Course: Light and force based molecular imaging

The Department of Physics at NTNU is offering a new PhD course; Light and force based molecular imaging. The course is organized in two sessions, each of five days and will be offered every two years starting from 2011. In 2011, session one is scheduled for week 41 and session two will be in week 45. PhD candidates from other universities participating in this course can apply for reimbursement of their travel- and accommodation costs from the Norwegian Research School in Medical Imaging (for more information, see www.medicalimaging.no) There is no registration fee.

Please sign up for the course by September 1st 2011 by sending an email to Snorre Hansen - snorre.hansen@ntnu.no. Remember to also by September 15th register yourself for the exam. Use the registration form for external candidates to PhD-courses / Research courses.

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Course content
The course gives in depth description of different types of instrumentation such as light microscopy, confocal laser scanning microscopy, optical tweezers and atomic force microscopy that are important for studying individual biological macromolecules, cells and other soft materials The course focuses on understanding the underlying principal of light-specimen and force-specimen interactions, and the design of essential components of the instrumentation as well as a theoretical and practical understanding of how to operate the instruments. For each instrument, the presentation of its components and the operation principles will be followed by examples of high quality recent research data obtained when using similar types of instrumentation.

Learning objectives
The learning outcomes are outlined in the following:

The student should have knowledge concerning the mechanism of light-biological specimen interactions, including also molecular excitation and de-excitation.

The student should have knowledge about the central techniques within light-microscopy as well as practical knowledge concerning the operation of a selection of these techniques. This includes an understanding of the construction, mode of function as well as application area of the following microscopy techniques:

- Bright field microscopy with different contrast techniques (phase contrast-, differential interference-, polarisation-, dark field-, reflection interference contrast microscopy)
- Epi-illumination microscopy, including fluorescence microscopy, confocal laser scanning microscopy, multiphoton microscopy.
- Total internal reflection interference microscopy
- Super resolution optical microscopy

The student should have knowledge concerning the design and mode of function of flowcytometry.

The student should have knowledge concerning the mode of function of different detectors used in the instrumentation presented.

- Photomultiplier tubes, photodiodes, video camera, CCD camera

The student should have knowledge concerning the mechanism of force-biological specimen interactions. This includes an understanding of the application of force as a tool to understand intra- and intermolecular aspects of various biological specimens, knowledge related to the nature of forces important for biological interactions, as well as the analysis and interpretation of data obtained through dynamic force spectroscopy.

The student should have knowledge concerning the construction, mode of function and application area of optical tweezers, as well as practical knowledge concerning the operation of this instrument.

- Knowledge of the processes underlying the trapping of particles with light
- Understanding of the determination of forces using optical tweezers.

The student should have knowledge concerning the construction, mode of function and application area of atomic force microscopy. This includes knowledge concerning:

- Contact mode, non-contact mode, operation in liquid
- Image processing of topographs.
- Force spectroscopy of single molecules
- Elasticity measurements on soft samples

The student should have skills concerning interpretation and presentation of scientific data obtained during the practical work in the laboratory. The student should have skills concerning reading of research literature and both written and oral presentation of the content of this literature.

Recommended previous knowledge
This course aims to provide PhD level training in light and force based molecular imaging to PhD students with various backgrounds such as biophysics, bionanotechnology, biotechnology, molecular biology, medicine and other potential users of the techniques presented. Former experience in the use of the techniques will be useful. Some basic understanding of physics and optics is needed in order to have full outcome of the lectures. Students who do not possess this knowledge will have to obtain it themselves. Suggestions for study material to provide the necessary background may be obtained from the lecturers upon request.

Learning methods and activities
42 hour lectures and 7 hour practical training in the laboratory. The practical training will be divided into 4 sessions related to the topics light microscopy, fluorescence - and confocal microscopy, optical tweezers and atomic force microscopy.

Course materials
Compendium: Biophysical Nanotechnologies. Authors: Sletmoen, Davies and Stokke. The compendium is available at the Dept of physics, NTNU.

Credit reductions
TFY4265 and FY8906: Full credit reduction.

Credits: 5

Examination plan:
Oral or written exam depending on the number of students. Reports from each of the four laboratory training sessions must be handed in and approved by the course responsible in order to have access to the exam.

Course plan for session one and two:
Week 1

Light-molecule interaction
Optical basis for light microscopy
Light microscopy techniques: Bright field, phase contrast, differential interference contrast, fluorescence - and confocal microscopy
Detectors: Photomultiplier tubes, video camera, CCD camera
Lasers
Non linear optics: multi-photon microscopy
Superresolution microscopy
Flow cytometry

Lab 1: Light Microscopy
Lab 2: Fluorescence microscopy, Confocal microscopy

Week 2
Single molecule studies: Beyond the ensemble average
Single molecule FRET and Total Internal Reflection Microscopy (TIRF)
Intermolecular forces
Optical traps and Optical tweezers
Atomic force microscopy
Dynamic force spectroscopy

Lab 3: Optical tweezers
Lab 4: Atomic force microscopy