
CSM group: summer projects for 2017

23.1.2017

This year, we offer summer internship projects in both experimental and computational physics.

Experimental

Foam flow in narrow channels

Foams are an archetypal example of a shear thinning yield stress fluid with properties that can be controlled by particle dopants in the future. This project concentrates on two-dimensional particle-laden foams, their rheology and behavior in a channel flow.

The interdisciplinary nature of the topic has huge potential in explaining fundamental physics and behavior of complex fluids that recently have become the industrial solution for manufacturing lighter, greener materials. The project continues a successful Bachelor's thesis from last year where particle laden foam was driven through a narrow opening.

The expected outcome(s) depending on applicant's background and interests are Bachelor's or Master's Thesis or similar report. The applicant is expected to have keen interest in running, maintaining or designing an experiment. Experience with automated systems and complex machinery is a plus.

Contact person: **Juha Koivisto**

Transition from discrete particles to complex liquids

Granular matter is between phases. For example, sand can flow from an hourglass or form a rigid structure that clogs the flow. Instead of sand, we are using oil droplets as grains and water as interstitial medium. In an hourglass like constriction flow, the sudden acceleration of particles near the exit creates non-trivial dynamics that determine the flow rate of particles.

This summer project reproduces the foam experiment from previous summer but with oil-water emulsions. Increasing the viscosity of oil changes the droplets from soft to hard as well as the behavior from Newtonian liquid to granular matter. The expected outcome is Bachelor's or Master's Thesis or similar report depending on applicant's background. The applicant is expected to have keen interest in running, maintaining or designing an experiment. Experience with automated systems and complex machinery is a plus.

Contact person: **Juha Koivisto**

Identifying materials by their optical spectrum

Every human knows that roses are red and violets are blue. But how is it with machines and colors? Recent advances in hyperspectral imaging and machine vision open a door to everyday household applications. For example, the CO₂ emissions and plant diseases are recognized from space. Pharmaceutical industry uses optical spectrum to verify raw compounds.

This application oriented project explores which materials are possible to recognize from their ultraviolet, visible and infrared absorption spectra. The focus area is to detect organic compounds in a laboratory setting and apply the results to healthcare and cleaning sectors. The projects contains experimental, theoretical, engineering and commercial aspects that lead to Bachelor's or Master's thesis, publications and/or patents based on applicant interests and skills.

Contact Person: **Juha Koivisto**

Deformation of materials

In a large enough scale all engineering materials deform in a smooth manner under loading. The global stress-strain response can be described by only a few elastic and viscoplastic parameters such as Young's Modulus and Yield point. However, in microscale the internal structure of the material starts to dominate and the behavior is intermittent and erratic.

This project explores the behavior of sample material and its relation to its internal structure. Depending of the material at hand, the deformation can be observed with optical imaging, increased heat or acoustic emission. The projects contains experimental, numerical and theoretical aspects that lead to Bachelor's or Master's thesis and/or publications based on applicant interests and skills.

Contact Person: **Juha Koivisto**

Computational

Plastic deformation of crystalline solids

Plastic deformation of crystalline solids, mediated by the stress-driven motion of topological defects of the crystal lattice called dislocations, has recently proven to be a more complex process than previously believed. Modern experimental techniques to study deformation of microscale crystals have revealed intermittent scale-free strain bursts with peculiar statistical properties, size effects of the sample strength, etc. In this project you will explore the complex nature of crystal plasticity by means of discrete dislocation dynamics simulations. The latter is a coarse-grained description where the dislocations are taken to be the basic degrees of freedom of the system, instead of the atoms of the underlying lattice. Another possible, closely related project would be to apply machine learning to predict and optimize mechanical properties of crystalline solids.

A successful candidate should have basic programming skills (preferably in C), and be familiar with the Linux environment. In addition, some basic knowledge of the materials science behind plastic deformation of solids, as well as of parallel programming, would be appreciated.

Contact person: **Lasse Laurson**

Micromagnetic simulations of magnetic domain wall dynamics

In this particular position, we investigate numerically domain wall dynamics in various ferromagnetic nanostructures (the specific problem may also be tailored according to the interest and background of the candidate), using a GPU-based micromagnetic simulation code. Possible problems to address include in particular magnetic field and electric current driven domain wall motion in nanowires and strips, which are also relevant for emerging domain wall based logic and memory devices.

The successful candidate is expected to possess basic skills in programming and data analysis, including familiarity with the standard Linux environment, and an undergraduate level understanding of basics of magnetism.

Contact person: **Lasse Laurson**

Modeling the flow of viscoelastic fluids in confined geometries

Viscoelastic fluids exhibit the characteristics of both solids and liquids. This is manifested by their capability of storing parts of the deformation energy in addition to the Newtonian viscous dissipation. In flow situations such fluids have much richer phenomenology compared to viscous fluids. Typical features include velocity overshoots, elastic recoil flows, and even rheochaos. Additional complexities arise when thixotropy (time-dependent viscosity) is present.

In this project, we study such systems using numerics applying methods of Computational Fluid Dynamics (CFD) and mesoscale viscoelastic models. These studies connect heavily to the experimental studies of foams detailed above.

The applicant should have some experience in programming and have basic knowledge in soft matter physics. This project can be included in physics studies as either special assignment or Bachelor's thesis.

Contact person: **Antti Puisto**

GPU implementation of a mesoscale foam model

We have developed an in-house foam model, which integrates the equations of motion of bubbles forming the foam. At present, the program runs as a serial code written in C++. For large 3D systems with tens of thousands of bubbles, the program becomes inefficient. The target of this project is to parallelize the code to run in a GPU-environment using a suitable programming environment.

The applicant should preferably have some experience in C/C++ programming and at least a strong interest to learn GPU programming – This is the perfect opportunity to learn new things. This project can be included in physics studies as either special assignment or Bachelor's thesis.

Contact person: **Antti Puisto**

Machine learning active phases

In this project, the intern uses image-oriented Artificial Intelligence –methods to study the dynamical patterns and phases present in active matter systems. The data is either created

by simulating appropriate models or derived, in collaboration, of the experiments of the prof. Jaakko Timonen group at the same department. The student should have an active interest and preferably some knowledge with the following topics: statistical mechanics, active matter, and machine learning.

Contact person: **Mikko Alava**