Dissipative emergent patterns

Field of study: Physics

Research group: Molecular Materials (MolMat)

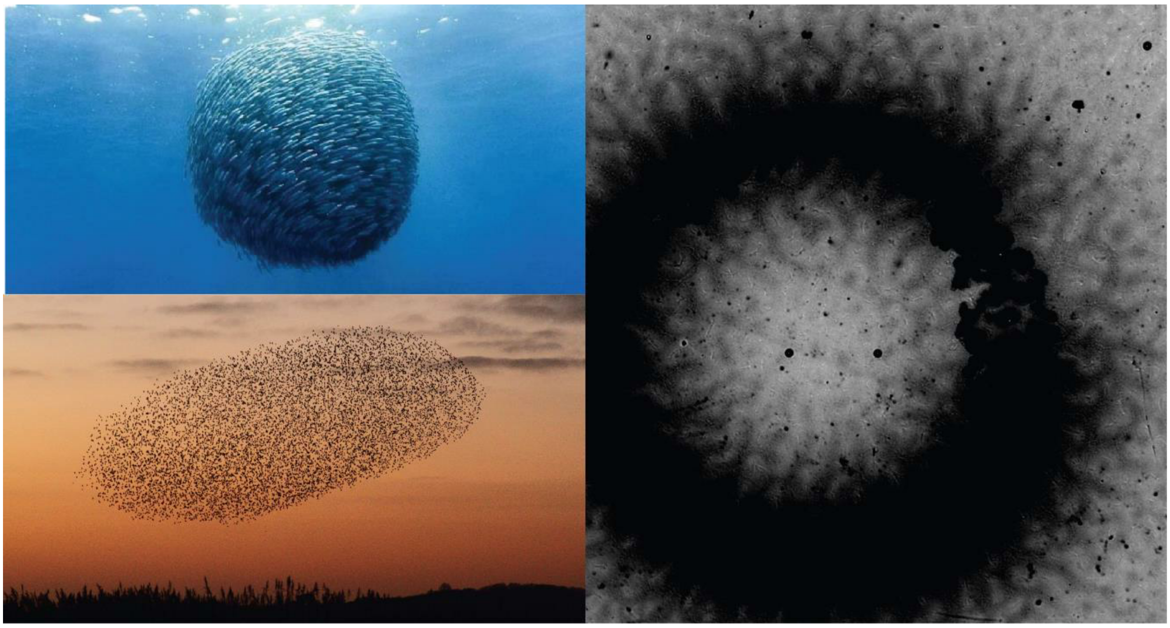
Supervisor: Prof. Olli Ikkala

Instructor: MSc. Tomy Cherian

Flock of starling birds and schools of fishes are fascinating examples of how nature forms macro-scale organisations. These organisations emerge when each individual abide by a simple set of rules, which scales up to a collective organisation. Moreover, these organisations have the ability to adapt in the presence of an external stimulus, an obstacle in case of starlings or a predator in case of fishes. Hence, these systems are out of equilibrium or "dissipative" systems.

Life itself is dissipative in nature. Cells and cellular organelles communicate and organize to form structures in micro and nanoscales. These structures adapt and reorganize, like starling birds, in response to chemical stimulus. Do cells and cellular matter communicate with simple rules that lead to collective complex structures? How do they adapt to stimuli? Understanding the fundamental laws that govern the formation of dissipative structures could take us a step closer to answering these questions, thus helping us understand life itself better.

Materials that respond to external fields and the ability to form collective structures could be good candidates to drawn analogy to these dissipative biological systems. In this project, we will use nano particles that respond to electric and magnetic fields by simple rules to form collective micro scale patterns. During the course of the project, we will try to figure out how these patterns adapt and change in response to changes in these external fields.



Top left: "Bait ball" formed by school of fishes to escape predator[1]. Bottom left: Flock of starling birds[2]. Right: Micro-scale structures formed by nano particles in presence of electric and magnetic fields.

We are looking for a student who is motivated and interested in this interdisciplinary topic. Previous laboratory experience is an advantage but not a requirement.

For more information, e-mail Tomy Cherian (tomy.cherian@aalto.fi)

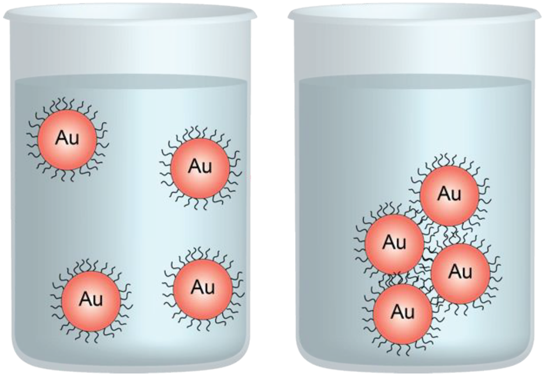
Image sources:

[1] "How Do Fish Swim In Schools? Scientists Say It's In Their Genes _ HuffPost"

[2] "Audubon's Zachary Slavin Explains Why Starling Flocks Captivate _ Audubon"

Title of the project: pH sensitive gold nanoparticles and their plasmonic properties

Field of study: Nanomaterials
Research group: Molecular Materials
Supervisor: prof. Olli Ikkala
Instructor: Dr. Hang Zhang



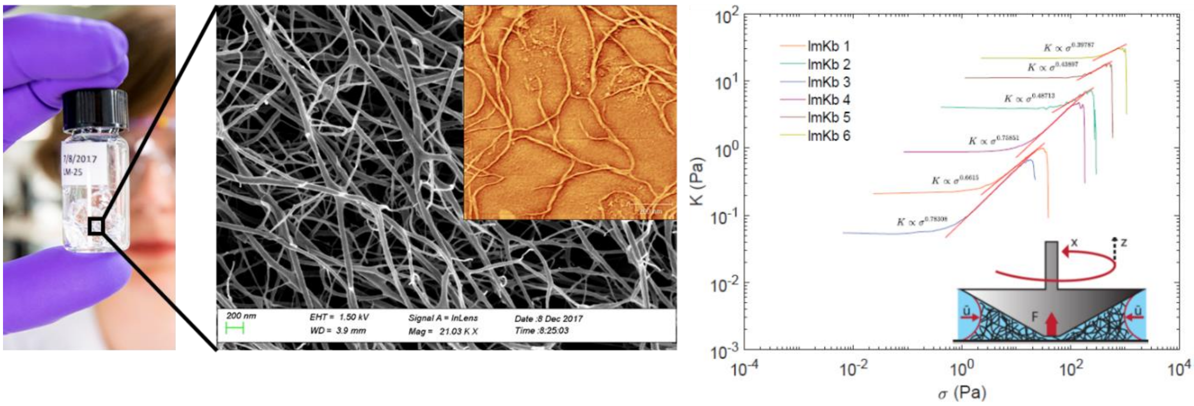
In the European Research Council Advanced Grant funded project "DRIVEN", we are studying materials that can adapt new states by feeding several competing stimuli. As one of the components therein in the multicomponent system, we need gold nanoparticles whose optical properties can be switched by stimuli, in this case by pH. The properties of gold nanoparticles depend on the size (nanometers) and molecules bound on their surface forming a protecting layer (denoted as "ligands"). By selecting different ligands, we can select whether the nanoparticles are well-dispersed in a solvent (the left figure above) or whether they aggregate (the right figure). They have different optical properties, as visualized by Ultraviolet-Visible (UV-Vis) spectroscopy.

We have synthesized a library of ligand modified gold nanoparticles. Your summer-project would be to measure and analyze the optical properties using UV-Vis spectroscopy. These results are next connected to a larger pool of results, related to the overall goal of the project. We expect a physics-oriented student willing to work in a multidisciplinary environment with chemists and materials scientists.

Please contact for additional information: olli.ikkala@aalto.fi, hang.zhang@aalto.fi

Title of the project: Polymer gels for biomedical applications

Field of study: Applications of materials physics in medical sciences
Research group: Molecular Materials
Supervisor: Doc Nonappa, prof Olli Ikkala
Instructor: M.Sc. Lahja Martikainen and M.Sc. Kia Bertula



In living organisms, the cells need a network-like scaffold to grow. This is denoted as an extracellular matrix. By contrast, in several biomedical applications, an artificial "manmade" scaffold is needed to grow living cells. To design and realize them needs that the materials are suitably biocompatible and their physical properties correspond to the natural extracellular matrix. This is where physicists are needed to collaborate with biochemists and medical experts.

We are searching physics oriented student who is willing to work in close collaboration with chemists and medical researchers. In this summer-work, you would study the mechanical and flow properties of manmade extracellular matrix mimics made of hydrogels using a dynamic rheometry. The hydrogels are polymers that form nanoscale networks in water medium (as shown in the above micrograph). We have preselected feasible candidates for you. Rheology is a practical tool to investigate the hydrogel properties such as viscosity, elasticity, flow and creep. You will use MATLAB for analysing the rheology and modelling the phenomenon. This work relates closely to the project “3D nanoscaffolds for breast cancer explant culture”, which main objective is to design and optimize the most reliable preclinical model for patient derived breast cancer tissues as a platform for personalized breast cancer therapy.

Please contact for additional information: lahja.martikainen@aalto.fi or kia.bertula@aalto.fi