This year, we offer summer internship projects in both experimental and computational physics. Submit your application through the Department of Physics summer trainee application system. After application stage, our primary interview date is 1.2.2019 (11.2. is a backup date).

### 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 with hyperspectral imaging and machine learning**

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 CO$_2$ 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 recently developed prototype produces billions of measurement points that are fed to a machine learning algorithm. The goal of this project is to further develop and optimize this algorithm and prototype. Based on applicant interests and skills, the projects can contain experimental, theoretical, engineering and commercial aspects that lead to Bachelor’s or Master’s thesis, publications and/or patents. One experimental goal is to pilot the device in a real industrial setting.

Contact Person: **Juha Koivisto**

**Rheological properties of particle laden fluids**

Newtonian fluids have linear force-displacement response. This project explores experimentally what happens when particles are added to liquids. With high particle concentrations the fluid has become non-Newtonian. In this project, optical and/or tomographic imaging is combined to measurements in a rheometer to observe internal local structures and their relation to global properties of the fluid. The goal is to define the transition from dilute Newtonian particle laden liquids to dense suspensions.

This topic contains multiple projects. One concentrates on inorganic and magnetic particles while the other deals with biological active matter. Both materials can be tuned with external stimulus. Based on applicant interests and skills, the projects can contain experimental parts that lead to Bachelor’s or Master’s thesis. The project is done in collaboration with the group of Jaakko Timonen at the department of applied physics.

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**

**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.

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

Coarsening of foams made of non-Newtonian liquids

Foaming of non-Newtonian fluids have an enormous application space varying from cosmetics and food industry to technological applications, for instance paper and board industry. Scientific interests on the matter relate to the stability and stabilization mechanisms imposed by the non-Newtonian fluid to the bubbles. Simulations of such systems have been scarce.

We have implemented a mesoscale foam model running on a GPU platform capable of describing the coarsening of wet foams on the scale of millions of bubbles. Your job is to apply and extend the model to practical use cases, involving foams made of non-Newtonian liquids.

The applicant should have some experience in C/C++ programming. This project can be included in physics studies as either special assignment or Bachelor’s thesis.

Contact person: Antti Puisto

Orientation of elongated particles by accelerating flow fields

The replacement of synthetic fibers in the products of fabric industry is an important step for sustainability. To make this transition possible, there are a number of technological advancements required. A fundamental process is the thread making. An important stage in the process is the fiber orientation in a capillary tube. The understanding of this stage is presently limited.

Here we study the orientation and rheology of cellulose suspensions in accelerating laminar flows using continuum level simulations in comparison to experimental orientation data. The simulations will be performed in simulations based on coupled CFD and orientation model in a Fokker-Planc fashion.

The applicant should have some experience in C/C++ programming and bachelor level physics knowledge. Experience on Computational Fluid Dynamics is an advantage. This project can be included in physics studies as either special assignment, Bachelor’s thesis or Master’s thesis.

Contact person: Antti Puisto

Computational Fluid Dynamics of multiphase suspension flows

Computational Fluid Dynamics (CFD) provides a powerful means for implementing various numerical models to describe complex fluids and multiphase flows in varying scenarios. The results obtained in this framework can be explored to yield both valuable generalizations and in-depth details on the rheology of such flows, which would be excessively difficult to obtain experimentally. Currently, two projects in the CSM group involving CFD include improving the efficiency of dewatering in commercial cellulose products and probing localized response to shear in a large amplitude oscillatory shear (LAOS).

In large-scale paper production, the dewatering of dilute cellulose suspensions to produce paper
sheets is performed mechanically by inducing a pressure-driven dewatering flow. Preliminary CFD simulations suggest that optimizing the pressure profile could significantly improve the dewatering rate, leading to considerable energy savings if implemented in a practical setting. Therefore, this project involves understanding, applying and studying the numerical model we have created to describe the dewatering scenario, as well as designing an optimized pressure scheme for the process.

LAOS has widely been accepted as the industry standard to reliably measure the intrinsic rheological properties of various fluids. The second project aims to numerically demonstrate that even in LAOS, highly non-trivial flow patterns can be recovered due to the effects of finite fluid inertia, contesting the general view that LAOS provides unbiased access to intrinsic flow quantities. The project involves developing the criteria that trigger the localized, non-linear shear response in LAOS. Finally, we develop novel rheological methods, which avoid the problems related to shear localization.

The applicants should have some experience in C/C++ programming. Experience on Computational Fluid Dynamics is an advantage. This project can be included in physics studies as either special assignment or Bachelor’s thesis.

Contact person: Antti Puisto

**Statistical physics of non-equilibrium systems and fracture**

In this project, the intern uses statistical physics models to look at the dynamics of cracks that propagate as if close to a phase transition. The work can be experimentally or theoretically oriented, where those models are used to explain the data. The student should have an active interest and preferably some knowledge with the following topics: statistical mechanics, condensed matter physics, and computational/experimental physics.

Contact person: Mikko Alava