SYDI 1: Imaging of biological systems

Time: Friday 10:30–12:30 Location: E 415

Invited Talk SYDI 1.1 Fr 10:30 E 415

Flash diffraction imaging with X-ray lasers — •Janos Hajdu — Laboratory of Molecular Biophysics, Uppsala University, Husargatan 3 (Box 596), SE-751 24 Uppsala, Sweden

Short, intense and coherent pulses from X-ray lasers provide exciting new capabilities in understanding the structure of biological cells, complex materials, and matter under extreme conditions. In previous work at FLASH (Hamburg), we have demonstrated that the imaging process can be faster than the damage process, which is a significant step towards our long-term goal of single-particle imaging at atomic resolutions. Biomolecular imaging has become one of the most exciting potential applications of X-ray lasers like the Linac Coherent Light Source (LCLS) at Stanford. However, the rate at which a large biomolecule explodes in the LCLS pulse while it is being imaged is one of the largest unknowns in this kind of experiment and will likely be one of the major factors in determining if such imaging will succeed. The dynamics of this explosion are complex, depending on an interplay of various aspects of energy deposition, evolution of ionization, and electron heating in the system. Therefore, it is a high priority to understand these dynamics. Experiments at the LCLS-AMO end station explore the underlying physics of how the LCLS pulse deposits energy in large clusters of atoms/molecules and the nature of the subsequent explosion. In parallel, new imaging experiments were also performed at LCLS and show interpretable diffraction data from single virus particles. The talk will survey recent experimental results.

Invited Talk SYDI 1.2 Fr 11:00 E 415

The hitchhikers guide to cryo-electron tomography - A voyage to the inner space of cells — •Juergen Plitzko — Max Planck Institute of Biochemistry, Department of Molecular Structural Biology, Martinsried, Germany

'One Picture is Worth Ten Thousand Words'; this slogan from former times depicts clearly the fact that human beings are, by and large, visually centred. A long hold dream, for example, of biologists is the ability to 'zoom' in on very fine details of living matter, literally in one go, from the complete organism to one single cell and beyond. However, today, we have to utilize different microscopes operating at different resolution levels to make this dream halfway come true. Therefore researchers use different probing signals to cover the different length scales and to visualize the gamut of organic and cellular functions. The cornucopia of available imaging methods and techniques is enormous, and we have already travelled a long way to reach our ultimate goal - the voyage to the inner space of cells. At the level of a single cell we might think that we already know a great deal, but at the supramolecular level the cell is still an uncharted territory. With this presentation we are trying to explain in detail the method of cryo-electron tomography and to teach the audience in the major concepts of tomographic imaging for structural biology. Moreover, we want to provide an outlook into future developments especially regarding hybrid approaches, where several methods are combined to work in unison for the one goal, which we have already stated - a voyage to the inner space of a cell.

Invited Talk SYDI 1.3 Fr 11:30 E 415

Far-Field Optical Nanoscopy by Optical Switching — •Andreas Schönle and Stefan Hell — Dept. for NanoBiophotonics, MPI f. biophysical Chemistry, Göttingen, Germany

In 1873 Ernst Abbe recognized that the resolution of every far-field microscope is fundamentally limited by diffraction and this barrier is indeed an unalterable fact for purely optical imaging. For more than a century it was thus naturally assumed that imaging systems operating with visible light will never be able to resolve features smaller than about 250nm. However, recent advances in optical microscopy have radically overcome this limit and resolutions of better than 10nm have been demonstrated. This groundbreaking development is based on the simple but powerful insight that the light-dye interaction rather than the propagation of waves have to be put at the core of the image formation process: The ability to transiently confine adjacent molecules to different states allows the time-sequential recording of spatial features thus eluding the limitations of diffraction. In 1994, the invention of stimulated emission depletion (STED) microscopy demonstrated the feasibility of this approach and several other more or less related diffraction-unlimited far-field optical approaches were successfully implemented since then. All these techniques switch molecules between states in order to record them sequentially in time, either by addressing molecule ensembles inside sub diffraction sized volumes or by stochastically turning on isolated single markers. The resulting resolution is then no longer fundamentally limited by diffraction and can be pushed to the macromolecular scale.

Invited Talk SYDI 1.4 Fr 12:00 E 415

Coherent Diffractive Imaging at LCLS — •Henry Chapman — CFEL, DESY, Hamburg, Germany

The ultrafast pulses from X-ray free-electron lasers may enable the determination of structures of proteins that cannot be crystallized. The specimen would be completely destroyed by the pulse, but that destruction will ideally only happen after the termination of the pulse. In order to address the many challenges that we face in attempting molecular diffraction, we have carried out experiments in coherent diffraction from protein nanocrystals at the Linac Coherent Light Source (LCLS) at SLAC. The periodicity of these objects gives us much higher scattering signals in order to determine the effects of pulse duration and fluence on the high-resolution structure of single objects. The crystals are filtered to sizes less than 2 micron, and delivered to the pulsed X-ray beam in a liquid jet. Diffraction patterns are recorded at the LCLS repetition rate with pnCCD detectors. Preliminary results will be presented on our first LCLS experiments.

This work was carried out as part of a collaboration, for which Henry Chapman is the spokesperson. The collaboration consists of CFEL DESY, Arizona State University, SLAC, Uppsala University, LLNL, The University of Melbourne, LBNL, the Max Planck Institute for Medical Research, and the Max Planck Advanced Study Group (ASG) at the CFEL. The experiments were carried out using the CAMP apparatus, which was designed and built by the Max Planck ASG at CFEL. The LCLS is operated by Stanford University on behalf of the U.S. Department of Energy, Office of Basic Energy Sciences.