mechanisms capture the physics of a variety of active polymeric systems, such as chains of active Brownian particles [3-5], polar filaments propelled along their contours [5], or cytoskeletal polar filaments propelled by motor proteins [6]. This leads to interesting single-particle behavior, such as a softening of a semiflexible filament of active Brownian particles at intermediate levels of activity [4], or a sperm-like beating motion of a filament pushing a load. At high polymer densities in two dimensions, collective dynamics characterized by active turbulence is observed [5,7]. Vesicles (in three dimensions) [8] and closed polymer rings (in two-dimensions) [9] with internal active components can be considered as highly simplifed models of cells. Here, the active components lead to enhanced fluctuations [8] and an intimate coupling of propulsion forces, membrane deformability, cell shape, and cell sensing and reactivity [9]. In all these systems, computational models of active matter play an essential role to elucidate their non-equilibrium behavior [10].

[1] J. Elgeti, R.G. Winkler, and G. Gompper, Rep. Prog. Phys. 78, 056601 (2015).
[2] G. Gompper et al., J. Phys. Condens. Matter 32, 193001 (2020).
[3] R.G. Winkler and G. Gompper, J. Chem. Phys. 153, 040901 (2020).
[4] T. Eisenstecken, G. Gompper, and R.G. Winkler, J. Chem. Phys. 146, 154903 (2017).
[5] O. Duman, R.E. Isele-Holder, J. Elgeti, and G. Gompper, Soft Matter 14, 4483 (2018).
[6] G. Vliegenthart, A. Ravichandran, M. Ripoll, T. Auth, and G. Gompper, Sci. Adv. 6, eaaw9975 (2020).
[7] K. Qi, E. Westphal, G. Gompper, and R.G. Winkler, Communications Physics 5, 49 (2022).
[8] H.R. Vutukuri et al., Nature 586, 52 (2020).
[9] C. Abaurrea Velasco, T. Auth, and G. Gompper, New J. Phys. 21, 123024 (2019).
[10] M.R. Shaebani, A. Wysocki, R.G. Winkler, G. Gompper, and H. Rieger, Nat. Rev. Phys. 2, 181 (2020).



Tuesday 9th August

1130–1200

Speaker **Chantal Valeriani**

Title *The role played by interactions in the assembly of active colloids: discovering dynamic laws from observations*

Abstract

Active matter systems are composed of non-equilibrium units that consume energy to perform directed motion [1,2,3]. Examples of acive particles at the mesoscopic scale are living, such as bacteria, or artificial, such as synthetic active colloids [4,5,6,7]. The theoretical framework describing these systems has shown tremendous success at finding universal phenomenology.
When dealing with active colloids, on the one side, one might think of studying the features of a suspension of particles whose interactions are inspired on Soft Matter (passive) systems, such as isotropic (strongly repulsive [8,9,10], attractive [11, 12,13], micelle-inducing [14]) or anisotropic (Janus-like) interactions[15], unravelling the relevance of hydrodynamics [12, 16].
On the other side, one might consider determining the forces that control the dynamics of the individual colloids directly from experiments. Accessing this local information would be the key for understanding the physics governing these systems and for creating models that explain the observed collective phenomena. For this purpose, we propose a machine-learning tool that uses the collective movement of the particles to learn the active and two-body forces, controlling particles' individual dynamics. The method has been successfully tested not only on numerical simulations of Active Brownian Particles, considering different interaction potentials and levels of activity, but also on experiments of electrophoretic Janus particles, extracting the active and two-body forces that control the dynamics of the colloids [17]. We foresee that this methodology can open a new avenue for the study and modelling of experimental systems of active particles.

[1] C. Bechinger, R. Di Leonardo, H. Lowen, C. Reichhardt, G. Volpe, and G. Volpe, Reviews of Modern Physics 88, 045006 (2016)
[2] M.E. Cates, J. Tailleur. Annu. Rev. of Condens. Matt. Phys. 6, pp. 219-244 (2015).
[3] S.Mallory, C.Valeriani and A.Cacciuto, Ann. Rev. Phys. Chem. 6959 (2018)
[4] S. Thutupalli, R. Seemann, S. Herminghaus New J. Phys. 13, 073021 (2011).
[5] W.F. Paxton et al. Chem. Commun. 441, 3 (2005).
[6] S. Fournier-Bidoz et al. J. Am. Chem. Soc. 126, 13424 (2004).
[7] I. Buttinoni, J. Bialke, F. Kummel, H. Lowen, C. Bechinger, T. Speck. Phys.Rev. Lett. 110, 238301 (2013).
[8] J.Martin Roca, R Martinez, A Luis Diez, L Alexander, D Aartz, F Alarcon, J Ramirez and C Valeriani J Chem Phys 154, 164901 (2021)
[9] DR Rodriguez, F Alarcon, R Martinez, J Ramírez, C Valeriani, Soft Matter 16 (5), 1162 (2020)
[10] J. Martin Roca, R. Martinez, F.Martinez Pedrero, J.Ramirez and C Valeriani, J. Chem. Phys. 156, 164502 (2022)
[11] B. Mognetti, A. Saric, S. Angioletti-Uberti, A. Cacciuto, C. Valeriani and D. Frenkel Phys. Rev. Lett. 111, 245702 (2013)
[12] F.Alarcon, C.Valeriani and I.Pagonabarraga Soft Matter 10.1039/ C6SM01752E (2017)
[13] J.Harder, S.Mallory, C.Tung, C.Valeriani and A.Cacciuto, J. Chem. Phys. 141 194901 (2014)
[14] C.Tung, J.Harder, C.Valeriani and A.Cacciuto, Soft Matter 12 555 (2016)
[15] S.Mallory, F.Alarcon, A.Cacciuto and C.Valeriani New Journal of Physics (2017)
[16] F.Alarcon, E.Navarro, C.Valeriani and I.Pagonabarraga, PRE submitted (2018)
[17] "Discovering dynamic laws from observations with Graph Neural Networks: the case of self-propelled, interacting colloids", M. Ruiz-Garcia, C.M.Barriuso, L.Alexander, D.Aarts, L.Ghiringhelli and C.Valeriani, submitted (2022)

Wednesday 10th August

1030–1130

Speaker	**Corinna Maaß**
Title	*Self-propelling droplets*
Abstract	Active matter can be characterised by the conversion of microscale free energy into meso- and macroscale mechanical work, and microswimmers are a fundamental class of active matter. Single-cellular bio-microswimmers form a large part to our ecosystem, whereas in mechanical and chemical engineering, biomimetic artificial swimmers provide opportunities to the development of smart materials - particularly when considering the emergence of collective phenomena based on the interactions between individual agents and their complex environment. In both cases, one relies on fundamental physical principles to understand and recreate specific behaviours. To disentangle the underlying nonequilibrium physics assumptions from complex biochemistry and sophisticated chemical engineering, one requires fundamental and generic experimental model systems. My research focuses on investigating these physical principles using oil droplets, whose self-propulsion is driven by their solubilisation in aqueous surfactant solutions. I use this very simple, spherically symmetric, and soft model system to investigate experimental realisations of generic microswimmer concepts ranging from 'dry' chemically active particles over pure hydrodynamic to coupled chemohydrodynamics, and the emergent biomimetic phenomena arising from these concepts.

1130–1200

Speaker	**Sumesh Thampi**
Title	*Channel confined microswimmers*
Abstract	We study the trajectories of a model microorganism (i) inside a three-dimensional rectangular channel and (ii) in presence of other passive particles using lattice Boltzmann simulations. Using far field approximations and method of images, analytical expressions are also derived to explain the observations. Our results indicate that the hydrodynamic interactions with the confining walls of the channel significantly affect the swimming speed and trajectory of the model microswimmer. Further, we propose a method based on the principle of superposition to understand the origin of the three dimensional trajectories of channel confined swimmers. According to this hypothesis, the three dimensional trajectories can be constructed from two planar trajectories, each produced by the swimmer when it is restricted to move in the center planes of the channel. This construction allows us to predict and justify the origin of apparent complex trajectories generated by different types swimmers in channels with square and rectangular cross sections. We also study the hydrodynamic collision between microswimmers and passive particles and show that the collision is essentially an asymmetric process – the trajectory of the microswimmer is altered only in an intermediate stage while the passive particle undergoes a three stage displacement with a net displacement towards or away from the microchannel walls. The path of the passive particle is a simple consequence of the velocity field generated by the swimmer: an open triangle in bulk fluid and a loop-like trajectory in confinement.

Thursday 11th August

1030–1130

Speaker **Patrick Charbonneau**

Title *Recent Advances on the Glass Problem*

Abstract

Over the last decade, theoretical advances have provided an exact solution to the glass problem in the limit of infinite spatial dimension. Interestingly, the dynamical arrest this work predicts is consistent with the mode-coupling theory of glasses, and the ensuing entropy crisis at the Kauzmann transition with the random first-order transition scenario. However, what survives of these features and what other processes contribute to the dynamics of three-dimensional glass formers remain largely open questions. In this talk, I present our recent advances toward a microscopic understanding of the finite-dimensional echo of these infinite-dimensional features, and of some of the activated processes that affect the dynamical slowdown of simple yet realistic glass formers.

1130–1200

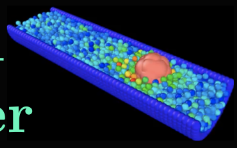
Speaker **Žiga Kos**

Title *Defect dynamics and coarsening in three-dimensional active nematics*

Abstract

Three-dimensional active nematics are exciting materials characterized by a network of continuously evolving defect lines and loops [1]. We peformed detailed numerical and analytical investigation of 3D active nematics with emphasis on the dynamics of topological defects [2-5]. The dynamics of a single active defect loop depends on the local crosssection of the director profile that can span from +1/2 or -1/2 winding numbers to twist profiles. Depending on the loop orientational profile, we observe spontaneous shrinking, growing, and bending modes [2]. In confinement, active nematics show irregular dynamics of multiple defect loops with distinct topological events of loop crossover, annihilation, splitting and merging occurring in time [3]. At constant activity, bulk three-dimensional active turbulence is characterized as an dynamic state state with an effectively constant density of reconfiguring defect lines [4]. The transitional dynamics towards and between different dynamic steady states of three-dimensional active turbulence is determined by the coarsening or refinement of the defect lines [5]. Specifically, using theory and numerical modelling, we are able to predict the evolution of the active defect density away from the steady state as due to quenching of the system or time-dependent activity, establishing a single length scale phenomenological description of defect line coarsening/refinement in a three-dimensional active nematic. The approach is first applied to growth dynamics of a single active defect loop, and then to a full three-dimensional active defect line network. Our phenomenological equations are then compared to the time evolution of the defect line coarsening in other physical systems. Our work aims to provide insight into 3D active nematic systems from the perspective of the topology of the emergent 3D defects and their self-induced dynamics.

[1] G. Duclos et al., Topological structure and dynamics of three-dimensional active nematics, Science 367, 1120 (2020).
[2] J. Binysh, Ž. Kos, S. Čopar, M. Ravnik, G. P. Alexander, Three-Dimensional Active Defect Loops, Phys. Rev. Lett. 124, 088001 (2020).
[3] S. Čopar, J. Aplinc, Ž. Kos, S. Žumer and M. Ravnik, Topology of Three-Dimensional Active Nematic Turbulence Confined to Droplets, Phys. Rev. X 9, 031051 (2019).
[4] Ž. Krajnik, Ž. Kos and M. Ravnik, Spectral energy analysis of bulk three-dimensional active nematic turbulence, Soft Matter 16, 9059 (2020).
[5] N. Kralj, M. Ravnik, Ž. Kos, Defect line coarsening and refinement in active nematics, arXiv:2204.11957 (2022).



Friday 12th August

1030–1130

Speaker **Angelo Cacciuto**

Title *Designing reconfigurable structures and squeezing through narrow openings*

Abstract

Two of the most intriguing challenges in active matter concern the development of smart materials capable of altering their structural properties when subject to external stimuli and the development of robust strategies to exploit active motion to generate work at the micro-scale. In this talk I will present new results on simple models developed to design reconfigurable active structures, and discuss ways in which active particles can transport passive components through complex narrow channels.

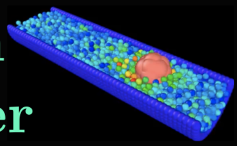
1130–1200

Speaker **Sankalp Nambiar**

Title *Hydrodynamics of slender swimmers near deformable interfaces*

Abstract

Self-propelling microscopic swimmers such as motile bacteria and algae often inhabit complex environments in the vicinity of boundaries. These swimmers interact with the boundaries for various biological imperatives that include formation of biofilm colonies, pathogenesis, foraging for nutrition as well as use interfaces for locomotion, to list a few. The intervening boundaries can be either rigid such as cracks in rocks, corrugated pipes, or deformable surfaces and interfaces such as intestinal tracts, blood vessels, membrane boundaries and fluid interfaces. Understanding the fluid-mediated hydrodynamics of such systems is important to gain insights into the dynamics, which crucially depends on the boundary. Of particular interest is the question of how the swimmer migration is influenced by the boundary. We study the coupled hydrodynamics of a microswimmer in the vicinity of a deformable interface. We characterize both the interface deformation due to swimming and the modification to the swimming due to the presence of the interface. The analysis considers the role of the swimmer type (pusher or puller) and interface deformation due to both surface tension and bending resistance, for a class of elongated swimmers. We highlight the non-trivial ways in which the fluid and interface properties influence the swimmer migration.



Monday 15th August

1030–1130

Speaker: **Mike Cates**

Title: *Biased Ensembles + Optimal Control in Active Particle Systems: Large Deviation Theory for Active Work*

Abstract:

Much is now known about the collective dynamics of Active Brownian Particles (ABPs) whose self-propulsion directions have no alignment interactions and so evolve independently of one another. Collectively ABPs show no orientational order, but do show motility-induced phase separation (MIPS). MIPS can also be seen in flocking models where it complicates the transition to an orientationally ordered state of "collective motion". Returning to ABPs, suppose we now bias (or filter) the dynamics to select time evolutions with atypically low collision rate or equivalently atypically high active work (entropy production). We then find a collective motion phase which does after all have orientational order. This is because the least unlikely way for collisions to be avoided is if the particles happen to be all moving in the same direction. Conversely, selecting an atypically high collision rate promotes MIPS in parameter ranges where it would not otherwise happen. In general, the biased dynamics maps onto the unbiased dynamics of some other system, known as the 'optimally controlled' system. This connection is general, and suggests strategies for designing the microscopic interactions of an active particle system to achieve some desired collective behaviour (with low collision rates as the example). In practice, accurate sampling of the biased dynamics is difficult to achieve numerically. If time permits, I will outline a specific active particle model for which this obstacle can be overcome by exact calculation of the large deviation rate function for the entropy production.

1130–1200

Speaker: **Cesare Nardini**

Title: *Capillary waves in active phase separation*

Abstract:

In passive liquid-vapour phase separation, a single interfacial tension sets both the capillary fluctuations of the interface and the rate of Ostwald ripening. We show that these phenomena are governed by two different tensions in active systems, and compute the capillary tension which sets the relaxation rate and the spectra of interfacial fluctuations, thus extending capillary wave theory to active systems. We characterise capillary fluctuations both at linear and non-linear level, showing that activity induces a new universality class for the roughening of the liquid-vapour interface. We characterise it by one-loop renormalisation group analysis and numerical simulations. Furthermore, we discover that strong enough activity can cause negative capillary wave interfacial tension. In this regime, depending on the global composition, the system self-organizes either into a microphase-separated state in which coalescence is highly inhibited, or into an "active foam" state. Our results are obtained for Active Model B+, a minimal continuum model which, although generic, admits significant analytical progress.

Tuesday 16th August

1030–1130

Speaker **Mogens Høgh-Jensen**

Title *DNA Repair, Droplet Formation and Chaos in Cells*

Abstract

When some human cells are damaged or stressed they respond by oscillating protein densities as have been observed for two famous proteins/transcription factors p53 and NF-kB [1]. The oscillations have a period of 3-5 hours and appear in both healthy and sick cells. p53 is a cancer gene while NF-kB plays a role in diabetes. For p53 we show that droplets of repair proteins form around damage sites in an oscillating fashion thus preventing Oswald ripening. The period of oscillations provides an optimal time scale for the repair mechanism. By applying an external periodic protein signal, the internal oscillation can lock to the external signal and thus controls the genes. The locking occurs when the ratio between the two frequencies is a rational number leading to Arnold tongues. If tongues overlap, chaotic dynamics appear which strongly influence gene production. The oscillations can be used as a diagnostic tool to distinguish different cancers. Our findings are in good agreement with experimental data from our collaborative groups at Harvard Medical, Beijing and Taiwan.

[1] M.L. Heltberg, S. Krishna, L.P. Kadanoff and M.H. Jensen, A tale of two rhythms: Locked clocks and chaos in biology (Review), Cell Systems, 12, 291-303 (2021).

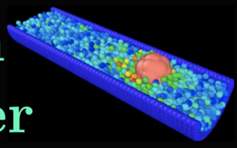
1130–1200

Speaker **Dhrubaditya Mitra**

Title *Entropy and active elasticity*

Abstract

The traditional field of continuum mechanics, which contains both elasticity and fluid mechanics is going through a resurgance due to possible applications to biology. Biological systems bring in two novel aspects : (a) biological samples are complex – often they cannot be clearly demarcated into solid and fluid. They may be viscoelastic. (b) biological samples are living. This second aspect is the most important one. The fundamental aspect of a living systems is that they are out of equilibrium – they generate entropy. This poses the question : how do the equations of elasticity and fluid mechanics must change to take into account the fundamental non-equilibrium nature of these systems. Within this broad framework, I will present two problems. One, how to estimate the entropy generation rate, which is a measure of activity, of living systems. Two, how the buckling of shells, a traditional non-linear problem in elasticity, change if the shells are made active.



Wednesday 17th August

1030–1130

Speaker **Jörn Dunkel**

Title *Towards programmable living materials and quantitative models of active matter*

Abstract

Over the last two decades, major progress has been made in understanding the self-organization principles of active matter. A wide variety of experimental model systems, from self-driven colloids to active elastic materials, has been established, and an extensive theoretical framework has been developed to explain many of the experimentally observed non-equilibrium pattern formation phenomena. Two key challenges for the coming years will be to translate this foundational knowledge into functional active materials, and to identify sparse quantitative models that can inform and guide the design and production of such materials. Here, I will describe joint efforts with our experimental collaborators to realize self-growing bacterial materials, and to implement computational model inference schemes for active and living systems dynamics.

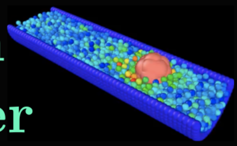
1130–1200

Speaker **Zhouyang (Anthony) Ge**

Title *Dynamics of periodically sheared shakers*

Abstract

Driven suspensions of active particles are important model systems for understanding diverse natural and industrial processes. Here we study a model active suspension where the suspended particles (so-called “shakers”) can only swim collectively due to their hydrodynamic interactions. Specifically, we simulate a monolayer of spherical shakers under cyclic shear using a recently proposed active Stokesian Dynamics method (G. J. Elfring & J. F. Brady, ArXiv:2107.03531). The numerical solver has an efficient implementation, thus allowing us to simulate thousands of particles with full hydrodynamics interactions. Preliminary results show that particles exhibit a crossover from ballistic to normal diffusive dynamics, similar to those observed for self-motile colloids, but with a diffusion coefficient varying non-monotonically with the strain amplitude under cyclic shear. Our work aims to further characterize the emergent dynamics and connect them to the suspension rheology through the underlying microstructure of the swimmers.



Thursday 18th August

1030–1130

Speaker: **Sriram Ramaswamy**

Title: *Chiral active matter*

Abstract: Chirality tends to cloak itself from the long-wavelength elastic and hydrodynamic properties of passive matter. For example, cholesteric and smectic liquid crystals are hydrodynamically indistinguishable. The picture is very different when active forces are included. We find that the effects of chirality and activity can reinforce each other, especially in translationally ordered systems, with interesting consequences which I will discuss in my talk. This work is done with SJ Kole, Ananyo Maitra and Gareth Alexander.

1130–1200

Speaker: **Farzan Vafa**

Title: *Diffusive growth sourced by topological defects*

Abstract: In this talk, we develop a minimal model of morphogenesis of a surface where the dynamics of the intrinsic geometry is diffusive growth sourced by topological defects. We show that a positive (negative) defect can dynamically generate a cone (hyperbolic cone). We analytically explain features of the growth profile as a function of position and time, and predict that in the presence of a positive defect, a bump forms with height profile $h(t) \sim t^{1/2}$ for early times t. To incorporate the effect of the mean curvature, we exploit the fact that for axisymmetric surfaces, the extrinsic geometry can be deduced entirely by the intrinsic geometry. We find that the resulting stationary geometry, for polar order and small bending modulus, is a deformed football. We apply our framework to various biological systems. In an ex-vivo setting of cultured murine neural progenitor cells, we show that our framework is consistent with the observed cell accumulation at positive defects and depletion at negative defects. In an in-vivo setting, we show that the defect configuration consisting of a bound $+1$ defect state, which is stabilized by activity, surrounded by two $-1/2$ defects can create a stationary ring configuration of tentacles, consistent with observations of a basal marine invertebrate Hydra.

Friday 19th August

1030–1130

Speaker	**Tyler Shendruk**
Title	*Mesoscopic models for active nematic fluids*
Abstract	Coarse-grained simulations have proved to be an invaluable tool in the study of soft condensed matter due to their computational efficiency and their ability to model systems in which the background solvent plays a significant role but is not of principle interest. One successful method is Multi-Particle Collision Dynamics (MPCD), a mesoscopic particle-based algorithm that replaces pair interactions between fluid molecules with a many-particle stochastic collision operator, reproducing flows in long length-scales. MPCD algorithms have been extended to simulate complex fluids including nematic liquid crystals and suspensions of swimmers. Since MPCD-based algorithms intrinsically contain fluid flow and stochastic thermal noise, this approach is particularly well suited to moderate Peclet number regimes. I'll present our work devising collision operators which extend MPCD to active systems, in particular to account for local dipole forces between nematogens. Comparing to experimental flows in active nematic films, we conclude that this algorithm successfully captures key characteristics such as the continuous creation and annihilation of defect pairs and active turbulence. We expect that our extended MPCD and other mesoscopic algorithms for active matter will shed new light in the study of composite active-passive systems.

1130–1200

Speaker	**Aboutaleb Amiri**
Title	*Emergent chirality in active rotation of pancreas organoids*
Abstract	Collective cell dynamics play a crucial role in many developmental and physiological contexts. While 2D cell migration has been widely studied, how 3D geometrical boundary conditions interplay with collective cell behavior to determine dynamics and functions remains an open question. In this work, we elucidate the biophysical mechanisms of tissue rotation on a sphere, a phenomenon widely reported in vivo (in Drosophila egg chamber) and in vitro (organoids and cancer spheroids). Using the pancreas sphere as a model system, we found that epithelial spheres can exhibit complex rotational dynamics, including rotation arrest and drift in the rotation axis. Furthermore, by combining biophysical modeling with quantitative microscopy, we found that the interplay between traction force and polarity alignment can account for these distinct rotational dynamics. Our analysis shows that the sphere rotates as an active solid and exhibits spontaneous chiral symmetry breaking in the cell shape orientation field.