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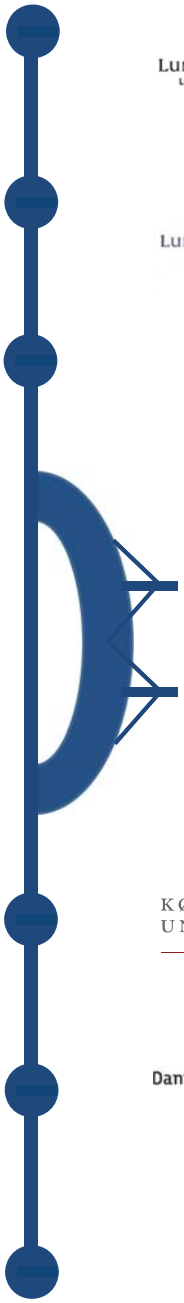
ÖMIC EDUCATIONAL MAPPING REPORT 2012



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The European Regional Development Fund

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ÖRESUND – KATTEGAT – SKAGERRAK

1. INTRODUCTION

The research and innovation landscape is about to be changed in the Öresund region. In particular, the emergence of the new giant world class facilities MAX-IV (X-rays) and ESS (neutrons) will create an enormous boost for sciences that deal with hard, soft, or biological materials. These possibilities have paved the way for the ÖMIC collaboration between universities, science parks, and regional/national authorities [1]. The aim of ÖMIC is to set the scene for utilization of the coming facilities by the regional science and industry.

This report concerns one important cornerstone of ÖMIC: University education. We present an overview of the current educational elements related to the scope of ÖMIC, i.e. related to neutron and X-ray science, in five main universities in this region: Lund University(LU/LTH), Malmö University (MAH), University of Copenhagen (KU), Technical University of Denmark (DTU), and Roskilde University (RUC). We are here concerned with the education on the B.Sc. and M.Sc. levels, as well as the course work during the PhD studies.

We have recorded educational activities at many degrees of specialization: Dedicated educational programs; course and project work that is concerned with materials in the sense relevant for MAX-IV and ESS; and general information on the topic in broader courses. This report lists a total of 52 courses, of which 20 are dedicated to neutron or X-ray science, and the topic is touched upon in the remaining courses which have a broader focus. It is seen that while there are many courses directed at physics and to some extent chemistry students, only relatively few dedicated courses are available for students from the biological sciences.

In addition, we have interviewed heads of studies (at KU and DTU) about their ideas on how to plan the future education in these topics. These inputs, along with the findings of our mappings, give rise to a number of preliminary ideas for an action plan. Some of these ideas may later be included in the recommendations from the ÖMIC working group to the heads of studies.

This report presents ideas for a stronger collaboration within the teaching of utilization of X-rays and neutron radiation for materials research within the Öresund Region. Our suggestions are particularly relevant within the biological sciences.

In chapter 2, we will list some relevant facts on the teaching in the region. The following chapters (3-5) presents existing courses, divided into 3 categories: Courses mainly directed to Physics, Chemistry, and Biology students. (Courses directed to more than one student population are listed in all relevant places.) Finally, chapter 6 summarizes and presents ideas for further discussion. In the appendices, we give a more thorough presentation of each of the courses under consideration, as well as a description of the dedicated LU study programs.

2. TEACHING IN THE ÖRESUND REGION

We here present general information on the teaching situation in the region, which goes beyond the presentation of actual courses in chapters 3-5. We discuss the study programs, including the specialized neutron/X-ray program at LU. We also compare the teaching terms and discuss barriers for student mobility. Finally, we consider individual projects.

It should be noted as a general remark that the neutron/X-ray groups at DTU are presently undergoing a major reorganization and that as a consequence the teaching situation at DTU is likely to change.

AIM OF EDUCATION ACTIVITIES

The new facilities, ESS and MAX-IV, will employ of the order 100 scientists over the next decade. However, many of these jobs are likely to be filled by experts from all over Europe. In any case, this job market is much too small to warrant a dedicated education on neutron and X-ray science or even to run a dedicated course. The real rationale behind a study program and/or courses dedicated to synchrotron research based science is to educate the many scientists that can be users at the facilities. Giving the students competences relevant for facility staff can at most be a secondary aim.

STUDY PROGRAMS

Most study programs in our survey are based upon the traditional division into disciplines: Physics, Chemistry, Biology, Engineering, etc. However, a number of cross-disciplinary study programs have emerged over the last decades, including Biochemistry, Biophysics, and Nanoscience/Nanotechnology, and these are also covered. We have been concerned only with studies within science and technology, leaving out e.g. economical sciences and health sciences. This means that study programs within biomedical sciences are included, while programs within pure medicine have been excluded based on content and course descriptions from their respective home pages.

Relevant in particular for this report is the new LU/LTH study program "Science with photons and neutrons", which covers both the B.Sc. and M.Sc. level. The contents in this program at the B.Sc. level are "standard" courses in Mathematics, Physics, and Chemistry, with the addition of specialized courses in neutrons and X-ray science on the 3rd study year. The program at the M.Sc. level contain a number of specialized courses on scattering, accelerators etc.. The existence of this study program has increased the visibility of this field; although at present only 6 students annually enter the B.Sc. program. Appendix C describes this study program in more detail.

No universities in the region, a part from LU/LTH, offer a specialized study program within this field. At KU and at DTU, the local study organization opens for "specializations" within an existing study program. For instance at KU, Astronomy is a specialization of Physics. This could be an easy and non-bureaucratic route to increase student visibility on the Danish side.

TEACHING PERIODS

The terms of teaching are different across the universities in the region [2-7]. KU and LU/LTH divide the year into 4 blocks (KU, denoted "B") or 4 study periods (LU/LTH, denoted "LP"). In contrast, DTU, RUC, and MAH divide the teaching year into 2 semesters (denoted "S"). In addition, DTU reserves 3 weeks in January and June for "3-week courses". For details on teaching periods, see Appendix A.

The difference in teaching periods is a challenge for potential collaboration on the course level between the universities. Even though the teaching starts last week of August or first week of September at all universities, the length of terms varies, and care must be taken when common courses are planned.

As a supplement to standard terms, most Universities may offer schools or training sessions outside the common semester periods, as for instance "summer courses". Such an arrangement could potentially constitute a platform for collaborative courses.

STUDENT MOBILITY

Since the inauguration of the Öresund Bridge, the collaboration between the universities in the region has intensified, with exchange either happening on the level of individual students, by creating common courses, or by joint study programs. Recently, the latter two possibilities were severely complicated, as the Danish government specified that all students from other EU countries (including Sweden) must pay tuition at Danish universities, unless they are enrolled as exchange or full degree students (500 Dkk pr ECTS point). This means that a student wishing to take a single course in Denmark will have to pay the tuition fee. In some cases, the home university will pay the fee, but this may not always be the case.

It is therefore now very important to take into account the regulations when considering cooperation on courses and programs. These rules are generally seen as a severe obstacle in the regional collaboration, and all ÖMIC university partners recommend that they are modified.

STUDENT PROJECTS

The study programs covered in this report all contain student projects at the B.Sc. and M.Sc. levels, lasting from few days to a full year. In particular RUC has a strong element of projects in the studies. A number of recent student projects in both Denmark and Sweden have been made with use of X-ray and neutron scattering.

The organization of student projects is often informal, and it is common to see active co-supervisors from other universities. Thus, this teaching element offers a potential for easy collaboration and student exchange across the country borders.

It is possible to do any student project, from small in-course projects up to M.Sc. theses at another institution. A common way of organizing such projects is by keeping the evaluation and grading at the home university. This way, the research group where the project is done receives the labor and results from the project, while the student and home university receive the ECTS points. This is usually considered a win-win-situation, and is an easy and bureaucracy-free way of collaborating.

Apart from the courses listed in chapters 3-4 and appendices A-E, all of the universities have the option of doing projects as separate study units on the level with courses as well as doing master's theses. Such project "courses" are not listed in the tables.

3. PHYSICS RELATED COURSES

We here present an overview of courses available to physics students.

By physics students we here understand students within e.g. Physics, Engineering Physics and in some cases Nanoscience/-technology, but also other physics related study programs. However, the relevance of the courses to individual students will depend not only on study program, but also level, prior courses etc.

The mathematical topic of Fourier transforms, which is highly relevant for the description of scattering, is covered by the Physics educations at KU and DTU, but is not mandatory at other study programs. This difference is important to bear in mind during the planning of collaboration in educations.

The courses we have selected are shown in Table 3.1 (courses devoted to neutron and X-ray science) and Table 3.2 (courses containing elements of neutron and X-ray science). It can be seen that the number of courses is rather high. Elements of neutron and X-ray scattering are found in a number of courses at all three large universities (LU/LTH, KU, DTU). Likewise, all three universities have courses dedicated to scattering, although Lund University clearly has the largest number of dedicated courses. In addition, LU/LTH provides courses with specialization in accelerator physics, while KU specializes in neutron and X-ray instrumentation. This reflects their present expertise and their roles at the planning and construction of ESS and MAX-IV. The two smaller universities have limited (RUC) or no (MAH) teaching in these fields.

All three large universities give the students possibilities for hands-on training at the large-scale facilities in connection with courses. In particular, MAXLAB is used by all universities, but also PSI (Villigen, CH) and DESY (Hamburg, D) is used.

Table 3.1. Physics related courses which are devoted to neutron/X-ray science [2-5].

Index (lang.)	Course name	University, Institute	**ECTS** Term	Appr. Stud.	Main contents including X-ray or neutron experiments
- (en)	Neutron scattering: theory, simul., and practice	KU, Physics (KU Chem.) (SDU Phys.)	**7.5** B1	M.Sc. 20	Scattering: powders, surfaces, molecules, phonons, magnetism. Sources, optics, instrument, simulation. Experiments at PSI
- (en)	Experimental X-ray Physics	KU, Physics	**7.5** B2 + B4	M.Sc. 15	Scattering from: crystals, powders, surfaces, atoms, molecules. Sources, optics, instruments. Experiments in Lab. and MAXLAB/PSI
- (en)	Grand Challenges with Neutrons	KU, Physics KU, NBIA (ESS/ÖMIC)	**5** June	PhD 20	Complementarity between neutron scattering and Physics simulations for materials research. International school.
45209 (dk)	X-ray and Neutron Experiments	Risø DTU	**5** 3W June	B.Sc. 6-12	Characterization of materials with x-rays and neutron scattering. Experiments at PSI, MAXLAB, and DESY
MAXC11/ EXTF90 (en)	Photon and neutron production for science	LU, MAX-lab+Physics	**7.5** LU1a+ LU1b	B.Sc. 13	Production of photons and neutrons, accelerators and their components, special focus on beamlines and neutron guides, current research methods and their applications.
MAXM16 / EXTN90 (en)	Exp. methods and instrumentation for SR research	LU, MAX-lab+Physics	**7.5** LU2a+ LU2b	M.Sc. 6-8	Properties of synchrotron radiation, optical components, experimental techniques, properties of FELs.
FKFN05/ FYSN15 (en)	Experimental tools for subatomic physics	LU Physics	**7.5** LTH2	M.Sc. ~25	Accelerators, radiation sources, radiation-matter interaction, detectors and nuclear physics related to electronics, statistic analysis, planning of experiments, simulation
MAXM05 / EXTN95 (en)	Accelerators and free electron lasers	LU, MAX-lab + Physics	**7.5** LU3a+ LU3b	M.Sc. max 20	Accelerators for synch.rad. production and how these work, theory of magnets and construction of simulation models of accel. process of FEL.
ETEN15 (en)	Accelerators, particles and fields	LU, El. and Inf. Tech.	**7.5** LTH3	M.Sc. 7 (starts 2012)	Activities at MAX-lab and ESS, particles and fields, theory of relativity, superconductors, storage rings, numerical calculations using FEM.

FKFN01/ FYST18 (en)	Applied subatomic physics	LU, Physics	**7.5** LTH3	M.Sc. ~20	Ion beam analysis and AMS, neutron physics, fission reactors. applications of neutron scattering and nuclear physics.
FKFN10/ FYST44 (en)	Nuclear reactor physics	LU, Physics	**7.5** LTH4	M.Sc. ~20	Neutron physics and scattering, theory of fission reactors, core design, reactor dynamics, introduction to safety and risk analysis.
FAF 080 (en)	Atomic and molecular spectroscopy	LU, Physics	**7.5** LTH1	M.Sc. 20-40	Review of atomic and molecular structure, radiative and scattering processes, spectroscopy methods, tunable lasers, and appl., demonstration of: synch.rad., NMR, etc
MAXM04 (en)	Experimental X-ray physics	LU(given by KU)	**7.5** LU4a+ LU4b	M.Sc. -	Scattering from: crystals, powders, surfaces, atoms, molecules. Sources, optics, instruments. Experiments in Lab. and MAXLAB/PSI
MAXA01 (en)	Frontiers of Science	LU, MAX-lab+Physics	**7.5** full year	B.Sc. ~6	The students take part in the work of a research group who work at MAX-lab.
MAXM06 (en)	Introduction to SR based science	LU, MAX-lab + Physics	**7.5** LU1a+ LU1b	M.Sc. 5-10	Construction and function of a storage ring, vacuum technology, survey of main areas of synch.rad. research, VUV light sources, application of free electron lasers
MAXM07 (en)	Intro. to accelerators and FELs	LU, MAX-lab + Physics	**7.5** LU1a+ LU1b	M.Sc. 5-10	Basic technology of accelerators and FEL, physical methods, layout/operation/safety in an accelerator laboratory.
- (en)	Applications of X-ray and Neutron Sc.	KU, DTU, LU, RUC	**7.5 or 5** Aug 12	M.Sc. 24	Intuitive overview of basic scattering. X-ray and neutron production/facilities. Scattering methods. Problem solving and virtual experiments. Hands-on experiments.

Table 3.2. Physics related courses, which contain elements of neutrons or X-rays [2-6].

Index (lang.)	Course name	University, Institute	**ECTS** Term	Appr. Stud.	Main contents including X-ray or neutron experiments
EF (dk)	Experimental Physics	KU, Physics	**7.5** B4	B.Sc. 78	General experimental course. Lab. work and statistics. Topical lectures, including x-ray and neutron scattering (2-week project in a research group)
- (dk)	Biophysics of Membranes	KU, Physics	**7.5** B3	B.Sc.	Thermodynamics of biological systems, e.g. membranes. Methods in structural biology, e.g. x-ray scattering.
- (en)	Protein Science A	KU, Biology	**15** B1	B.Sc. 33	Structure and function of proteins. Protein design. Methods, including X-ray crystallography and small-angle X-ray scattering
CMP1 (en)	Cond. Mat. Physics 1	KU, Physics	**7.5** B1	B.Sc. 50	Crystal structure, diffraction, lattice vibrations, thermal and electrical properties of materials
CMP2 (en)	Cond. Mat. Physics 2	KU, Physics	**7.5** B3	M.Sc. 10-20	Elasticity, electron transport, magnetic order, magnetic excitations, superconductivity
- (en)	Structural Tools in Nanoscience	KU, Physics KU, Chem.	**7.5** B4	M.Sc. 20-25	Methods: STM, AFM, Electron microscopy, TOF-SIMS. X-ray scattering from: powders, surfaces, nanostructures Experiments in Lab.
- (en)	Magnetism and Magnetic Materials	KU, Physics	**7.5** B3	M.Sc. 10	Theory of magnetism in materials, experimental methods to study magnetic materials. Includes magnetic neutron scattering.
10313 (en)	Magnetism and Magnetic Materials	DTU, Physics (Risø DTU)	**10** S2	M.Sc. 10	Theory part identical to KU course above, (In addition an experimental project)
45204 (en)	Development in Materials Research	Risø DTU	**2.5** S2	PhD	Different subjects in materials science. Characterization techniques, including X-ray and neutron diffraction
10303 (dk)	Condensed Matter Physics…	DTU, Physics	**10** S1	B.Sc. 50	Crystal lattices, reciprocal space, and X-ray diffraction, electronic structure, Boltzmann equation, mean field approximation
23407 (dk/e)	Applied Physics	RUC, Science	**7.5** (Jan)	M.Sc. 4-8	Experimental and Numerical methods for determination of physical properties of materials.
- (en)	Methods in Soft Mat.Science	RUC, Science	**12** ev. 2nd winter	PhD 10-20	Different experimental and simulation methods, including small-angle scattering. Application of methods to participants' projects.

- (en)	Molecular Biophysics	SDU, RUC, KU (NBI + Life), AU, LU	**10** spr. 2012	PhD 30	Lecture series
EXTF 85/ FYS A31 (en)	Particle physics, cosmology and accelerators	LU, Physics	**7.5** LU2a+ LU2b/ LU4a+ LU4b	B.Sc. 25 (fall), 40 (spr.)	Elementary particles, Feynman diagram, standard model, Higgs mechanism, high energy physics, accelerators, storage of particle beams, examples relevant for MAX and ESS.
ETEN 01 (en)	Microwave theory	LU, El. and inf. tech.	**7.5** LTH4	M.Sc. min. 6	Applications from accelerators to be used in MAXIV and ESS, wires for transmission, smith diagram, S-matrix, cavities for resonance, particle-field coupling, optics.
FYS T16/ FYS 246 (en)	Modern subatomic physics	LU, Physics	**7.5** LU4a+ LU4b	B.Sc./ M.Sc. 10-15	Models and reactions, interactions at low energy to high energy collisions, combining information about basic interactions with tools (accel. , detectors) and models and simulations to understand the process.
TEK1 77/ FYST 19 (en)	The physics and chemistry of surfaces	LU, Physics	**7.5** LU4a+ LU4b	M.Sc. 20-30	Surfaces and their importance in physics, chemistry, nanoscience and biology, (STM, AFM, MFM, AES, XPS, LEED, SXRD).
FKM 070 (en)	Advanced materials technology	LU, Mat. Eng.	**7.5** LU2a+ LU2b	M.Sc. 40-50	Crystal structure, dynamics, phase diagrams, characterization (optical and also SEM, DTA, DSC, TGA)
FKM N05 (en)	Powder technology	LU, Mat. Eng.	**7.5** spr. (Odd years)	M.Sc. 5-30	Metallic and ceramic powder, powder characterization, compaction and sintering, powder products and their usage.

4. CHEMISTRY RELATED COURSES

We here present an overview of courses directed towards chemistry students.

By chemistry students we here understand students within e.g. Chemistry, Biochemistry or Medicinal Chemistry, but also other chemistry related study programs. However, the relevance of the courses to individual students will depend not only on study program, but also level, prior courses etc. E.g. for some Biochemistry students the following section on Biology related courses might be more relevant.

The courses we have selected are shown in Tables 4.1 (dedicated courses) and Table 4.2 (courses containing elements of X-ray and neutron science). The number of courses with scattering content is rather high at all three large universities (LU/LTH, KU, DTU), while few dedicated courses exist. The two smaller universities have limited (RUC) or no (MAH) teaching in these fields.

All three large universities give the students possibilities for hands-on training at the large-scale facilities in connection with the courses. In particular, MAXLAB is used by all universities.

Table 4.1. Chemistry related courses which are devoted to neutron/X-ray science.

Index (lang.)	Course name	University, Institute	**ECTS** Term	Appr. Stud.	Main contents including X-ray or neutron experiments
- (en)	Experimental X-ray Physics	KU, Physics	**7.5** B2 + B4	M.Sc. 15	Scattering from: crystals, powders, surfaces, atoms, molecules. Sources, optics, instruments. Experiments in Lab. and MAXLAB/PSI
- (en)	Biophysical techniques	KU, Chemistry	**7.5** B4	M.Sc. 5	Study of proteins, particularly with large scale facilities
45209 (en)	X-ray and Neutron Experiments...	Risø DTU	**5** 3W June	M.Sc. 6-12	Characterization of materials with x-rays and neutron scattering. Experiments at PSI, MAXLAB, and DESY
26322 (en)	Crystal Structure Analysis	DTU, Chemistry	**5** 3W June	M.Sc. 5-12	X-ray scattering from crystals, structure determination, phase identification by powder diffraction, structural databases, experimental work including crystal mounting and X-ray work, tour to X-ray synchrotron in Lund
26912 (en)	The Rietveld Method and X-ray Powder Diffraction	DTU, Chemistry	**5** spring	PhD 5-10	X-rays, diffraction, Rietveld method, practical exercises in sample preparation, data collection, data handling, crystal structure refinements and reports
EXTN 85	Scattering methods	LU, Chemistry	**7.5** LU4a+	M.Sc. 10-15	Scattering theory, different experimental methods such as SANA, SAXS and static and dynamic light scattering

(s/en)			LU4b		
- (en)	Applications of X-ray and Neutron Sc.	KU, DTU, LU, RUC	**7.5 or 5** Aug 12	M.Sc. 24	Intuitive overview of basic scattering. X-ray and neutron production/facilities. Scattering methods. Problem solving and virtual experiments. Hands-on experiments.

Table 4.2. Chemistry related courses in the Öresund region, which contain elements of neutrons or X-rays.

Index	Course name	University, Institute	**ECTS** Term	Appr. Stud.	Main contents including X-ray or neutron experiments
- (en)	Crystallo-graphy	KU, Chem.	**7.5** B2	M.Sc. 20	Diffraction theory, crystal symmetry, large and small molecules, structure determination. Experiments at MAXLAB
- (en)	Advanced Protein Science 1	KU, Biology	**7.5** B3	M.Sc.	Techniques to measure structural and biophysical properties of proteins. Includes small-angle X-ray scattering.
- (dk)	Biophysics of Membranes	KU, Physics	**7.5** B3	B.Sc.	Thermodynamics of biological systems, e.g. membranes. Methods in structural biology, e.g. x-ray scattering.
- (dk)	Biophysical Chemistry 2	KU, Life	**7,5** B2	M.Sc. 2-7	Methods in biophysical chemistry: Spectroscopy, thermodynamics, scattering methods, imaging
- (en)	Protein Science A	KU, Biology	**15** B1	B.Sc. Max. 33	Structure and function of proteins. Protein design. Methods, including X-ray crystallography and small-angle X-ray scattering
- (en)	Structure and function of proteins	KU, Chem.	**7.5** B4	M.Sc. 10	Three-dimensional structure and dynamics of proteins. Proteases, enzymes, transcription factors and designed proteins.
- (en)	Protein Cryst. – Refinement and validation	KU, Health and Med. Sci.	**3** Jan	PhD 16	R-values, target functions, graphic model in crystallographic refinement. PHENIX, ArpWarp, DEN. Structure refinement at high/ultra high resolution. Protein structure validation.
45204 (en)	Development in Materials Research	Risø DTU	**2.5** S2	PhD 10-12	Different subjects in materials science. Characterization techniques, including X-ray and neutron diffraction
26325 (en)	Protein Crystallograp hy	DTU, Chemistry	**5** S2	M.Sc.5 -12	Crystal structure, experimental work with crystallization and test of crystal quality, solving protein structures using e.g. X-ray diffractometer
- (en)	Methods in Soft Mat.Science	RUC, Science	**12** ev. 2nd winter	PhD 10-20	Different experimental and simulation methods, including small-angle scattering. Application of methods to participants' projects.
- (en)	Molecular Biophysics	SDU, RUC, KU (NBI + Life), AU, LU	**10** spr. 2012	PhD 30	Lecture series

KOO 045 (en)	Material Chemistry	LU/LTH	**7.5** LTH1	M.Sc. 25	Solid state chemistry, synthesis methods and characterization of crystalline materials. Relationship between structure and properties. Theoretical and practical parts involving X-ray diffraction.
KOO 052/ KOO 095 (s)	Materials and Polymer Technology/ Functional Materials	LU/LTH	**7.5** LTH4	M.Sc. 80	Inorganic and polymer materials. Crystal structures, dislocations, defects and diffusion. Strengthening of metals and binary phase diagrams. Processing and rheology of polymers.
KOO 105 (s/en)	Materials analysis at the nanoscale	LU/LTH	**7.5** LTH2	M.Sc. 60	Overview of solid state micro analysis methods; electron microscope, morphology chemistry composition, electron diffraction, HR-TEM, SEM, XEDS, EELS, AFM, STM, LEED, XPS and synchrotron based analysis in general.
KOO 065 (s/en)	Microscopic char. of materials	LU/LTH	**7.5** LTH4	M.Sc. 12	Elastic and inelastic scattering, magnetic lenses, TEM, SEM, XEDS and EELS. Spectra. Biological sample preparation and imaging techniques.
KEM M15 (en)	Structural Bio-informatics	LU	**15** LU2a+ LU2b	M.Sc. 25-30	Structure, stability, interaction and dynamics of proteins. Theoretical knowledge and practical experience of X-ray crystallography, including the use of synchrotrons (site visit to MAX-lab). Enzyme structure/function. Electronic databases and computer-based tools.

5. BIOLOGY RELATED COURSES

We here present an overview of courses that are available to biology students.

By biology students we here understand students within e.g. Biology, Biotechnology and Pharmaceutical Sciences, but also other biology related programs which exist at the different universities. E.g. biomedical study programs are included, while study programs within pure medicine are considered outside the target group.The courses we have selected are shown in Tables 5.1 (dedicated courses) and Table 5.2 (courses containing elements of X-ray and neutron science). It is seen that very few dedicated courses exist. Also it is evident that University of Copenhagen is responsible for most of the courses directed at students in the bio-sciences, which reflects well the research that is done at the university.

Table 5.1. Biology related courses which are devoted to neutron/X-ray science.

Index (lang.)	Course name	University, Institute	**ECTS** Term	Appr. Stud.	Main contents
- (en)	Biophysical techniques	KU, Chemistry	**7.5** B4	M.Sc. 5	Study of proteins, particularly with large scale facilities
- (en)	Applications of X-ray and Neutron Sc.	KU, DTU, LU, RUC	**7.5 or 5** Aug 12	M.Sc. 24	Intuitive overview of basic scattering. X-ray and neutron production/facilities. Scattering methods. Problem solving and virtual experiments. Hands-on experiments.

Table 5.2. Biology related courses in the Öresund region which contain elements of neutron or X-ray science.

Index	Course name	University, Institute	**ECTS** Term	Appr. Stud.	Main contents
- (en)	Advanced Protein Science 1	KU, Biology	**7.5** B3	M.Sc.	Techniques to measure structural and biophysical properties of proteins. Includes small-angle X-ray scattering.
- (dk)	Biophysical Chemistry 2	KU, Life	**7,5** B2	M.Sc. 2-7	Methods in biophysical chemistry: Spectroscopy, thermodynamics, scattering methods, imaging
- (dk)	Biophysics of Membranes	KU, Physics	**7.5** B3	B.Sc. 15	Thermodynamics of biological systems, e.g. membranes. Methods in structural biology, e.g. x-ray scattering.
- (en)	Protein Science A	KU, Biology	**15** B1	B.Sc. 30-40	Structure and function of proteins. Protein design. Methods, including X-ray crystallography and small-angle X-ray scattering

- (en)	Protein Science C	KU, Biology	**7.5** B1	**B**.Sc. 10-12	Protein chemistry, protein structures, folding. Protein physics, thermodynamics, interactions, design and engineering, dynamics.
- (en)	Medicinal and Biostructural Chemistry	KU, Health and Med. Sci.	**7.5** B2	M.Sc. 210	Drug design and discovery, Bioinformatics and structural biology, Genome structure, Sequence alignment, Protein Structure
- (en)	Protein Cryst. – Refinement and validation	KU, Health and Med. Sci.	**3** Jan	**P**hD 16	R-values, target functions, graphic model in crystallographic refinement. PHENIX, ArpWarp, DEN. Structure refinement at high/ultra high resolution. Protein structure validation.
- (en)	Receptor Structure and Function	KU, Health and Med. Sci.	**4.5** Apr	**P**hD 16	Receptors – biochemical characterization, crystallization, structure. Cloning and overexpression of proteins. Purification of receptor proteins and receptor purity/homogeneity tests.
26325 (en)	Protein Crystallography	DTU, Chemistry	**5** S2	M.Sc. 5-12	Crystal structure, experimental work with crystallization and test of crystal quality, solving protein structures using e.g. X-ray diffractometer
- (en)	Methods in Soft Mat.Science	RUC, Science	**12** ev. 2nd winter	**P**hD 10-20	Different experimental and simulation methods, including small-angle scattering. Application of methods to participants' projects.
- (en)	Molecular Biophysics	SDU, RUC, KU (NBI + Life), AU, LU	**10** spr. 2012	**P**hD 30	Lecture series
KEM M15 (en)	Structural Bio-informatics	LU	**15** LU2a+ LU2b	M.Sc. 25-30	Structure, stability, interaction and dynamics of proteins. Theoretical knowledge and practical experience of X-ray crystallography, including the use of synchrotrons (site visit to MAX-lab). Enzyme structure/function. Electronic databases and computer-based tools.

6. OTHER RELEVANT STUDIES

Finally, there may be study programs where scattering experiments are relevant, but where the students do not necessarily fall into any of the above categories. DTU has some such engineering programs, e.g. “Sustainable Energy”, “Engineering Design and Applied Mechanics” and “Materials and Manufacturing Engineering”. Student from these programs may be able to take some of the courses listed in tables 3.1-5.2, and could certainly be interested in experimental projects involving scattering.

Furthermore, Lund University has a dedicated program in Medical Radiation Physics. The educational program focuses on the uses of radiation for medical and diagnostic purposes. Students within this program would fall into the category of physics students, i.e. they are able to follow many of the courses listed in this report, and may also be interested in doing projects in collaboration with ESS or MaxLab/Max IV.

7. REFLECTIONS FROM THE KU STUDY LEADERS

The study leaders at University of Copenhagen were interviewed about education related to X-ray and neutron scattering. There was generally a great interest in the possibility of offering such courses, as the majority believed that their education could benefit from it.

Different models for how such a course or study element could be given were discussed

- A summer course
- Case studies in existing courses
- Separate lectures within existing courses
- An external elective course

A summer course would make it easiest to fit the study element into many different study programs. A benefit from this would be the networking of students within the Öresund region. The summer course should be in a format where it is accessible to the students from the life sciences, as e.g. physics students already have other possibilities for learning about scattering methods.

8. BRIEF SUMMARY OF FINDINGS

As this report shows, there are many existing courses in materials science in general and in scattering methods in particular. Most of these courses are accessible to physics and to some extent chemistry students.

The distribution of the courses is shown in figures 8.1 and 8.2 in relation to their academic level and their main subject. In cases of identical or almost identical collaborative courses, the course has only been listed once (courses “Experimental X-ray Physics” and “Magnetism and Magnetic Materials”). Some of the courses may be available to both Bachelor and Master students (e.g. many Master courses can be taken by final-year Bachelor students), but the courses are only listed as either for Bachelor or Master students. See the course descriptions in appendices B-E for more detail on individual courses.

It is seen that the majority of the courses dedicated to scattering methods are given in Lund (13 out of 21), while the Danish universities have chosen to introduce the method in many courses with a more general aim. The Swedish dedicated courses are almost entirely focused on physics students, while several general materials chemistry courses introduce the concepts. The number of Danish courses directed at physics and chemistry students is about equal, and also some courses for biology students exist on the Danish side.

The distribution of PhD courses may not be completely correct, as such courses are often arranged on a more ad hoc basis. Therefore, the number and topics of courses will vary each year, and all such courses may not have been included in these findings. All of the ones listed here are Danish, although one is actually a collaboration with LU. This is due to a different structure in the two countries. Where all the Swedish courses found that are available to PhD students are also available to M.Sc. students, Denmark also has courses available only to PhD students.

Some further points to be noted are:

- A dedicated educational program on scattering exists at LU as well as the possibility of specializing in accelerators within a physics education program.
- There is only limited collaboration between universities on programs, courses, or projects.
- Some courses are very similar, even within universities, and are only attended by a small number of students from one or a few study programs. This mapping may help to make these similarities more visible and promote collaboration on courses or parts of courses (e.g. experiments or projects).
- The current Danish rules for part-time students severely hinder collaboration on courses or programs. ØMIC suggests that work should be done to enable special agreements in the region.
- The KU study leaders in life sciences point to a lack of courses and lectures in scattering methods, mostly due to a lack of expert lecturers. All of the study leaders agree that an important study element needed is a summer course in August rather than a “standard” PhD school.

Figure 8.1: Distribution of courses on academic level. Each course is only listed once, although some courses are available to two student populations. E.g. all the courses found in Sweden for PhD students were also available to M.Sc. students.

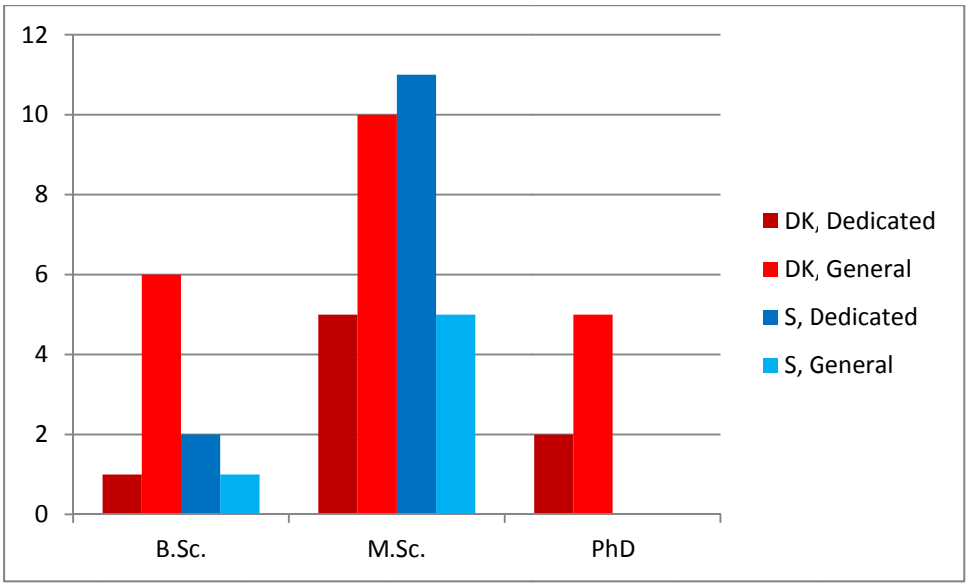
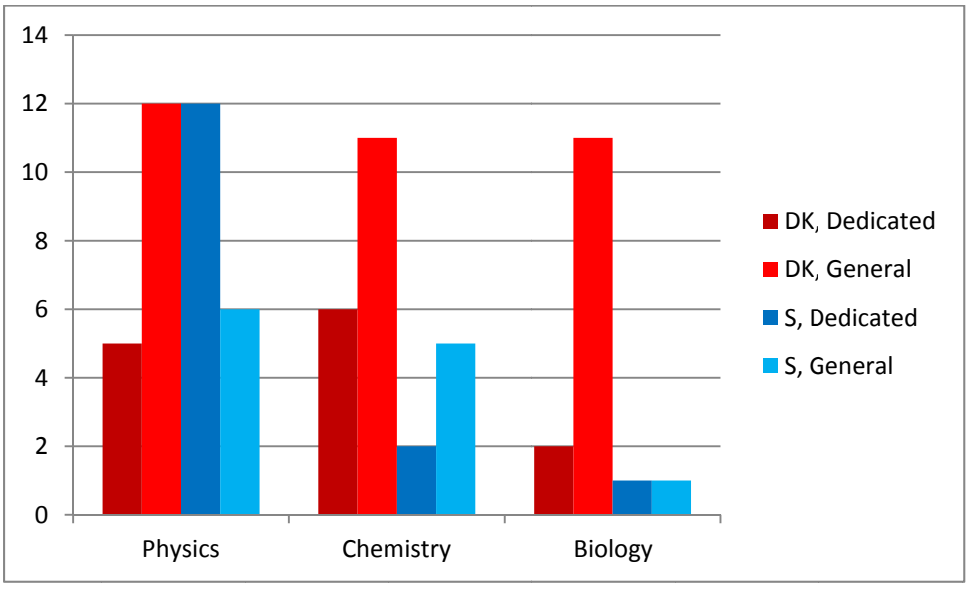


Figure 8.2: Distribution of courses on subjects. Note that some of the courses are listed with more than one subject. Furthermore, the ØMIC summer course is listed as both Swedish and Danish and relevant to all student groups.



APPENDIX A: TEACHING PERIODS IN THE ÖRESUND REGION

At LTH the academic year is divided into 4 studying periods (each followed by an examination period), here after called LTH1-4 [3];
LTH1: 29.8.2011 – 14.10.2011
LTH2: 24.10.2011 – 9.12.2011
LTH3: 16.1.2012 – 2.3.2012
LTH4: 12.3.2012 – 30.3.2012 + 17.4.2012 – 16.5.2012 (split by Easter vacation)

Although LTH is formally a part of LU, the teaching periods are slightly different. LU divides each semester into 4 periods[2], where a 7.5 ECTS course can e.g. take up two subsequent periods. Examination is included in the periods. In order to compare with the LHT periods, the eight LU periods are denoted LU1a-b, etc.. Note that LTH1 begins on the same date as LU1a and LHT3 begins on the same date as LU3a:
LU1a: 29.8.2011-27.9.2011
LU1b: 28.9.2011-26.10.2011
LU2a: 27.10.2011-28.11.2011
LU2b: 29.11.2011-15.1.2012
LU3a: 16.1.2012-16.2.2012
LU3b: 17.2.2012-20.3.2012
LU4a: 21.3.2012-25.4.2012
LU4b: 26.4.2012-3.6.2012

The academic year at KU (faculties of science, pharmaceutical sciences and life sciences) is divided into 4 blocks of each 9 weeks (including examination). In the course list these blocks will be denoted B1-4[4]:
B1: 5.9.2011 - 11.11.2011
B2: 21.11.2011 - 28.1.2012
B3: 6.2.2012 - 6.4.2012
B4: 16.4.2012 - 22.6.2012

DTU divides the year into two semesters, where each semester consists of a 13-week period where several courses can be followed simultaneously (followed by an exam period) and a 3-week period where a single course is studied full time (including examination). For the academic year 2011-2012, the periods are[5];
S1 (13-week, fall): 29.8.2011-2.12.2011
3-week, winter: 2.1.2012-22.1.2012
S2 (13-week, spring): 30.1.2012-9.5.2012
3-week, summer: 1.6.2012-22.6.2012

RUC divides the academic year into two semesters, beginning in September and February[6].

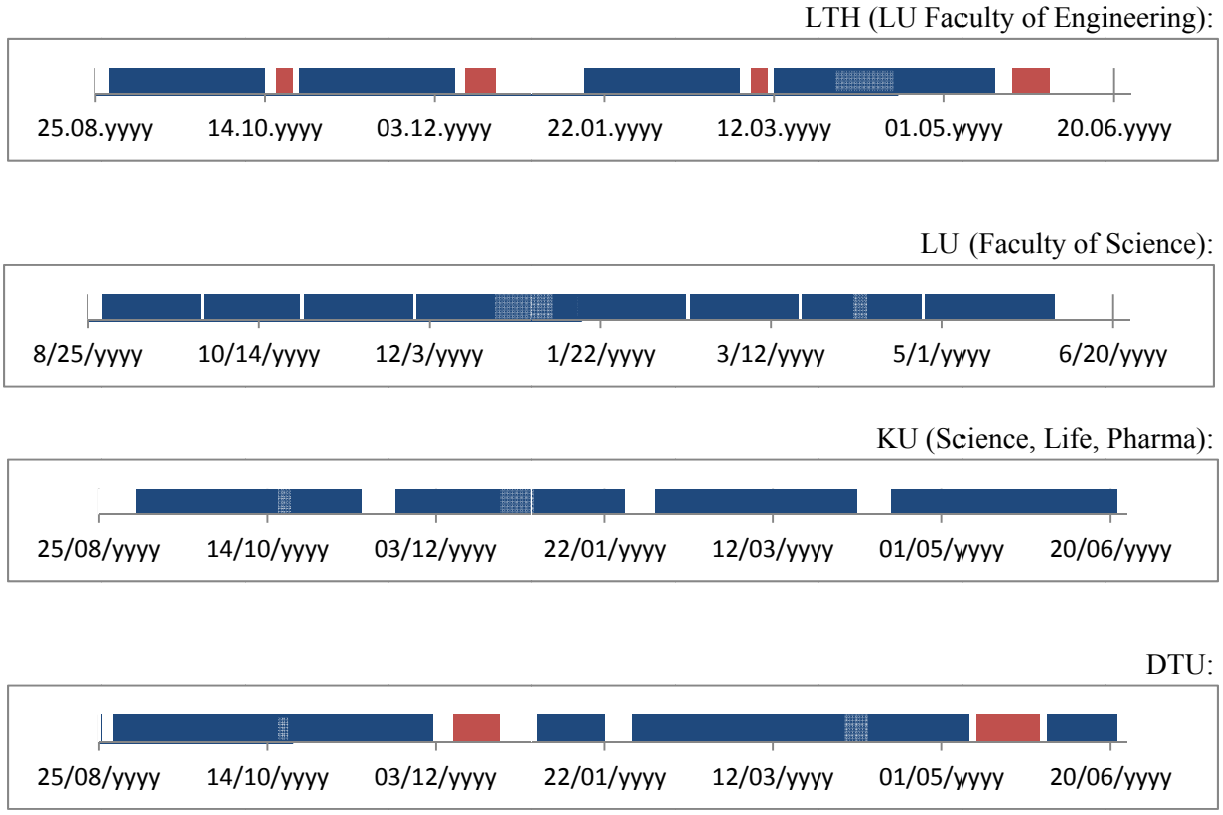
MAH uses the two semesters somewhat differently, as each semester is divided into blocks of 5 or 10 weeks (7.5 or 15 ECTS), where the courses are studied in succession [7].

In addition, the universities may offer schools or training sessions outside the common semester periods, as for instance “summer courses”, which are mainly held in August.

Figure A.1 shows an overview of the study periods at KU, DTU and LU/LTH. It is seen that even within LU there is a difference in the placement of the study periods between the Faculty of Science and the Faculty of Engineering (LTH). It is also clear why it may be difficult for students from any of

the universities to take courses at any of the other universities, as the teaching terms are quite different. If a course should be made available for all students within the region, the best option may therefore be to place it in the summer vacation.

Figure A.1: Study periods at the three main universities. For those universities where the exam periods are scheduled separately from the study periods, the exam periods are marked in pink. Some major vacations have been indicated by a lighter colour.



APPENDIX B: COURSES AND EDUCATIONAL PROGRAMS AT UNIVERSITY OF COPENHAGEN

The University of Copenhagen is the largest institution of research and education in Denmark. The university activities take place in various environments ranging from the plant world of the Botanical Gardens, through high-technology laboratories and auditoriums, to the historic buildings and lecture rooms of Frue Plads and other locations.

The University of Copenhagen educates around 37,000 students and has more than 7,000 employees. The University of Copenhagen is a self-governing unit under the state. It comprises eight faculties and more than 100 departments and research centers. The faculties which are of particular interest in relation to scattering experiments are the Faculty of Science, the Faculty of Life Sciences and the Faculty of Pharmaceutical Sciences.

More comprehensive information is given at http://www.ku.dk

Course plans can be found at: http://sis.ku.dk/kurser/portal2.aspx?pnr=0

COURSES WHICH FOCUS TO A GREATER EXTENT ON NEUTRONS AND/OR PHOTONS FOR SCIENCE AND TECHNOLOGY

COURSE TITLE: BIOPHYSICAL TECHNIQUES
Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: a basic knowledge of Protein Chemistry. If the major subject module "Protein structure and function" is taken at the same time, this will also provide the requested background in protein structure.

For whom: Master students.

By whom: Department of Chemistry, KU

Language: English

When: B4

Brief summary contents:

- A solid introduction to the techniques used to investigate properties of proteins, their structure, function and dynamics.
- Methods that make use of large research infrastructures like synchrotrons and neutron facilities.
- X-ray diffraction from crystals and in solution, different spectroscopic methods as well as biochemical and bioinformatics methods.
- Application to problems in protein science, with enough theory for the students to relate critically to the techniques.
- Enzymatic reaction mechanisms, understanding of the causes of protein aggregation, protein folding and protein interactions with small molecules and other proteins.
- Independent study of original literature on the application of the techniques will be discussed in the classes.

Usually attended by 4-6 students.

Contact person: Sine Larsen, Department of Chemistry, tel. +45 3532 0282, e-mail: sine@chem.ku.dk

http://sis.ku.dk/kurser/viskursus.aspx?knr=121251

COURSE TITLE: NEUTRON SCATTERING IN THEORY, SIMULATION AND PRACTICE

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: basic solid state physics crystallography knowledge, Basic programming knowledge, Quantum Mechanics, Electromagnetism

For whom: Master students.

By whom: Materialeforskning at Risö/DTU, NBI, Grundvidenskab at KU/Life, Fysik at SDU, Department of Chemistry (Kemisk institut) at KU

Language: English

When: B1

Brief summary of contents:

- Usage, strengths and weakness of neutron diffraction
- Scattering from atoms, crystals and nanostructures
- Magnetic scattering
- Scattering from lattice vibrations, phonons, spin waves, diffusion, surface layers, nanoparticles, large molecules, soft condensed matter and magnetic materials
- Neutron Instrument design and simulation
- Monte Carlo simulations
- 3 mayor types of scattering: Elastic/Inelastic, coherent/incoherent, Nuclear/Magnetic

Approximate number of students: 20

Contact persons: Kim Lefmann, Nanophysics, Niels Bohr Institute, e-mail: lefmann@fys.ku.dk, tel. 35 32 04 76 and Lise Arleth, E-mail: lia@life.ku.dk, tel. +45 353-32317, Faculty of Life Sciences, Nanobioscience, Department of Basic Sciences and Environment.

http://sis.ku.dk/kurser/viskursus.aspx?knr=130483

COURSE TITLE: EXPERIMENTAL X-RAY PHYSICS
Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: Basic Physics

For whom: Master students in physics. PhD students in Chemistry or Biology, Postdocs in Chemistry or Biology

By whom: Department of Chemistry at Copenhagen University

Language: English, Danish if only Danish students are attending

When: B2 and B4

Brief summary of contents:

- Utilization of X-rays in physics, chemistry, biophysics, materials science and biology.
- Lectures are given on the basics of X-ray physics, exercises in the lab will provide "hands-on" experience.
- A number of the basic experiments with X-ray synchrotron radiation will be carried out at the synchrotron facility MAXlab in Lund.
- X-ray optics
- Thomson spreading
- Reflectivity at smooth and rough surfaces
- Atomic and molecular scattering
- Spreading due to thermal fluctuations
- Crystal structures
- Edwald construction and powder diffraction
- Solving of Protein structures using Resonant scattering and Multiple Anomalous Diffractions

Approximate number of students: 15, course runs twice a year.

Contact person: Robert Krarup Feidenhans'l, NanoPhysics, Niels Bohr Institute, e-mail: robert@fys.ku.dk, tel. 35320397

http://sis.ku.dk/kurser/viskursus.aspx?knr=131312

COURSE TITLE: GRAND CHALLENGES WITH NEUTRONS
Credits: 5 ECTS

Prerequisites/Entrance qualifications: PhD student

For whom: PhD students, International school

By whom: University of Copenhagen, Niels Bohr Institute, Niels Bohr International Academy, ØMIC

Language: English

When: First time in the summer of 2011, scheduled to continue every summer

Brief summary of contents:

- Complementarity between neutron scattering and Physics simulations for materials research.

20 students attended the course in 2011

Contact person: Kim Lefmann, tel. 35 32 04 76, office: HCØ, D314, e-mail lefmann@fys.ku.dk

COURSE TITLE: APPLICATIONS OF NEUTRON AND X-RAY SCATTERING IN BIOLOGY, CHEMISTRY AND PHYSICS

Credits: 5 or 7.5 ECTS

Prerequisites/Entrance qualifications: B.Sc. or equivalent

For whom: Master students

By whom: ØMIC, University of Copenhagen, Technical University of Denmark, University of Lund, Roskilde University

Language: English

When: Summer of 2012. Whether the course will be given again is still unknown and depends on alternative funding after the end of ØMIC

Brief summary of contents:

- Introduction to the scientific concepts, e.g. biological matter, materials chemistry, soft matter and hard condensed matter
- Intuitive overview of basic scattering
- X-ray and neutron production/facilities
- Scattering methods including examples from science
- Problem solving and virtual experiments
- Hands-on experiments including proposal writing, data analysis and presentation of data

Maxmum number of students: 24

Contact persons: Kim Lefmann (KU), tel. 35 32 04 76, office: HCØ, D314, e-mail lefmann@fys.ku.dk, Poul Norby (DTU), Tomas Brage (LU)

COURSES WHICH HAVE A GENERAL FOCUS AND THAT TO A MINOR EXTENT FOCUS ON NEUTRONS AND/OR PHOTONS FOR SCIENCE AND TECHNOLOGY

COURSE TITLE: STRUCTURAL TOOLS IN NANO SCIENCE
Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: Bachelor within Natural Sciences.

For whom: Master students

By whom: Niels Bohr Institute

Language: English

When: B4

Brief summary of contents:

- Introduction to modern characterization tools in surface and nano science. The students will choose their own set of samples which they will characterize with a subset of the techniques presented in the lectures. The students will learn about the applicability of the techniques and learn how to use them in practice.
- STM
- AFM
- Electron microscopy
- X-ray photoelectron spectroscopy
- Scanning Electron Microscopy
- Transmission Electron Microscopy
- XPS (Chemical Characterization)
- Contact angle (Chemical Characterization)
- TOF-SIMS (Chemical Characterization)

Approximate no. of students: 20-25

Contact person: Robert Krarup Feidenhans'l, NanoPhysics, Niels Bohr Institute, e-mail: robert@fys.ku.dk, tel. 35320397

http://sis.ku.dk/kurser/viskursus.aspx?knr=131213

COURSE TITLE: EXPERIMENTAL PHYSICS (EF)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: None

For whom: Bachelor students

By whom: University of Copenhagen, Niels Bohr Institute

Language: Danish

When: B4

Brief summary of contents:

- Typical laboratory setups for research purposes (guest lecture)
- Typical experimental setups in the industry (guest lecture)
- Correlation between experiment and theory, conclusions from the measurement data and knowledge
- Typical "large facilities", for example CERN, plasma research, satellites, x-ray / neutron radiation (guest lecture)
- Theory and software for nonlinear scientific computing, including model set up
- Oral and written scientific presentation
- Computer Exercises for training in data processing and data presentation
- Small experimental exercises in groups training of data processing and data presentation
- A large experimental project in groups, conducted in a research group at NBI (individual tutors)

Approximate number of students: the course has increased its participant number each year, with 78 students attending in 2012, where the course is taught for the 3rd time.

Contact persons at Copenhagen University: Kim Lefmann, NanoPhysics, Niels Bohr Institute, e-mail: lefmann@fys.ku.dk, tel. 35 32 04 76, Ian Bearden, Experimental Particle Physics, Niels Bohr Institute, tel. 35 32 53 23, E-mail: bearden@nbi.dk

http://sis.ku.dk/kurser/viskursus.aspx?knr=131480

COURSE TITLE: ADVANCED PROTEIN SCIENCE 1 - PROTEIN INTERACTIONS AND SEQUENCES

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: Bachelor degree either in biochemistry, nanotechnology, chemistry, or molecular biomedicine. Other applicants may be admitted on the basis of an evaluation of their individual qualifications. Basic knowledge of protein science is a requirement.

For whom: Master students

By whom: Department of Biology

Language: English

When: B3

Brief summary of contents:

- Introduction to biophysical techniques used in protein science to measure structural and biophysical properties of proteins.
- Biophysical methods of optical spectroscopy (circular dichroism, fluorescence, absorbance)
- Mass spectrometry
- Surface plasmon resonance
- Isothermal and differential scanning calorimetry
- NMR spectroscopy
- Small angle x-ray scattering.
- The focus is on the theoretical background of the methods, the instrumentation, and on the application of these methods in protein science.
- A mixture of lectures and group discussions of fundamental topics in each of the methodologies, and for most of these hands on introduction to both the experimental and analytical tools of these methods.

Contact person: Birthe Kragelund, Department of Biology, E-mail: bbk@bio.ku.dk , tel. +45 3532 2081

http://sis.ku.dk/kurser/viskursus.aspx?knr=131630

COURSE TITLE: MAGNETISM AND MAGNETIC MATERIALS

Credits: 7.5

Recommended Prerequisites/ Recommended Entrance qualifications: Knowledge of Solid State Physics

For whom: Master students

By whom: University of Copenhagen (NBI) and DTU

Language: English

When: B3

Brief summary of contents:

- Introduction to the field of magnetism in condensed matter.
- One-body and many-body problems of magnetism.
- Simple mean-field and reciprocal space techniques for a solution of the many-body problems.
- The physical basis of experimental techniques used in current research projects and typical data are discussed
- Theory of magnetism and magnetic materials
- bulk magnetic techniques, NMR, Mossbauer spectroscopy, and magnetic neutron scattering

Approximate number of students: Together with the DTU course (10 ECTS), about 20-25 students, half from each institution.

Contact persons: Kim Lefmann, tel. 35 32 04 76, office: HCØ, D314, e-mail lefmann@fys.ku.dk, Cathrine Frandsen, Institut for Fysik, DTU

http://sis.ku.dk/kurser/viskursus.aspx?knr=131214

COURSE TITLE: BIOPHYSICAL CHEMISTRY 2 – MODERN EXPERIMENTAL METHODS

English title: Biophysical Chemistry 2, Modern Experimental Methods

Credits: 7.5

Prerequisites/Entrance qualifications: B.Sc., Basic physics or biophysics, basic chemistry and biochemistry, basic physical chemistry (Biophysical Chemistry I, or equivalent course)

For whom: Master students

By whom: University of Copenhagen, Department of Basic sciences and environment

Language: Danish

When: B2

Brief summary of contents:

- Introduction to a variety of typical systems and topics within Biophysical Chemistry, e.g. proteins in solutions, biological membrane systems, food products, and personal care products.
- Examples on topics include pharmaceutics protein formulations and drug delivery, and consistency and physical/chemical stability of emulsions in specific type of food products.
- Experimental works within biophysical chemistry. The lectures will provide proposals on given systems, but the students are most welcome to formulate their own topic to be treated experimentally.
- Spectroscopic methods, e.g. nuclear magnetic resonance (NMR), circular dichroism spectroscopy(CD), perturbed angular correlation of gamma rays (PAC), UV- and visible light spectroscopy.
- Thermodynamic and macroscopic methods, calorimetry, viscosity, rheology, densitometry
- Structural methods using scattering methods. Light scattering, x-ray and neutron scattering, crystallography.
- Structural methods such as Optical microscopy, fluorescence microscopy, electron microscopy, scanning probe microscopy.

Approximate number of students: 2-7. Course may be cancelled or run on an individual basis if there are very few participants. No upper limit.

Contact persons: Kell Mortensen, kell@life.ku.dk, Department of Basic sciences and environment, tel. 353-32311. Lise Arleth, lia@life.ku.dk, Department of Basic sciences and environment, tel. 353-32317

http://www.kursusinfo.life.ku.dk/Kurser/LKEF10101.aspx

COURSE TITLE: BIOPHYSICS OF MEMBRANES (MEMBRANE)

Credits: 7.5

Prerequisites/Entrance qualifications: Corresponding to Introduction to biophysics (recommended).

For whom: Bachelor students

By whom: University of Copenhagen, Niels Bohr Institute

Language: Danish

When: B3

Brief summary of contents:

- Thermodynamics of biological systems, e.g. biological macromolecules, protein binding, protein and DNA folding, cooperative transitions, cold denaturation, biological membranes, their electrostatics, the hydrophobic effect, elastic theory and lipid-protein interactions.
- Enzyme activity and allosteric reactions
- Heat capacity profiles of protein folding and membrane melting
- Structural biology methods, e.g. x-ray diffraction and nuclear magnetic resonance
- Major structural features of proteins, DNA and membranes
- The role of water in biology.
- The phases of membranes, cooperative transitions and the nature of the fluctuations.
- Simple phase diagrams from ideal solution theory or regular solution theory, including the lever rule and Gibbs' phase rule
- Anesthetics on membranes
- The Guy Chapman theory for the electrostatic potential of membranes

Approximate number of students: 15

Contact person: Thomas Heimburg, tel. 35 32 53 89, office Kc-9, E-mail: theimbu@nbi.dk

http://sis.ku.dk/kurser/viskursus.aspx?knr=131489

COURSE TITLE: PROTEIN SCIENCE A

Credits: 15 ECTS

Prerequisites/Entrance qualifications: Basic course in protein science e.g. Biokemi2: Protein and nucleic acid biochemistry, molecular biology and cell biology (Biochemistry), Protein structure and function (Chemistry), Nanobio1 (Nanotechnology). Students of Biochemistry are given priority.

For whom: Bachelor students in Chemistry, Biochemistry or Nanotechnology

By whom: University of Copenhagen, Department of Biology, Biomolecular Sciences

Language: English

When: B1

Brief summary of contents:

- physics, chemistry, structure and function of proteins
- protein chemistry methods and strategies, protein structures and structure determination, folding and misfolding, proteome analysis, enzyme mechanisms and engineering.
- protein physics, thermodynamics, protein-protein interactions, protein design and engineering, protein dynamics, misfolding and disease.
- purification and characterization of proteins from natural sources and of recombinant proteins.
- fractionation methods, electrophoresis, chromatography, peptide mass finger printing, protein crystallization, X-ray crystalography, small-angle X-ray scattering, applied bioinformatics, chemical modification, and mass spectrometry. It includes also CD-, fluorescence-, and NMR-spectroscopy, molecular graphics and modeling, ligand binding, pKa values and data processing.

Approximate number of students: 30-40. Theory taught together with Protein Science C.

Contact person: Birthe B. Kragelund, bbk@bio.ku.dk, tel. 3532 2081

http://sis.ku.dk/kurser/viskursus.aspx?knr=136683

COURSE TITLE: PROTEIN SCIENCE C

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: Basic course in protein science, such as Biokemi2 (biokemi), Proteinkemi og Enzymologi I (molbiomed), Proteiners struktur og funktion (kemi), Nanobio1 (nano).

For whom: Bachelor students in Biochemistry, Nanotechnology, Chemistry, and Molecular Biomedicine who have passed all first year courses and half of the second year courses (corresponding to a total of 90 ECTS-points) of their curriculum.

By whom: University of Copenhagen, Department of Biology, Biomolecular Sciences

Language: English

When: B1

Brief summary of contents:

- General subjects include: protein chemistry methods and strategies, protein structures and structure determination, folding and misfolding, proteome analysis, enzyme mechanisms.
- Specific subjects include: protein physics, thermodynamics, protein-protein interactions, protein design and engineering, protein dynamics, misfolding and disease.

Approximate number of students: 10-12. Theory taught together with Protein Science A.

Contact person: Birthe B. Kragelund, bbk@bio.ku.dk, tel. 3532 2081

http://sis.ku.dk/kurser/viskursus.aspx?knr=130490

COURSE TITLE: CRYSTALLOGRAPHY
Credits: 7.5

Prerequisites/Entrance qualifications: The course is open to students with a BSc-degree in biochemistry, chemistry or nanotechnology. Students with related bachelor degrees (for example biology or molecular biomedicine) may be admitted, but are recommended to contact the teacher before registering in order to discuss their background and qualifications as compared to the level of the course.For whom: B.Sc. students in Chemistry, Biochemistry or Nanotechnology

For whom: Master students

By whom: University of Copenhagen, Department of Chemistry

Language: English

When: B2

Brief summary of contents:

- Crystallographhic methods for determining structure
- Single crystals of bio-macromolecules and small molecules
- Practicals, including structural databases
- Individual projects

Approximate number of students: 20.

Contact person: Leila Lo Leggio, 3532 0295, HCØ, C310, e-mail: leila@kemi.ku.dk

http://sis.ku.dk/kurser/viskursus.aspx?knr=130537

COURSE TITLE: STRUCTURE AND FUNCTION OF PROTEINS

Credits: 7.5

Prerequisites/Entrance qualifications: A basic knowledge of protein chemistry is recommended

For whom: Master students

By whom: University of Copenhagen, Department of Chemistry

Language: English

When: B4

Brief summary of contents:

- Advanced aspects of protein science based on critical reading of original literature
- Relationship between protein structure and function
- Aspects of structure and function of proteases, carbohydrate-active and nucleotide metabolism enzymes, transcription factors and designed proteins

Approximate number of students: 10.

Contact person: Leila Lo Leggio, 3532 0295, HCØ, C310, e-mail: leila@kemi.ku.dk

http://sis.ku.dk/kurser/viskursus.aspx?knr=131314

COURSE TITLE: CONDENSED MATTER PHYSICS 1 (CMP1)

Credits: 7.5

Prerequisites/Entrance qualifications: Quantum mechanics and statistical mechanics

For whom: Bachelor students

By whom: University of Copenhagen, Niels Bohr Institute

Language: English

When: B1

Brief summary of contents:

- Properties of solids
- Crystal structures and reciprocal lattice
- Phonons and thermal properties
- Electron Fermi gases
- Energy band structures
- Semiconductors

Approximate number of students: 50.

Contact person: Robert Feidenhans'l, Telefone: 35 32 03 97, E-mail: robert@fys.ku.dk, Office: D318

http://sis.ku.dk/kurser/viskursus.aspx?knr=130430

COURSE TITLE: CONDENSED MATTER PHYSICS 2 (CMP2)

Credits: 7.5

Prerequisites/Entrance qualifications: The following courses or equivalent: Quantum mechanics 1&2, Statistical physics, Condensed Matter Physics 1.

For whom: Master students

By whom: University of Copenhagen, Niels Bohr Institute

Language: English

When: B3

Brief summary of contents:

- Electrons in solids, elasticity theory and phonons
- Semiclassical electron dynamics and the Boltzmann equation
- Mean-field theory of ordering and second-order phase transitions
- Magnetism of ions and electrons
- Phenomenological theory of superconductivity.

Approximate number of students: 10-20.

Contact persons: Jens Jensen, tlf. 35 32 04 23, e-mail: jens@fys.ku.dk Karsten Flensberg, tlf. 35 32 04 18, e-mail: flensberg@fys.ku.dk

http://sis.ku.dk/kurser/viskursus.aspx?knr=131568

COURSE TITLE: MEDICINAL AND BIOSTRUCTURAL CHEMISTRY

Credits: 7.5

Prerequisites/Entrance qualifications:

For whom: Master students

By whom: University of Copenhagen, Department of Medicinal Chemistry

Language: English

When: B2

Brief summary of contents:

- Drug design and discovery
- Bioinformatics and structural biology
- Genome structure
- Sequence alignment
- Protein Structure

Approximate number of students: 210

Contact persons: Kristian Strømgaard krst@farma.ku.dk and Michael Gajhede mig@farma.ku.dk, Department of Medicinal Chemistry

http://www.farma.ku.dk/index.php/Samlet-2011-2012/11136/0/?&tx_browser_pi1[showUid]=141&cHash=78bf52bbd0

COURSE TITLE: PROTEIN CRYSTALLOGRAPHY – REFINEMENT AND VALIDATION

Credits: 3

Prerequisites/Entrance qualifications:

For whom: PhD students

By whom: University of Copenhagen, Department of Medicinal Chemistry

Language: English

When: January 9-13 2012, given every year

Brief summary of contents:

- Introduction to R-values and different target functions in crystallographic refinement
- Graphic model building/adjustment in structure refinement
- The PHENIX software environment
- Integrated automated model building and refinement in ArpWarp
- Structure refinement of low resolution, DEN-assisted refinement
- Structure refinement at high/ultra high resolution
- Protein structure validation

Approximate number of students: 16

Contact persons: Ole Kristensen, Jette Sandholm Kastrup, Karla Frydenvang, Department of Medicinal Chemistry

Additional information: The course is part of a joint initiative (Aarhus University, Faculty of Pharmaceutical Sciences at the University of Copenhagen, and Faculty of Science at the University of Copenhagen) to provide a solid background to PhD students in central aspects/disciplines of protein crystallography with three course modules: "From Protein to Data" (module 1), "Getting Phases" (module 2), and "Refinement and Validation" (module 3). Students are recommended to take modules 1 and 2 or acquire similar experience as background for module 3. Module 1 is offered at the Faculty of Science at the University of Copenhagen, module 2 at Aarhus University and module 3 at the Faculty of Pharmaceutical Sciences at the University of Copenhagen.

http://www.farma.ku.dk/index.php/Protein-Crystallography/11056/0/

COURSE TITLE: RECEPTOR STRUCTURE AND FUNCTION

Credits: 4.5

Prerequisites/Entrance qualifications: The course is primarily offered to PhD students who have completed undergraduate courses in biochemistry, biology, chemistry, molecular biology, pharmacology, or pharmacy, or researchers within the pharmaceutical industry. Applicants enrolled in part-time master's programs at the Faculty of Pharmaceutical Sciences, University of Copenhagen may participate in the course.

For whom: PhD students

By whom: University of Copenhagen, Department of Medicinal Chemistry

Language: English

When: April 23-27 2012, given every year

Brief summary of contents:

- Introduction to receptors
- Cloning and overexpression of proteins in various species
- Purification of receptor proteins and receptor purity/homogeneity tests
- Biochemical characterisation of receptors
- Crystallisation of receptor proteins
- Protein crystallography
- Structural analysis and databases
- Structure prediction (molecular modelling)
- State of the art 3D receptor structures

Approximate number of students:16

Contact persons: Ole Kristensen, Jette Sandholm Kastrup

http://www.farma.ku.dk/index.php/Receptor-Structure-and-Functio/11038/0/

APPENDIX C: COURSES AND EDUCATIONAL PROGRAMS AT LUND UNIVERSITY, INCLUDING LTH

Lund University was founded in 1666, and is today one of the largest, oldest and broadest universities in Scandinavia and is consistently ranked among the world's top 100 universities. The majority of the University's activities are in Lund, but a number of education and research departments are based in Malmö. The University also has a growing campus in Helsingborg and a School of Aviation in Ljungbyhed.

The Lund University educates around 47 000 students has some 6 300 employees. It comprises eight faculties and has some 30 world-leading research environments.

More comprehensive information is given at http://www.lu.se

Course plans can be found at:
http://mimer.kanslimn.lu.se/kursplanering/faststalldakursplaner/default.aspx

http://www.ceq.lth.se/LoTwebb/

LIST OF EDUCATIONAL PROGRAMS RELATING TO THE COURSES

In the following course list, these abbreviations are used to indicate which study programs and years the courses are relevant for[10].

F#: Master of Science in Engineering Physics, year #

F#aft: Master of Science in Engineering Physics, specialization ”Accelerators – Physics and Technology”, year #

F#es: Master of Science in Engineering Physics, specialization ”Energy Systems”, year #

F#bem: Master of Science in Engineering Physics, specialization ”Computational Mechanics”, year #

F#mt: Master of Science in Engineering Physics, specialization ”Biomedical Engineering”, year #

F#f: Master of Science in Engineering Physics, specialization ”Photonics”, year #

N#: Master of Science in Engineering Nanoscience, year #

N#m: Master of Science in Engineering Nanoscience, specialization “Materials”, year #

N#nf: Master of Science in Engineering Nanoscience, specialization ”Nanophysics”, year #

E#: Master of Science in Electrical Engineering, year #

E#hn: Master of Science in Electrical Engineering, specialization ”High-frequency and Nanoelectronics”, year #

E#f: Master of Science in Electrical Engineering, specialization ”Photonics”, year #

I#: Master of Science in Industrial Management and Engineering, year #

Pi#: Master of Science in Engineering Mathematics, year #

MD#: Master of Science in Mechanical Engineering with Industrial Design, year #

M#pr: Master of Science in Mechanical Engineering, specialization ”Production Engineering”, year #

M#pu: Master of Science in Mechanical Engineering, specialization ”Product Development”, year #

MNAV#: Master program in Nanoscience, year #

COURSES WHICH FOCUS TO A GREATER EXTENT ON NEUTRONS AND/OR PHOTONS FOR SCIENCE AND TECHNOLOGY

COURSE TITLE: PHOTON AND NEUTRON PRODUCTION FOR SCIENCE (MAXC11, EXTF90)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: Basic courses in mathematics and physics or FYSA21 (Thought Tools in Science, 30 ECTS)

For whom: Optional for F4 aft, F4, N5 (Faculty of Engineering) and year 3 or 4 for international students in physics. Compulsory course (year 3) within the bachelor´s program in physics called: "Naturvetenskap med fotoner och neutroner". Basic level (Bachelor students).

By whom: MAX-lab and the Department of Physics (LU).

Language: Is given in English on demand.

When: LU1a+LU1b

Brief summary of contents:

- How photons and neutrons are produced for scientific use.
- Different accelerators and their components are introduced and the theory of how they are used. (Machines for producing synchrotron light and neutrons are described in more detail.)
- Overview of conventional light sources and reactor based neutron sources, special focus on beamlines (photons) and neutron guides (for neutrons).
- Current research methods, with their applications in natural science, medicine and technology, based on synchrotron radiation and neutrons.

This course was given for the first time the fall 2011 and it had 13 students. No formal/official restriction in the number of students has yet been given but it could be that too large groups of students make it difficult in general to handle laboratory exercises.

Contact person: Rami Sankari (Rami.Sankari@maxlab.lu.se) and Erik Wallén, erik.wallén@maxlab.lu.se, Department of Physics

http://www.ka.lth.se/kursplaner/11_12%20eng/EXTF90.html

COURSE TITLE: EXPERIMENTAL METHODS AND INSTRUMENTATION FOR SYNCHROTRON RADIATION RESEARCH (EXTN90/MAXM16)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: Knowledge corresponding to the introductory course MAXC11/EXTF90 (Photon and neutron production for science)

For whom: Optional for f4aft, F4, N5. Compulsory course in a Master´s degree in Science with a major in Synchrotron Radiation based Science. Also given as a single subject course. Advanced level (Master students).

By whom: MAX-lab and the Department of Physics (LU).

Language: English

When: LU2a+LU2b

Brief summary of contents:

- Studies of the properties of synchrotron radiation (including bending magnets and insertion devices and how the properties of the radiation are coupled to the parameters of the storage ring).
- Studies of optical components used for focusing, monochromatization and polarization of synchrotron radiation.
- Studies of experimental techniques based on synchrotron radiation.
- Studies of properties of free electron lasers and experimental techniques used in connection with this radiation source type.

Approximately 6-8 students attend the course. No information available regarding an upper limit in the number of students. Due to overlapping content, this course cannot be included in a degree together with MAXM11.

Contact person: Rami Sankari (Rami.Sankari@maxlab.lu.se)

http://www.ka.lth.se/kursplaner/11_12%20eng/EXTN90.html

COURSE TITLE: EXPERIMENTAL TOOLS FOR SUBATOMIC PHYSICS (FKFN05/FYSN15)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: FAFF10 (Atomic and Nuclear Physics with Applications).

For whom: Given as a single subject course/optional course for E4, E4mt, F4aft, F4, F4mt and within the master in science program in physics. Advanced level (Master students).

By whom: Department of Physics (LU) and LTH.

Language: English on demand.

When: LTH2

Brief summary of contents:

- The course consists of a general part for all students (accelerators and statistics)
- In parallel, students chose to follow one of the following:
- Modern analogue and digital technique
- Radiation interaction and detectors for ionizing radiation

The course is partly the same course as the course "FysN15 Experimental Tools" (first term course in the Science Faculty Masters program in Physics) and the two courses will be run in parallel. Can be cancelled if the number of students is less than 8. No upper limit, but usually about 25 students attend. Due to overlapping content, this course cannot be included in a degree together with previous courses FKF032 and FKF065.

Contact person: Per Kristiansson (per.kristiansson@nuclear.lu.se) and Anders Oskarsson, Anders.Oskarsson@hep.lu.se, Department of Physics

http://www.ka.lth.se/kursplaner/11_12%20eng/FKFN05.html

or

http://mimer.kanslimn.lu.se/kursplanering/faststalldakursplaner/Dokumentbibliotek6/1/Kursplaner%20Fysik/Avancerad%20niva/FYSN15%20Experimentella%20verktyg%207,5%20hp.pdf

COURSE TITLE: ACCELERATORS AND FREE ELECTRON LASERS (EXTN95/MAXM05)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: EXTF90/MAXC11 (Photon and neutron production for science).

For whom: Optional for F4aft and F4. Advanced level (Master students).

By whom: MAX-lab and Department of Physics (LU).

Language: English on demand.

When: LU3a+LU3b

Brief summary of contents:

- Focus on accelerators for synchrotron radiation production (linear accelerators and synchrotrons), how these works, are build and their properties coupled to different areas of application.
- Analysis of different components in an accelerator.
- Theory for magnets and how these are used within radiation dynamics (particle optics, focusing, and so on) and the construction of simulation models of accelerators.
- The process of the free electron laser and different types of free electron lasers and the physics concerning amplification is analyzed.

Will be given the first time during 2012. Maximum number of students is limited to 20 by the fact that some of the parts are done in lab.

Contact person: Sverker Werin (sverker.werin@maxlab.lu.se)

http://www.ka.lth.se/kursplaner/11_12%20eng/EXTN95.html

COURSE TITLE: ACCELERATORS, PARTICLES AND FIELDS (ETEN15)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: Basic course in Electromagnetic Fields.

For whom: Optional for E4, E4hn, F4aft, F4, Pi4. Advanced level (Master students).

By whom: Electrical and Information Technology (LTH/LU).

Language: English on demand.

When: LTH3

Brief summary of contents:

- Description of the activities at MAX-lab and ESS.
- Calculation of trajectories of particles in electromagnetic fields.
- Steering of charged particles.
- Synchrotron radiation.
- Fields generated by moving charged particles.
- Transformation of fields between inertial frames.
- Theory of relativity.
- Superconductors.
- Storage rings for electrons and linear accelerators.
- Numerical calculations using a finite element program.

Due to overlapping content, this course cannot be included in a degree together with ETI015. Is given the first time next spring (2012) and 7 students have signed up. The plan is that it should be given every year but if the there are too small number of students this will be changed into every second year. There is no upper limit to how many students that can take the course.

Contact person: Anders Karlsson (anders.karlsson@eit.lth.se)

http://www.ka.lth.se/kursplaner/11_12%20eng/ETEN15.html

COURSE TITLE: APPLIED SUBATOMIC PHYSICS (FKFN01/FYST18)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: FAFF10 (Atomic and Nuclear Physics with Applications).

For whom: Optional for F4aft, F4, MNAV1. Advanced level (Master students).

By whom: Department of Physics (LU).

Language: English on demand.

When: LTH3

Brief summary of contents:

- Ion beam analysis and AMS.
- Neutron Physics, neutron scattering with applications like ESS
- Theory of fission reactors
- Medical and technical applications of nuclear physics.

Course overlap with FKF032 and FKF065.

Approximately 20 students attend. The course is a collaboration between the Faculty of Science and the Faculty of Engineering.

Contact persons: Jan Pallon (Jan.Pallon@pixe.lth.se), Mikael Elfman (Mikael.Elfman@nuclear.lu.se)

http://mimer.kanslimn.lu.se/kursplanering/faststalldakursplaner/Dokumentbibliotek6/1/Kursplaner%20Fysik/Avancerad%20niva/FYST18%20Till%C3%A4mpad%20subatom%C3%A4r%20fysik%207,5%20hp.pdf

COURSE TITLE: NUCLEAR REACTOR PHYSICS (FKFN10/FYST44)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: FKFN01 (Applied Subatomic Physics).

For whom: Master students, part of specialization "Accelerators – physics and technology"

By whom: Department of Physics (LU).

Language: English on demand.

When: LTH4

Brief summary of contents:

- Neutron physics and neutron scattering with relevance for reactor physics.
- Theory of fission reactors, core design, reactor dynamics and fuel optimization.
- Radiation monitoring and instrumentation for neutron monitoring as well as monitoring and analyses of emissions of radioactive particles and gases.
- Introduction to safety and risk analyses for large complex facilities.

Approximately 20 students attend. Can be cancelled if the number of students is less than 8.

Contact person: Jan Pallon (Jan.Pallon@pixe.lth.se)

http://mimer.kanslimn.lu.se/kursplanering/faststalldakursplaner/Dokumentbibliotek6/1/Kursplaner%20Fysik/Avancerad%20niva/FYST44%20-%20Reaktorfysik.pdf

COURSE TITLE: ATOMIC AND MOLECULAR SPECTROSCOPY (FAF080)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: FYSA31 (Particle Physics, Cosmologi and Accelerators). FAFA10 (Quantum Phenomena and Nanotechnology) is recommended.

For whom: Optional for F4, F4es, F4f, F4mt, MFOT1, MNAV1, N5m, N4nf. Advanced level (Master students).

By whom: Department of Physics (LU).

Language: English on demand.

When: LTH1

Brief summary of contents:

- Review of atomic and molecular structure.
- Radiative and scattering processes.
- Spectroscopy of inner electrons.
- Optical spectroscopy and resonance methods.
- Tuneable lasers, laser spectroscopy and applications.
- Demonstrations: Synchrotron radiation, NMR, ultrafast spectroscopy, laser-radar, coherent Raman spectroscopy in combustion diagnostics, astro-physical applications.

Number of students is around 20-40 and there is no upper limit. The course may be cancelled if the number of students is less than 8.

Contact person: Cleas-Göran Wahlström (cleas-goran.wahlstrom@fysik.lth.se)

http://www.ka.lth.se/kursplaner/11_12%20eng/FAF080.html

COURSE TITLE: EXPERIMENTAL X-RAY PHYSICS (MAXM04)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: MAXM06, MAXM07 and MAXM11

For whom: Master students

By whom: Is given by KU but within a master program at LU. This course is identical to the KU course by the same name.

Language: English on demand.

When: LU4a+LU4b

Brief summary of contents:

- Basic interaction between x-ray radiation and materials going from Thomson scattering from free electrons to the classical reciprocal space description of scattering from crystal
- Discussion on new x-ray sources and the development of modern x-ray optics using the refractive properties of materials
- Discussions of applications of X-rays will include the Extended X-ray Absorption and phasing of structure factors using anomalous scattering
- The exercises will contain a discussion of detectors and anode x-ray sources as well as x-ray reflectometry
- Exercises at MAXlab in Lund

This course is problematic due to the tuition fees that Swedish students are charged at KU. At present, only very few students take the course.

Contact person: Sverker Werin (sverker.werin@maxlab.lu.se)

COURSE TITLE: FRONTIERS OF SCIENCE (MAXA01)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: 30 ECTS in natural science (any subject within the field of natural science).

For whom: Bachelor students. Optional within a bachelor of science and is also given as a single-subject course.

By whom: MAX-Lab, Department of Physics (LU).

Language: English on demand.

When: Starts both during the spring and the fall and continues during two semesters (1 year).

Brief summary of contents:

- There is no description. The students take part in the work of a research group who work at MAX-lab. Once a week during 2 semesters the students meet with the research group and every second week they also take part in seminars and discussions

Approximately 6 students take the course and the maximum number is limited to 20 due to limitations in available contacts with research groups.

Contact person: Bent Schröder (Bent.Schroder@nuclear.lu.se)

http://mimer.kanslimn.lu.se/kursplanering/faststalldakursplaner/Dokumentbibliotek10/1/Kursplaner%20Synkrotronljusbaserad%20vetenskap/Grundniv%C3%A5/MAXA01%20Vetenskapens%20frontlinjer%207,5%20hp.pdf

COURSE TITLE: INTRODUCTION TO SYNCHROTRON RADIATION BASED SCIENCE (MAXM06)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: Three years of undergraduate studies in natural sciences.

For whom: Master students. Compulsory in a Master of Science with a major in Synchrotron Radiation Based Science and is given also as a single subject course.

By whom: MAX-Lab, Department of Physics (LU).

Language: English

When: LU1a+LU1b

Brief summary of its content:

- Orientation on the construction and function of a storage ring
- Orientation on vacuum technology
- Survey of main areas of Synchrotron Radiation Research
- Orientation on other VUV light sources, on applications of free electron lasers and on applied and industrial research related to Synchrotron Radiation
- The history of Synchrotron Radiation Research

Approximate number of students: 5-10

Contact person: Sverker Werin (sverker.werin@maxlab.lu.se)

http://mimer.kanslimn.lu.se/kursplanering/faststalldakursplaner/Dokumentbibliotek10/1/Kursplaner%20Synkrotronljusbaserad%20vetenskap/Avancerad%20niv%C3%A5/MAXM06%20Introduktion%20till%20Synkrotronljusvetenskap%207,5%20hp.pdf

COURSE TITLE: INTRODUCTION TO ACCELERATORS AND FEL (MAXM07)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: Bachelor´s degree in natural science.

For whom: Master students. Compulsory in a Master of Science with a major in Synchrotron Radiation Based Science and is given also as a single subject course.

By whom: MAX-Lab, Department of Physics (LU).

Language: English.

When: LU1a+LU1b

Brief summary of contents:

- Focus on basic technology of accelerators, different accelerators and their working principles are described
- An overview of accelerators use in research, medicine and industry
- Basic understanding of free electron lasers and different types of FELs
- Basic physical methods relevant for accelerators and FELs
- Layout, operation and safety in an accelerator laboratory

Approximate number of students: 5-10.

Contact person: Sverker Werin (sverker.werin@maxlab.lu.se)

http://mimer.kanslimn.lu.se/kursplanering/faststalldakursplaner/Dokumentbibliotek10/1/Kursplaner%20Synkrotronljusbaserad%20vetenskap/Avancerad%20niv%C3%A5/MAXM07%20Introduktion%20till%20acceleratorer%20och%20frielektronlaser%207,5%20hp.pdf

COURSE TITLE: SCATTERING METHODS (EXTN85)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: Compulsory courses in mathematics and fundamental courses in physics and/or chemistry, minimum 90 ECTS in total are needed.

For whom: Master students. Optional for a degree of Master of Science in chemistry and compulsory for a degree of Master of Science in Organizing Molecular Matter. Is also given as a single-subject course. Advanced level.

By whom: Department of Chemistry (LU).

Language: English on demand.

When: LU4a+ LU4b

Brief summary of contents:

- Basic scattering theory and derivation of the scattering from a dispersion of spherical colloidal particles
- Presentation of different experimental methods such as SANA (small angle neutron scattering), SAXS (small angle X-ray scattering) and static and dynamic light scattering

Approximate number of students: 10-15

Contact person: Ulf Olsson (ulf.olsson@fkem1.lu.se)

http://www.ka.lth.se/kursplaner/11_12%20eng/EXTN85.html

COURSE TITLE: APPLICATIONS OF NEUTRON AND X-RAY SCATTERING IN BIOLOGY, CHEMISTRY AND PHYSICS

Credits: 5 or 7.5 ECTS

Prerequisites/Entrance qualifications: B.Sc. or equivalent

For whom: Master students

By whom: ØMIC, University of Copenhagen, Technical University of Denmark, University of Lund, Roskilde University

Language: English

When: Summer of 2012. Whether the course will be given again is still unknown and depends on alternative funding after the end of ØMIC

Brief summary of contents:

- Introduction to the scientific concepts, e.g. biological matter, materials chemistry, soft matter and hard condensed matter
- Intuitive overview of basic scattering
- X-ray and neutron production/facilities
- Scattering methods including examples from science
- Problem solving and virtual experiments
- Hands-on experiments including proposal writing, data analysis and presentation of data

Maxmum number of students: 24

Contact persons: Kim Lefmann (KU), tel. 35 32 04 76, office: HCØ, D314, e-mail lefmann@fys.ku.dk, Poul Norby (DTU), Tomas Brage (LU)

COURSES WHICH HAVE A GENERAL FOCUS AND THAT TO A MINOR EXTENT FOCUS ON NEUTRONS AND/OR PHOTONS FOR SCIENCE AND TECHNOLOGY

COURSE TITLE: PARTICLE PHYSICS, COSMOLOGY AND ACCELERATORS (EXTF85/FYSA31)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: FAFF10 (Atomic and Nuclear Physics with Applications).

For whom: Optional for F4aft and F4. Upper basic level (Bachelor students).

By whom: Department of Physics (LU).

Language: English on demand.

When: Twice a year, in LU2a+LU2b and LU4a+LU4b

Brief summary of contents:

- An overview of elementary particles and their interactions (including electromagnetic, weak and strong forces and its mediators)
- Feynman diagrams
- Introduction to particle physics standard model and possible theories beyond this model
- Higgs mechanism
- Orientation of the research frontier in high energy physics
- Methods and principles of high energy physics experiments
- Principles of acceleration, mainly synchrotron and linear accelerator and storage of particle beams
- Examples from subatomic physics front line, including studies relevant for MAX and ESS

Due to overlapping content, this course cannot be included in a degree together with EXTF05 (Particle physics and cosmology) and FKF050 (Particle Physics). The number of students varies depending on if it is given during the spring or fall. During the fall the number of students is less, around 25, and during the spring more, around 40. The number of students is limited by the space in the laboratory and the maximum number is around 45-50 students.

Contact person: Else Lytken (else.lytken@hep.li.se)

http://www.ka.lth.se/kursplaner/11_12%20eng/EXTF85.html

COURSE TITLE: MICROWAVE THEORY (ETEN01)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: ETE110 (Modellering och simulering inom fältteori eller Elektromagnetisk fältteori (ETE055, ESS050, ETEF01).

For whom: Optional for E4, E4f, E4hn, F4aft, F4, F4f, F4hn, MFOT1. Advanced level (Master students).

By whom: Electrical and Information Technology (LTH/LU).

Language: English on demand.

When: LTH4

Brief summary of contents:

- Many of the applications that are introduced are from the accelerators which will be used in MAXIV and ESS.
- Wires for transmission (twisted pair, coaxial wire)
- Smith diagram, S-matrix, cavities for resonance, …
- Coupling between accelerating particles and electromagnetic fields
- Optical fibers and components of optics.

Overlapping with ETE091. Can be cancelled when the number of students is below 6. No upper limit to number of students, but usually 15-20 students attend.

Contact person: Anders Karlsson (anders.karlsson@eit.lth.se)

http://www.ka.lth.se/kursplaner/11_12%20eng/ETEN01.html

COURSE TITLE: MODERN SUBATOMIC PHYSICS (FYST16/FYS246)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: FYSA31 Fysik3 Modern Physics (30 ECTS).

For whom: Advanced level (Master students). Optional for Bachelor- and Master of Science students and is also a single subject course.

By whom: Department of Physics (LU).

Language: English on demand.

When: LU4a+LU4b

Brief summary of contents:

- Models and reaction used in contemporary subatomic physics within their proper context are presented (i.e. close connection with actual experiments and projects presently in progress in research groups)
- The topics will range from interactions at low energy via intermediate energies to very high-energy collisions
- Combining information about basic interactions with tools (accelerators, detectors) needed to study them and the models and simulations used to describe/interpret the processes to arrive at a "complete picture"

No restriction in the number of students. Typically around 10-15 attend the course

Contact person: Joakim Cederkall (joakim.cederkall@nuclear.lu.se)

http://mimer.kanslimn.lu.se/kursplanering/faststalldakursplaner/Dokumentbibliotek6/1/Kursplaner%20Fysik/Avancerad%20niva/FYST16%20Modern%20subatom%C3%A4r%20fysik%207,5%20hp.pdf

COURSE TITLE: THE PHYSICS OF AND CHEMISTRY OF SURFACES (TEK177/FYST19)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: FFFF05 (Solid State Physics) or FFFF01 (Electronic Materials).

For whom: Optional for F4aft, F4, F4nf, MNAV1, N5m, N4nf. Advanced level (Master students).

By whom: Department of Physics (LU).

Language: English on demand.

When: LU4a+LU4b

Brief summary of contents:

- Introduction to surfaces and their fundamental importance in physics, chemistry, nanoscience and biology.
- Basic description of surface structure, adsorption, reactions and growth on surfaces (especially how physics and chemistry of the surfaces can differ fundamentally from their 3D counterparts).
- Experimental measurements of surface structure, chemistry and morphology using the following techniques are discussed: STM, AFM, MFM, AES, XPS, LEED, SXRD.
- Surface physics and chemistry at larger facilities such as MAX-lab.

No upper limit to number of students, but usually 20-30 students attend.

Contact person Edvin Lundgren, edvin.lundgren@sljus.lu.se

http://mimer.kanslimn.lu.se/kursplanering/faststalldakursplaner/Dokumentbibliotek6/1/Kursplaner%20Fysik/Avancerad%20niva/FYST19%20Ytors%20fysik%20och%20kemi%207,5%20hp.pdf

COURSE TITLE: ADVANCED MATERIALS TECHNOLOGY (FKM070)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: FKM015 (Materials Engineering, Basic Course)

For whom: Optional for F4, F4bem, M4bem, M4pr, M4pu, MD4, N5m. Advanced level (Master students)

By whom: Materials Engineering (LTH/LU)

Language: English on demand.

When: LU2a+LU2b

Brief summary of contents:

- Crystal structures (stereographic projections and pole figures)
- Phase equilibria, solidification processes, phase diagrams and alloy theory
- Materials characterization using optical and scanning electron microscopy and some other techniques (DTA, DSC, TGA)
- Thermophysical properties
- Diffusion, plastic deformation, creep

Approximate number of students: 40-50.

Contact person: Srinivasan.Iyengar@material.lth.se

http://www.ka.lth.se/kursplaner/11_12%20eng/FKM070.html

COURSE TITLE: POWDER TECHNOLOGY (FKMN05)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: FKM015 (Materials Engineering, Basic Course)

For whom: Optional for I4, M4pr, N5m. Advanced level (Master students).

By whom: Materials Engineering (LTH/LU)

Language: English on demand.

When: Spring term, odd years

Brief summary of contents:

- Metallic and ceramic powders
- Powder characterization, compaction and sintering.
- Powder products and their usage.

Number of students varies significantly - between 5 and 30.

Contact person: Srinivasan.Iyengar@material.lth.se

http://www.ka.lth.se/kursplaner/arets_eng/FKMN05.html

COURSE TITLE: MATERIAL CHEMISTRY (KOO045)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: Fundamental Chemistry (KOO101), Inorganic Chemistry (KOO022), Materials- and Polymer Technology (KOO052).

For whom: Students within the two educational programs K and N at LU/LTH or as an elective course. Advanced level (Master students).

By whom: Chemistry (LTH/LU)

Language: English

When: LTH1

Brief summary of contents:

- Basic knowledge in solid state chemistry, synthesis methods and characterization of crystalline materials.
- Focus on inorganic materials.
- Relationship between atomic structure and physical properties.
- Theoretical and practical parts involving X-ray diffraction.

Approximate number of students: 25.

Additional information: This course is given within two educational programs (K and N).

Contact person: Staffan Hansen (staffan.hansen@polymat.lth.se).

http://www.polymat.lth.se/courses/materials_chemistry/materials_chemistry.html

COURSE TITLE: MATERIALS AND POLYMER TECHNOLOGY/FUNCTIONAL MATERIALS (KOO052/KOO095)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: Fundamental Chemistry (KOO101), Organic chemistry (KOK012) and Inorganic Chemistry (KOO022).

For whom: K3, B4, N2. Advanced level (Master students).

By whom: Chemistry (LTH/LU)

Language: Swedish

When: LTH4

Brief summary of contents:

- Overview of inorganic and polymer materials of technical importance and their applications, from an atomic and a molecular perspective.
- Crystal structures, dislocations, defects and diffusion.
- Strengthening of metals and binary phase diagrams.
- Processing and rheology of polymers.

Approximate number of students: 80.

Additional information: This course is given within two educational programs (K and N).

Contact persons: Staffan Hansen (staffan.hansen@polymat.lth.se) and Patric Jannasch (patric.jannasch@polymat.lth.se)

http://www.polymat.lth.se/courses/mat_func/mat_func.html

COURSE TITLE: MATERIALS ANALYSIS AT THE NANOSCALE (KOO105)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: General and inorganic chemistry (KOKA01) and Organic chemistry (KOKA05) or fundamental chemistry (KOO101).For whom: Optional for I4, M4pr, N5m. Advanced level (Master students).

By whom: Chemistry (LTH/LU)

Language: English on demand.

When: LTH2

Brief summary of contents:

- Overview of solid state micro analysis methods
- Electron microscope as an analytical tool.
- Identification of phases by morphology chemistry composition, electron diffraction and high resolution TEM.
- SEM, XEDS, EELS, AFM, STM, LEED, XPS and synchrotron based analysis in general.

Approximate number of students: 60.

Additional information: This course is given within the educational program N at LU/LTH. It is possible for students also not taking the N program to take the course. However, there are strict prerequisites/entrance qualifications as the students in general have a hard time following the course when they haven't followed the program.

Contact person: Reine Wallenberg (reine.wallenberg@polymat.lth.se).

http://www.polymat.lth.se/courses/nanoanalys/nanoanalys.html

COURSE TITLE: MICROSCOPIC CHARACTERIZATION OF MATERIALS (KOO065)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: Materials Analysis at the Nanoscale (KOO105 or equivalent).

For whom: Students within the educational programs N and K at LU/LTH.. Advanced level (Master students).

By whom: Chemistry (LTH/LU)

Language: English on demand.

When: LTH4

Brief summary of contents:

- Elastic and inelastic scattering.
- Magnetic lenses.
- Principles and functions of different types of electron microscopes (TEM, SEM).
- Spectrometers for element analysis, XEDS and EELS.
- Identification and quantification of spectra.
- Biological sample preparation and imaging techniques.

Approximate number of students: 12.

Additional information: This course is given within the educational programs N and K at LU/LTH and 12 students can take it each time. Usually the course is filled with the students from the programs and students outside the programs can therefore usually not take the course.

Contact person: Reine Wallenberg (reine.wallenberg@polymat.lth.se).

http://www.polymat.lth.se/courses/microchar/micro.html

COURSE TITLE: STRUCTURAL BIOINFORMATICS (KEMM15)

Credits: 15 ECTS

Prerequisites/Entrance qualifications: 90 ECTS in Science courses including (or equivalent courses): General and Analytic Chemistry (KEMA00), Organic chemistry and inorganic chemistry (KEMA01 + KEMA02), Biochemistry (KEMA03) and Chemistry of the Cell (MOBA02).

For whom: Advanced level (Master students).

By whom: Chemistry/Biochemistry and structural biology (LU)

Language: English

When: LU2a+LU2b

Brief summary of contents:

- Three dimensional structure, stability, interaction and dynamics of proteins.
- Theoretical knowledge and practical experience of X-ray crystallography, including the use of synchrotrons (site visit to MAX-lab).
- Relationship between enzymes and enzyme complex structures and how they function and basic principles that govern interaction between proteins.
- Electronic databases and computer-based tools for analyzing protein sequences and structures.

Approximate number of students: 25-30.

Additional information: The course is included in the master program at the Center for Molecular Protein Science.

Contact person: Derek Logan (Derek.Logan@biochemistry.lu.se)

http://www.kemi.lu.se/utbildning/avancerad/kemm15/

EDUCATIONAL PROGRAMS WHICH HAVE A SPECIALIZATION ON NEUTRONS AND/OR PHOTONS

PROGRAM LEVEL AND TITLE: BACHELOR´S PROGRAM IN PHYSICS, "NATURVETENSKAP MED FOTONER OCH NEUTRONER"

English title: Science with photons and neutrons

The program is a specialization, where the first two years of coursework are identical to the B.Sc. in physics. The third year offers specialized courses on scattering, atomic and solid state physics, photons and neutrons and spectroscopy.

Additional information: 1st year is in Swedish.

http://www.naturvetenskap.lu.se/o.o.i.s?id=9719&lukas_id=NGNAT.FONE

PROGRAM LEVEL AND TITLE: MASTER´S PROGRAM IN PHYSICS, SYNCHROTRON RADIATION PHYSICS.

Prerequisites: a B.Sc. in Physics, Physical Chemistry, Engineering Physics or Engineering Nanoscience.

The program consists of the following 7 courses (7.5 ECTS each) and a master's thesis:

- Photons and neutron production for science
- Introduction to synchrotron radiation based science
- Introduction to accelerators and free-electron lasers
- Experimental methods and instrumentation for synchrotron radiation based science
- Project in synchrotron radiation based science
- Accelerators and free-electron lasers
- Accelerators, particles and fields

Additional information:

http://www.naturvetenskap.lu.se/o.o.i.s?id=9722&lukas_id=NASLV

http://www.edu.physics.lu.se/masters

PROGRAM LEVEL AND TITLE: ENGINEERING PHYSICS WITH SPECIALIZATION IN "ACCELERATORS – PHYSICS AND TECHNOLOGY

This is a specialization under the Engineering Physics program. The students are encouraged to choose their elective courses among a list of relevant courses from LU Physics and LTH.

Additional information:

http://www.student.lth.se/tekniskfysik/specialiseringar_f/acceleratorer_fysik_och_teknik

APPENDIX D: COURSES AND EDUCATIONAL PROGRAMS AT DTU.

DTU, Technical University of Denmark was founded in 1829 by H.C. Ørsted – the father of electromagnetism. DTU is dedicated to fulfilling his vision to develop and create value using the natural sciences and the technical sciences to benefit society, and is ranked as one of the foremost technical universities in Europe.

Risø DTU contributes to research, development and international exploitation of sustainable energy technologies and strengthens economic development in Denmark.

The international dimension is of vital importance to DTU. In 2010, DTU welcomed 410 international students into their MSc programs, half of their PhD students are recruited from abroad, and more than one third of their scientific staff are highly qualified researchers of international backgrounds.

More comprehensive information is given at http://www.dtu.dk

Course plans can be found at: http://www.kurser.dtu.dk/search.aspx

COURSES WHICH FOCUS TO A GREATER EXTENT ON NEUTRONS AND/OR PHOTONS FOR SCIENCE AND TECHNOLOGY

COURSE TITLE: 45209 X-RAY AND NEUTRON EXPERIMENTS AT INTERNATIONAL RESEARCH FACILITIES

Credits: 5 ECTS

Prerequisites/Entrance qualifications: 01005: Advanced Engineering Mathematics 1, 10020: Physics 1/10033: Mechanics and Physical Modeling,,10036: Electromagnetism for physicists or similar courses

For whom: Bachelor students

By whom: Risø DTU, National laboratory for Sustainable Energy

Language: Danish

When: June, 3 weeks

Brief summary of contents:

- Theory of scattering and absorption of X-ray and neutron beams.
- Chrystal diffraction, Powder diffraction, Small angle scattering, Tomography.
- Applications in nanoscience / nanotechnology, materials science and sustainable energy.
- Overview of applications with laboratory sources and large facilities.
- Selected laboratory exercises and simulations of experiments.
- Neutron scattering experiments at a neutron spallation source facility at the Paul Scherrer Institute near Villigen, Switzerland
- X-ray scattering experiments at the synchrotron at MAXLAB, Lund, Sweden

6-12 students allowed

Contact persons: Poul Norby, 229, 120, (+45) 4677 4726, pnor@risoe.dtu.dk. Martin Meedom Nielsen, 228, mmee@risoe.dtu.dk

http://www.kurser.dtu.dk/45209.aspx?menulanguage=da

COURSE TITLE: 26322 CRYSTAL STRUCTURE ANALYSIS

Credits: 5 ECTS

Prerequisites/Entrance qualifications: 26000/26171/26027 General Chemistry

For whom: M.Sc. students

By whom: Department of Chemistry

Language: English

When: 3-week period, June

Brief summary of contents:

- Theory of X-ray scattering from crystals
- Single crystal diffractometry
- Theory of crystal structure determination
- Phase identification by powder diffraction
- Use of structural databases and internet resources
- Experimental work including crystal mounting and X-ray work
- To enlighten the theory a project inclusive of structure determination and structure analysis is carried out on selected compounds (e.g. zeolites, carbohydrates or coordination compounds)
- Tour to X-ray synchrotron in Lund

5-12 students allowed

Kenny Ståhl, 206, 202, (+45) 4525 2019, kenny@kemi.dtu.dk

http://www.kurser.dtu.dk/26322.aspx?menulanguage=en-gb

COURSE TITLE: 26912 THE RIETVELD METHOD AND X-RAY POWDER DIFFRACTION

Credits: 5 ECTS

Optional prerequisites/Entrance qualifications: 26320 Structural and Solid State Chemistry/26322 Crystal Structure Analysis

For whom: PhD students

By whom: Department of Chemistry

Language: English

When: Spring, does not follow normal DTU schedule

Brief summary of contents:

- X-rays
- General diffraction theory
- Powder diffraction
- Data collection strategies
- Least-squares method
- Rietveld method
- Refinement strategies
- Particle size and defects
- Quantitative analysis
- Practical exercises in sample preparation, data collection, data handling, crystal structure refinements and reports

5-10 students allowed

Kenny Ståhl, 206, 202, (+45) 4525 2019, kenny@kemi.dtu.dk

http://www.kurser.dtu.dk/26912.aspx?menulanguage=en-gb

COURSE TITLE: APPLICATIONS OF NEUTRON AND X-RAY SCATTERING IN BIOLOGY, CHEMISTRY AND PHYSICS

Credits: 5 or 7.5 ECTS

Prerequisites/Entrance qualifications: B.Sc. or equivalent

For whom: Master students

By whom: ØMIC, University of Copenhagen, Technical University of Denmark, University of Lund, Roskilde University

Language: English

When: Summer of 2012. Whether the course will be given again is still unknown and depends on alternative funding after the end of ØMIC

Brief summary of contents:

- Introduction to the scientific concepts, e.g. biological matter, materials chemistry, soft matter and hard condensed matter
- Intuitive overview of basic scattering
- X-ray and neutron production/facilities
- Scattering methods including examples from science
- Problem solving and virtual experiments
- Hands-on experiments including proposal writing, data analysis and presentation of data

Maxmum number of students: 24

Contact persons: Kim Lefmann (KU), tel. 35 32 04 76, office: HCØ, D314, e-mail lefmann@fys.ku.dk, Poul Norby (DTU), Tomas Brage (LU)

COURSES WHICH HAVE A GENERAL FOCUS AND THAT TO A MINOR EXTENT FOCUS ON NEUTRONS AND/OR PHOTONS FOR SCIENCE AND TECHNOLOGY

COURSE TITLE: 45204 PH.D. COURSE IN RECENT DEVELOPMENTS IN MATERIALS RESEARCH

Credits: 2.5

Prerequisites/Entrance qualifications: 41652 Metals Technology (theory and practicals), M.Sc. in or Engineering, Physics, Chemistry or Mathematics

For whom: PhD- Construction, Production, Civil Engineering and Transport, Mathematics, Physics and Informatics

By whom: National Laboratory for Sustainable Energy

Language: English

When: S2 (spring 2012, 13 weeks, 2 hours/week)

Brief summary of contents:

- The PhD students will prepare a lecture and give a presentation on their own research project.
- Introduction to the scientific publishing process and the peer-reviewing system.
- The content depends on the invited guests and the interests of the PhD students
- Subjects within materials science and different types of materials, such as thermo-mechanical treatment of metals (plastic deformation, annealing, synthesis of nanostructures, testing and failure, composites, superconducting materials, energy storage)
- Characterization techniques (electron microscopy, X-ray and neutron diffraction)

Approximate number of students: 10-12.

Contact person Wolfgang Pantleon, National Laboratory for Sustainable Energy, Risø DTU 228, 028, (+45) 4677 5791, pawo@risoe.dtu.dk

http://www.kurser.dtu.dk/45204.aspx?menulanguage=en-gb

COURSE TITLE: 10313 MAGNETISM AND MAGNETIC MATERIALS

Credits: 10 ECTS

Optional Prerequisites/ Optional Entrance qualifications: 10303 Condensed Matter Physics and Nanoscale Materials Physics, Solid state physics.

For whom: Master Students

By whom: Department of Physics, Department of Micro and Nanotechnology, Center for Electron Nanoscopy at DTU. Niels Bohr Institute / Nanophysics at Copenhagen University

Language: English

When: S2

Brief summary of contents:

- Magnetic moments in solids, magnetic interaction, magnetic ordering, ferromagnetism, ferrimagnetism and antiferromagnetism, magnetic model systems, magnetic domains, magnetic nanoparticles and low-dimensional systems, magnetic materials, nuclear magnetism, NMR, magnetization measurements
- Mössbauer spectroscopy, neutron scattering, magnetic force microscopy, electron holography, and magneto caloric effect

Approximate number of students: Together with the KU course (7.5 ECTS), about 20-25 students, half from each institution.

The course is given in collaboration with The University of Copenhagen (KU). Teaching takes place at both KU and DTU.

Contact persons at DTU: Cathrine Frandsen, 307, 126, (+45) 4525 3167, fraca@fysik.dtu.dk, Jørn Bindslev Hansen, 309, 058, (+45) 4525 3242, jbh@fysik.dtu.dk, Mikkel Fougt Hansen, 344, 110, (+45) 4525 6338, mikkel.hansen@nanotech.dtu.dk, Marco Beleggia, 307, 120, (+45) 4525 3147, mb@cen.dtu.dk. Contact person at RISØ-DTU: Luise Theil Kuhn, luku@risoe.dtu.dk. Contact persons at University of Copenhagen: Kim Lefmann, lefmann@fys.ku.dk, Brian Møller Andersen, bma@fys.ku.dk

http://www.kurser.dtu.dk/10313.aspx?menulanguage=en-gb

COURSE TITLE: 26325 PROTEIN CRYSTALLOGRAPHY

Credits: 5 ECTS

Prerequisites/Entrance qualifications: 01005 Mathematics 1, 26000 General Chemistry, 10022 Physics 1, 12001 Introduction to bio, chemical and environmental engineering, 26400 Organic chemistry 1, 26201/26202 introductory physical chemistry

For whom: Master students

By whom: Department of Chemistry

Language: English

When: S2

Brief summary of contents:

- Primary, secondary, tertiary and quaternary structure
- Symmetry operations, crystal systems and space group notation
- Experimental work with crystallization and test of crystal quality
- Solving protein structures using different methods
- Use of data bases
- Structure validation and article reading

5-12 students allowed

Contact person; Pernille Harris, 206, 210, (+45) 4525 2024, ph@kemi.dtu.dk

http://www.kurser.dtu.dk/26325.aspx?menulanguage=en-gb

COURSE TITLE: 10303 CONDENSED MATTER PHYSICS AND NANOSCALE MATERIALS PHYSICS

Credits: 10 ECTS

Prerequisites/Entrance qualifications: 10102/10110/10111 Quantum Mechanics

For whom: Bachelor students

By whom: Department of Physics

Language: Danish

When: S1

Brief summary of contents:

- Crystal lattices, reciprocal space, and X-ray diffraction
- Phonons, heat capacity, heat conduction, and anharmonic effects
- Electronic structure, free-, nearly-free-, and tight-binding models
- The diatomic molecule, metallic binding, and the Friedel model
- Boltzmann's equation, transport theory and optical properties of metals and semiconductors
- Semiconductor nanostructures: Quantum wells, wires and dots
- Itinerant magnetism and mean-field approximation

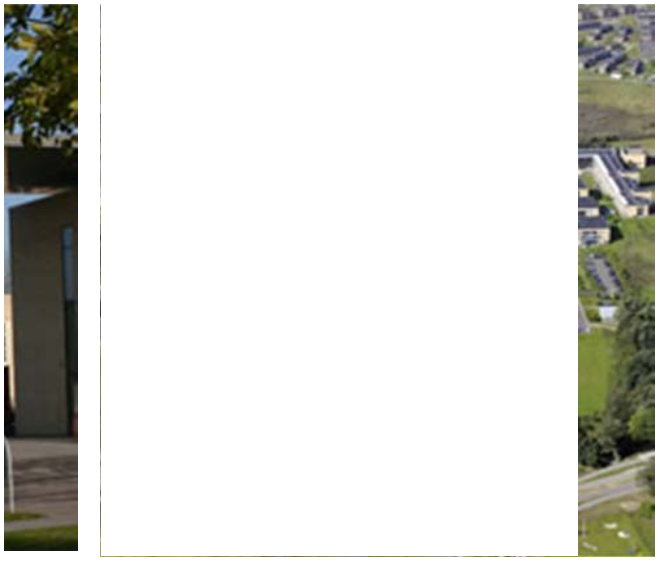
No student limit. Approximate number of students: 50.

Contact persons: Jørn Bindslev Hansen, 309, 058, (+45) 4525 3242, jbh@fysik.dtu.dk
Jakob Schiøtz, 307, 249, (+45) 4525 3228, schiotz@fysik.dtu.dk

http://www.kurser.dtu.dk/10303.aspx?menulanguage=en-gb

APPENDIX E: COURSES AND EDUCATIONAL PROGRAMS AT RUC

RUC has more than 9500 students and is thus the fifth-largest university in Denmark. RUC was founded as the Roskilde University Centre, but 'Centre' was dropped from its name in 2008, and the institution became simply Roskilde University.



The most important task of Roskilde University is to contribute to experimental, innovative forms of learning and knowledge creation. RU can be said to have brought to Denmark the Anglo-Saxon concepts of interdisciplinary and less well-defined boundaries between academic fields.

More comprehensive information is given at http://www.ruc.dk

Course plans can be found at: http://kursus.ruc.dk/view/all

COURSES WHICH HAVE A GENERAL FOCUS AND THAT TO A MINOR EXTENT FOCUS ON NEUTRONS AND/OR PHOTONS FOR SCIENCE AND TECHNOLOGY

COURSE TITLE: APPLIED PHYSICS (U23407)

Credits: 7.5 ECTS

Prerequisites/Entrance qualifications: B.Sc. in Physics

For whom: Master students, optional

By whom: RUC, Department of Science, Systems and Models

Language: Danish or English

When: January 2012

Brief summary of contents:

- Computer Simulation, "Random Walk and Diffusion", with application development. Statistical mechanics - Monte Carlo simulation. The Ising model in two and three dimensions
- Response functions and linear network with transducers. Piezoelectric measuring cells (transducer). Calibration of the transducer and measuring the compressibility for a simple fluid with it
- Thermal analysis. Network Modelling of the thermal system. Thermal impedance through the 3ω method (based on Fourier analysis). Air heat conductivity and specific heat of glass. Cryo and vacuum technology
- X-ray structure analysis, safety in the laboratory, detection of electromagnetic radiation, data analysis, counting statistics
- Orientation and training in machine workshop

Approximate number of students: 4-8. The course can take up to about 12 students.

Additional information: Contact persons: Tine Nyegaard Pedersen (tinenp@ruc.dk), Bo Jakobsen (boj@ruc.dk)

http://kursus.ruc.dk/class/view/1599

COURSE TITLE: MOLECULAR BIOPHYSICS
Credits: 10 ECTS

Prerequisites/Entrance qualifications: PhD student

For whom: Optional

By whom: SDU, RUC, KU (NBI+Life), AU, LU

Language: English

When: Fall semester 2010, spring semester 2012

Brief summary of contents:

- The course is cross-disciplinary and cross-institutional and will be given by a series of lecturers who are experts within each their subfield of biophysics. The coherence of the course is assured by emphasizing the molecular basis of modern biophysics
- The course will take place at different institutions in order to expose the students to different research groups and their researchers and experimental research facilities
- The course will thus give the student a unique opportunity of orienting himself or herself within an active and diverse field of cross-disciplinary science
- Topics covered:
- Proteins, lipids, membranes, DNA, enzymes, receptors, transport, permeability, photoactivity, electrostatics, scattering theory, thermodynamics, forces in biological systems, light-, neutron- and X-ray scattering, magnetic resonance, protein folding, calorimetry, (confocal) fluorescence microscopy and spectroscopy, molecular modeling and simulation, mechanical spectroscopy, optical tweezers, micromechanics, atomic-force microscopy, single-molecule techniques, and ellipsometry/neutron reflectometry, electrophysiology.

Approximate number of students: 30.

The course takes place at different institutions.

Contact person: Mathias P. Clausen mpc@memphys.sdu.dk

http://www.memphys.sdu.dk/graduateschool/courses.php

COURSE TITLE: METHODS IN SOFT MATERIALS SCIENCE
Credits: 12 ECTS (Corresponds to 40% of a semester's workload)

Prerequisites/Entrance qualifications: PhD students, particularly in the program "Soft and Biomolecular Matter"

For whom: PhD students

By whom: RUC, DTU, KU

Language: English

When: Given every second year. Last time December 2010-February 2011, next time December 2012-February 2013.

Brief summary of contents:

- Random Walks and Diffusion
- Presentation of the participants Ph.D. projects
- Computer Simulations
- Applications of NMR
- Static and Dynamic Light Scattering
- Small Angle Scattering
- Rheology
- Spectroscopy of Ordered Systems
- Molecular characterization methods
- Calorimetric Methods
- Applications of above Methods to participants Ph.D.-projects

Approximate number of students: 10-20.

Contact person at Roskilde University; Jeppe Dyre, dyre@ruc.dk

http://magenta.ruc.dk/upload/application/pdf/f51d6748/phd_soft2011.pdf

http://akira.ruc.dk/~poulerik/Graduate%20Programme%20Soft%20and%20Biomolecular%20matter.htm

APPENDIX F

Table F1 lists some recent or on-going student projects from universities in the Øresund Region. The projects listed all contain neutron and X-ray based science, and most/all(?) of them involved experiments at a large research facility.

The list is not exhaustive or up-to-date with the newest projects, but is merely included to give some examples from the large number of projects available. The list is ordered by research group to give some inspiration for students about whom to go to for future projects. In order to keep table F1 short, the descriptions of the projects are given in the following table F2.

Table F1:

Supervisor/ University	Year	Proj. type	Facility	Student(s)	Title	Description (TabF2)
Kim Lefmann/ KU	2011	B.Sc. thesis	ILL (including molecular dynamics simulations and old data)	Henrik Jacobsen	Spin dynamics of hematite nanostructures	1)
Kim Lefmann/ KU	2009	M.Sc. thesis	PSI	Jacob Larsen	Quantum phase transition in the near-Ising antiferromagnet CoCl2.2D2O	2)
Kim Lefmann/ KU	2009 - 2013	PhD	(visits to) ESS, J-PARC, SNS, ILL, PSI, ISIS	Kaspar Klenø	Simulation of instruments for the ESS	3)
Kim Lefmann/ KU	2010 - 2013	PhD	PSI, FRM2 (and analytical calculations)	Astrid Tranum-Rømer	Magnetism in superconductors	4)
Poul Norby, Rune Johnsen/ DTU	2012	M.Sc. course	Maxlab	Anders Westergaard Jensen	In situ studies of materials for lithium batteries	5)
Peter Holtappel, Poul Norby, Søren Højgård Jensen/ DTU	2011 -	PhD	ESRF, Maxlab	Ane Sælland Christensen	Development and characterization of advanced lithium batteries	6)
Tejs Vegge, Poul Norby, Mogens Mogensen/	2011 -	PhD	ESRF, Maxlab, ILL, FRM-II	Daði Þ. Sveinbjörnsson	In situ characterization of structure and transport in battery electrolytes and electrodes	7)

DTU						
Kenny Ståhl/DTU	2012	M.Sc. thesis	MAX II	Jonas Andersen	In situ spectroscopic studies of chromium catalysts in ionic liquids	8)
Kenny Ståhl/DTU	2012	M.Sc. thesis	MAX II	Bastian Brink	Ordering phenomena of carbon and nitrogen in iron based systems investigated by X-ray synchrotron methods	9)
Kenny Ståhl/DTU	2012	PhD	MAX II	Christian Grundahl Frankær	Characterization of metalloproteins and biomaterials by X-ray absorption spectroscopy and X-ray diffraction	10)
Kenny Ståhl/DTU	2012	M.Sc. thesis	MAX II	Jonas Andersen	In situ spectroscopic studies of chromium catalysts in ionic liquids	11)
Heloisa Bordallo/ KU, Markus Strobl /ESS	2011 -	PhD	(ESS), ISIS, ILL, PSI, HZB. Planned exp in JP+USA	Johan Jacobsen	Dental cement	12)
Marité Cardenas /KU, Hanna Wacklin /ESS	2011 -	PhD	(ESS), ILL, ISIS	Tania Kjellerup Lind	Nanodrug Reflectometry	13)
Richard Hall Wilton /ESS, Stefan Kröll /LU	2012 -	PhD	(ESS)	NN	Detectors	14)
Arno Hiess /ESS, Dimitri Argyriu /ESS, Tommy Nylander /LU	2008 - 2012	PhD	(ESS)	S. Ossowski	Milk Proteins	15)
Rami Sankari, Ralf Nyholm/ LU	2011	PhD	MAX IV laboratory	Walan Grizolli	X-ray optics and analysis for low emittance synchrotron light sources	16)
Rami Sankari, Ralf Nyholm/ LU	2011	PhD	MAX IV laboratory	Christian Stråhlman	Timing based instrumentation and research in the soft-X-ray region.	17)
Sverker Werin, Francesca Curbis / LU	2011	PhD	MAX IV laboratory	Olivia Karlberg	Linear accelerator and short pulses	18)
Erik Wallén, Lars	2011	PhD	MAX IV laboratory	Galina Skripka	Electromagnetic Fields	19)

Malmgren, Anders Karlsson / LU						
Åke Andersson, Simon Leeman / LU	2011	PhD	MAX IV laboratory	Jonas Breunlin	Emittance diagnostics in electron storage rings	20)
Dorthe Posselt, RUC	2011	B.Sc. thesis	BW4 Hamburg	Mikkel Hartmann Troels Vejen Christensen	SAXS undersøgelse af sammenhæng mellem nanostrukturen og elastiske egenskaber af træ svejset med forskellig orientering af træårerne	21)
Dorthe Posselt RUC	2011	M.Sc. thesis	RUC SAXS ILL D22	Kasper Swiatek	Undersøgelse af vækstbevirkede strukturændringer af planters tylakoidsystem ved brug af småvinkelrøntgen-spredning, absorptions-spektroskopi og elektronmikro-skopi.	22)
Dorthe Posselt, RUC	2007	M.Sc. thesis	SANSII PSI RUC SAXS	Anders Lund	A study of n-alcohol alkyl chain length dependent structural perturbations of unilamellar 1,2-Dimyristoyl-sn-Glycero-3-Phosphocholine (DMPC) vesicle	23)
Dorthe Posselt RUC	2007	M.Sc. thesis	RUC SAXS	Thomas Hecksher Bitten Plesner	A characterization of the alcohol-induced structural changes of unilamellar dipalmitoyl-phosphatidylcholine (DPPC) vesicles	24)
Dorthe Posselt RUC	2004	PhD	RUC SAXS Budapest BNC SANS	Jens K. Holm	Structure and structural flexibility of chloroplast thylakoid membranes	25)

Table F2: project descriptions

1)	Spin excitations were studied in hematite nanoparticles and nano-porous hematite using inelastic neutron scattering. The results were understood in terms of analytical theory and detailed numerical modeling. The nano-porous material display properties in between those of

	the bulk mineral and the nanoparticles.
2)	The magnetic structure and dynamics was studied at a model system for the Ising chain magnet CoCl2.2D2O in an applied transverse field. It was found that the material approached the quantum phase transition expected for this type of system, but that the critical field was about 16 T, slighty higher than the 15 T available.
3)	A number of proposed instruments for the ESS have been simulated using the package McStas. The use of the instrument types have been assessed as a function of the length and frequency of the neutron pulses. In addition, the delivery of neutrons to the samples by neutron guide systems have been systematically studied in order to optimize guide geometry and cost.
4)	The magnetic order and fluctuations in the high-temperature superconductor LSCO has been studied by neutron scattering and theoretical modeling. The emphasis has been put on dopings near the anomalous 1/8-phase, where magnetism is seen to be enhanced and superconductivity suppressed. The goal is to elucidate the integuing coupling between superconductivity and magnetism in the cuprate superconductors.
5)	Development and construction of a capillary based in situ cell for synckrotron X-ray diffraction studies of lithium battery materials. Participation in *in situ* experiments performed at the Maxlab synchrotron in Lund. Specific focus on LiFePO4 as a cathode material.
6)	New cathode materials for lithium batteries are developed and tested in battery cells. Structural characterization is done using both ex-situ and in situ methods. In situ synchrotron X-ray diffraction is used for studying the materials under charge/discharge conditions.
7)	One of the main tasks for the project is to synthesize and develop new solid electrolytes for lithium batteries. The materials are tested in electrochemical cells, using e.g. impedance spectroscopy, and in real battery cells. In situ studies include synchrotron X-ray radiation to study structural effects during operation and neutron scattering (quasi elastic neutron scattering) to study the dynamics of lithium ions in the solid electrolyte during operation.
8)	Studies of the glucose to fructose conversion in ionic liquids catalyzed by Cr(II) and Cr(III) salts studied in situ by EXAFS and other spectroscopic methods.
9)	In situ synchrotron powder diffraction and EXAFS of the heat transformations of expanded carbonitrided austenites and other steels.
10)	Studies of conformations of Zn-insulin by single-crystal, powder diffraction and EXAFS methods. Studies of strontium incorporated in bone by EXAFS.
11)	Studies of the glucose to fructose conversion in ionic liquids catalyzed by Cr(II) and Cr(III) salts studied in situ by EXAFS and other spectroscopic methods.
12)	One of the aims of this study is to evaluate the influence of various cement thickness and water storage time prior to mouth motion fatigue testing on the reliability of the restoration structure. All available dental cements allow fluid absorption from saliva and dentin. In a moist environment, the cement matrix absorbs water and swells, decreasing the cement elastic modulus and ultimate strength, also increasing the material creep. The research will combine X-rays and neutron imaging to traditional laboratory measurements, such as flexural strength and modulus, compressive strength, fatigue testing and FTIR, to get a better view of the tooth-restoration inner structure, evaluate the crack as well as water front propagation. The additional goal is related to the development of a more effective way of controlling the hydration process of the dental cements.
13)	It is of utmost importance to identify the mechanism by which a novel drugs interact with cells, and a key pre-requisite is access to model cell systems resembling the properties of specific cell membranes. This project will investigate the interaction of novel antimicrobial peptide dendrimers with model cell surfaces with the particular aim to develop Grazing Incidence Small Angle Scattering (GISANS) as a tool for detecting lateral interactions on biosurfaces.
14)	N/A
15)	N/A
16)	The thesis work concentrates on developing novel optical schemes and tools for analyzing the radiation used at the experiments.

17)	The thesis work deals with developing timing based instrumentation and utilizing it in novel experiments at synchrotron light sources.
18)	Simulations and measurements on effects that can destroy short electron pulses in electron accelerators.
19)	N/A
20)	N/A
21)	N/A
22)	N/A
23)	N/A
24)	N/A
25)	N/A

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