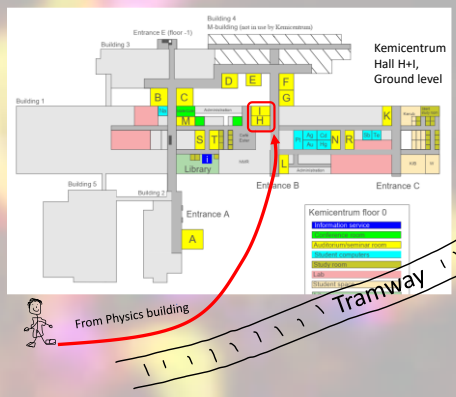
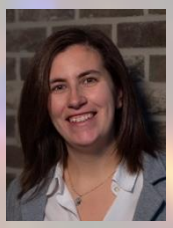
Workshop on advanced optical microscopy for biology, physics and chemistry



15th December (Thursday), 13.00 – 17.00.
Chemical Center, Lecture hall **H+I**.

The workshop is organized in connection with the Ph.d. defence of Boris Louis.
Workshop organizer: **Prof. Ivan Scheblykin**, SMS group, Chemical Physics and NanoLund.
Ivan.scheblykin@chemphys.lu.se
At least 10 min after each presentation will be devoted to questions and discussions.

13.00 – 1345. **Theo Lasser**
EPFL, Switzerland
Seeing is believing -looking into tissue structure and function and to see cell and subcellular organelles with a resolution well below 100 nm.



1345 – 1415. **Susana Rocha**
KU Leuven, Department of Chemistry, Leuven, Belgium
Synthetic fibrous hydrogels as a platform to decipher cell-matrix mechanoreciprocity

Tea/coffer break (15 min)

1430 -1515. **Jurgen Köhler**
University of Bayreuth, Germany
Chlorosomes in the Light of Single-Molecule Spectroscopy

1515-1600. **Victoria Birkedal**
Department of Chemistry and iNANO center, Aarhus University, Denmark
Applications of DNA functionalized conjugated polymers

Tea/coffer break (15 min)

1615 – 1645. **Hiroshi Ujii**
Graduate School of Information Science and Technology and Research Institute for Electronic Science, Hokkaido University, Sapporo, Japan,
KU Leuven, Department of Chemistry, Leuven, Belgium;
Remote excitation of enhanced Raman spectroscopy

No registration needed, just join us! Enough coffeee++ will be provided.
See the full program here: https://www.nano.lu.se/calendar

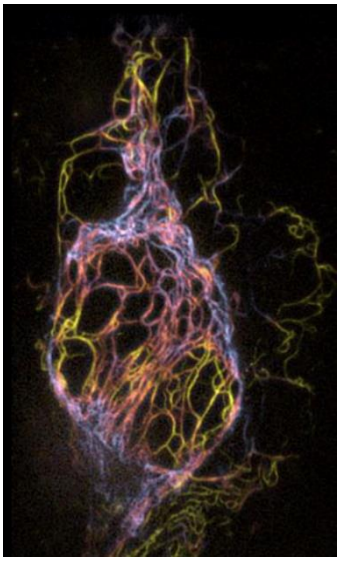
Seeing is believing

Theo Lasser
EPFL, Switzerland

Voir fait SaVoir

This talk invites for a promenade looking into tissue structure and function and to see cell and subcellular organelles with a resolution well below 100 nm (see image aside). Based on coherent imaging techniques we will try to see “diabetes”, to look into the brain for Alzheimer disease and we will finish our walk with novel insight on the cellular level based on SOFI which provide 3D even 4D super-resolved images of living cells. We will try to present the underlying optical concepts, and conclude with an outlook for imaging with applications in medicine and life sciences.

Prof. emeritus Theo Lasser has been full professor at the Ecole Polytechnique Fédérale de Lausanne and was heading the Laboratoire d’Optique Biomédicale (LOB). His research focuses on functional imaging, the development of coherent imaging methods and its application in medicine and life sciences. Low coherence microscopy (OCM) and high speed Laser Doppler Imaging (LDI) with applications in diabetes, neuroscience and infectious diseases represent well current research interests. Fluorescence microscopy and spectroscopy and in particular super resolution imaging (SOFI) applied to cell imaging complement this research.



Synthetic fibrous hydrogels as a platform to decipher cell-matrix mechanoreciprocity

Susana Rocha

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By pushing and pulling on the extracellular matrix (ECM), cells continuously sense the dynamic mechanical cues from their micromilieu and generate mechanical feedback. Mechanical characterization of the matrix surrounding the cells has shown that contractile cells are able to generate a massive stiffness gradient in biological gels. Such cell-generated forces can reorganize and deform the natural ECM fibers, causing fiber densification and alignment. Recent reports have shown that the nonlinear viscoelastic character of the natural ECM play a crucial role in this cell-matrix mechanoreciprocity. Due to the lack of a fibrous architecture and nonlinear mechanics these phenomena are difficult to reproduce using synthetic hydrogels. Here we used confocal imaging and bead-free traction force microscopy (TFM) to show how a fully synthetic biomimetic hydrogel can be used as a platform for the systematic study of the influence of biochemical and mechanical cues in the reciprocal cell-matrix interactions. This biomimetic hydrogel is formed from oligo(ethyleneglycol)-functionalized polyisocyanate (PIC) polymers and exhibits non linear mechanical response at low stresses. Rheological tests showed that the PIC matrix can be intensively stiffened by cell-generated forces within 24h after cell encapsulation. Three dimension TFM indicates that matrix stiffening is correlated with the cell induced fiber displacements that occur at the micrometer scale. Similar to what is observed in collagen and fibrin gels, PIC-based hydrogels also support a striking long-range force propagation distance. Interestingly, changes in the mechanical properties affect the degree of fiber remodeling while the distance of the force propagation remains similar. Our results show the potential of PIC gels as a platform to decipher cell-matrix interactions.

Chlorosomes in the Light of Single-Molecule Spectroscopy

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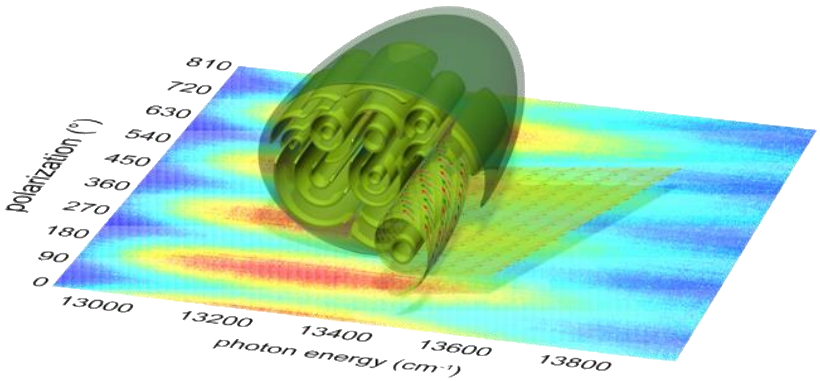
The light-harvesting apparatus of green sulfur bacteria - so called chlorosomes - is highly efficient and allows these species to grow photosynthetically under extremely low light conditions. The chlorosomes contain supramolecular structures comprising hundreds of thousands of bacteriochlorophyll molecules, and details of the structural organization of the molecular aggregates are the subject of ongoing debates. Since the electronic energies and the photophysical properties of a molecular aggregate are imposed by its geometrical structure, spectral information obtained can be compared with predictions derived from structural models. Thereby, the single-particle approach is particularly suited for the elucidation of specific, distinctive spectral features that are key for a particular model structure, and that would not be observable in ensemble-averaged spectra due to the heterogeneity of the biological objects. In other words, spectroscopy can search for the presence (or lack) of spectral signatures that are characteristic of specific structural features and thereby test whether a proposed structural model is compatible with the experimentally observed spectra. The talk will discuss these topics on the example of natural chlorosomes as well as biomimetic light-harvesting nanotubes. Employing quantum-chemical molecular modelling, the spectra of the individual artificial nanotubes can be explained consistently only for a molecular packing model that is fundamentally different from those considered so far for the natural systems. Subsequent theoretical simulations reveal that the remaining spectral variations between single nanotubes can be traced back to small variations of the mutual orientations of the monomer transition-dipole moments that are far beyond the resolving power of high-resolution electron microscopy imaging techniques.



References

- L.M. Günther, M. Jendrny, E.A. Bloemsma, M. Tank, G.T. Oostergetel, D.A. Bryant, J. Knoester, J. Köhler
  Structure of Light-Harvesting Aggregates in Individual Chlorosomes
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- L. M. Günther, A. Löhner, C. Reiher, T. Kunsel, T. L.C. Jansen, M. Tank, D. A. Bryant, J. Knoester, J. Köhler;
  Structural Variations in Chlorosomes from Wild-Type and a bchQR Mutant of Chlorobaculum tepidum Revealed by Single-Molecule Spectroscopy
  J. Phys. Chem. B **122** (2018) 6712-6723
- Löhner, T. Kunsel, M.I.S. Röhr, T.L.C. Jansen, S. Sengupta, F. Würthner, J. Knoester, J. Köhler;
  Spectral- and structural variations of biomimetic light-harvesting nanotubes
  J. Phys. Chem Lett. **10** (2019), 2715-2724

Applications of DNA functionalized conjugated polymers

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Conjugated polymers and their water-soluble counterparts, conjugated polyelectrolytes, have interesting emission, energy transfer and light harvesting properties. They are, however, intrinsically highly heterogeneous, which impacts their performance. Here, we focus on DNA-functionalized conjugated polymers and their attachment on DNA origami platforms. The use of DNA origami enables many spatial arrangements of conjugated polymers and placement of additional fluorophores at defined distances from conjugated polymer molecules. Probing these systems with single molecule fluorescence microscopy allowed uncovering polymer aggregate heterogeneity in the presence of mono- and divalent ions as well as manipulating the polymer aggregation state through buffer exchange and studying energy transfer effects from and to close by fluorophores. DNA origami platforms in combination with single molecule fluorescence provide new avenues for the quantification of polymer aggregates and light harvesting properties and concurrently give access to their conformational dynamics.

Remote excitation of enhanced Raman spectroscopy

Hiroshi Uji-i[1,2,3]

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Silver nanowires (AgNWs) serve as plasmonic waveguides for propagating surface plasmon polaritons (SPPs), allowing the spatial confinement and transfer light energy over micrometer distance through the structures below sub-diffraction limited diameter. In addition to this, surface plasmon allows us to concentrate light energy in nanometer regions, such as at the nanowire end, leading to a massive enhancement of electromagnetic filed that can be used for surface enhanced Raman scattering (SERS) or fluorescence (SEF) spectroscopy/microscopy.
In this contribution, we will discuss noble nanoscopic techniques using a combination of SERS/SEF detection and sub-diffraction limit SPPs waveguiding for spectroscopic/microscopic. Specifically, we demonstrate that SPPs launched along an AgNW can remotely excite SERS [1] and SEF [2] in the vicinity of the nanowire surface due to the SPPs wave-guiding effect. The ability to transfer SERS/SEF excitation over several microns will be discussed with respect to single-cell endoscopy, understanding of the interaction between anti-cancer drug molecules and cellular components such as DNA for drug delivery systems [3], and surface characterization using tip-enhanced Raman/fluorescence microscopy [4].

[1] H. Uji-i et al., Analytical Chemistry, 93, 12, 5037–5045 (2021). Advanced Materials, 26, 5124-5128 (2014). Nano Lett., 9, 995 – 1001 (2009).
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[3] H. Uji-i et al, Sci. Rep., 9, 2666 (2019).
[4] H. Uji-i et al, Nanoscale, 14, 5439 – 5446 (2022).