

## SOFT CONDENSED MATTER AND BIOPHYSICS (SCM&B)



The *Biophysics* section of the *SCM&B* programme is active in the fields of fluorescence microscopy and spectroscopy. Novel fluorescence microscopy techniques are developed for state-of-the-art (bio)physical research at the microscopic level. Fluorescence spectroscopy is an essential part of the research activities.

One of the main challenges in microscopy is to obtain detailed, quantitative information at the microscopic level. To this end we combine fluorescence spectroscopy based methods with microscopy. For instance, we employ the (nano second) fluorescence decay time of fluorescent molecules for imaging. Here, the fluorescent molecules are excited with a short laser pulse after which the intensity decay of the emission is followed in time. This technique turns out to be extremely valuable for the study of interactions between molecules. We used this technique to image interactions between membrane proteins. However, this technique can also be employed to study the photo physics of luminescent nano-particles such as quantum dots at the single particle level. Another example of our work is the use of the polarization properties of fluorescence in microscopy. Here, the fluorescent molecules are excited with polarized light and the depolarization of the fluorescence is measured for each pixel in the microscope image. This depolarization is strongly affected by clustering of molecules and it can be used to quantify cluster sizes of fluorescent molecules.

A part of the research of the group deals with the use of non-linear effects in microscopy. An important example of non-linear microscopy is two-photon excitation microscopy. Here, the fluorescent molecules are excited by the simultaneous absorption of two photons, each with approximately half of the energy required to excite the molecule. This process has only a very low probability and depends quadratically on the excitation intensity. This type of microscopy is usually carried out with intense near-infrared laser pulses. The advantage of two-photon excitation microscopy is that 3-D images can be recorded (comparatively) deep inside specimens, including living animals.

Examples of applications that we are working on include the image of pH in biofilm, live cell imaging, imaging of protein-protein interaction and the imaging of processes in (model) membranes. In addition we work on the imaging of semiconductor nano crystals (quantum dots) and nano tubes. Most of the projects are carried out in collaboration with biological, chemical and physical groups.

More information can be found at: <http://www1.phys.uu.nl/wwwmbf/>

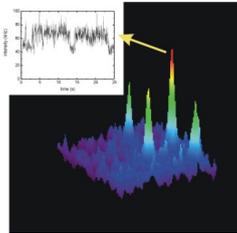
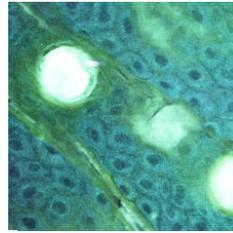


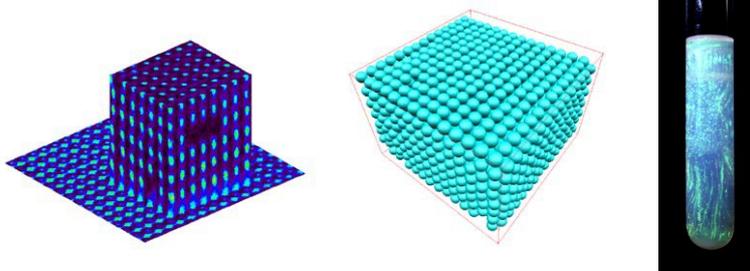
Image of single Quantum Dots



Two photon excitation Image of cells in a living mouse.

Research of the *Soft Condensed Matter* section of the SCM&B programme focuses on the quantitative 3D real-space analysis and manipulation of colloidal structures and processes. Colloidal particles are suspended in a liquid and have sizes ranging from several nm to several  $\mu\text{m}$  and can consist of macromolecules or particles built up from much smaller units. The size range of a colloid is such that in the theoretical description of its behaviour the liquid can be considered a continuum, while particles perform Brownian motion. This erratic motion results from the continuous bombardment by individual solvent molecules. The Brownian motion ensures that colloidal particles have a well-defined thermodynamic temperature and thus can lower their free energy by forming analogous phases as molecules, such as: colloidal liquids and crystals. Our motivation in studying and developing these systems comes both from the use of colloids as a condensed matter model system, and from their use in advanced materials applications like photonic crystals and electro-rheological fluids. In addition we perform computer simulations on soft condensed matter systems.

Our approach is illustrated in the following figure showing a 3D data set taken with a confocal microscope (left). The positions of the colloidal particles in this crystal can be determined quantitatively (middle) making direct comparisons with simulations and theory possible. The particles were made and developed in our group and consist of silica spheres with fluorescent groups chemically incorporated inside the particle core. The colloidal crystal has such a large lattice constant that Bragg diffraction takes place in the visible (right). Also as a consequence of the size of the colloids the crystals are very soft ("*soft condensed matter*"), but can be sintered to make more robust photonic crystals (right).



#### COLLABORATIONS AND INTERNSHIPS

We have close collaborations with the FOM Institute for Atomic and Molecular and Physics (AMOLF) in Amsterdam, the Van 't Hoff Laboratory for Physical and Colloid Science (Debye Institute) and theorists in the Institute for Theoretical Physics (UU). Combined projects with these groups covering combinations of experiments with synthesis of particles, computer simulations and theory are possible. More information and possible projects can be found at: [www.colloid.nl](http://www.colloid.nl).

#### REQUIREMENTS

A MSc research project of 60 EC within the group of Soft Condensed Matter is divided in the following way:

- experimental or simulation work including literature study 80%
- writing MSc thesis on research 10%
- oral presentation on research 5%
- weekly work discussions and seminars 5%

The final mark will be the average of the different marks obtained on (i) experimental work, (ii) theory relating to experiment, (iii) initiative and organizational skills, and (iv) presentation of results orally and in writing.

It is recommended (but not required) to take the primary elective course on Soft Condensed Matter. Also, a background in thermal physics / thermodynamics is recommended.

#### FOR MORE DETAILS CONTACT

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