Universiteit Utrecht

Information Booklet 2017/2018
September 1st, 2017

Master's Programme Experimental Physics

Physics of Light and Matter

Bright minds, better future

Physics Utrecht
ΕΜΜΕΦ

The Programme in a Nutshell

Welcome to the programme "Experimental Physics" here at Utrecht University! Experimental Physics is one of the three brances of Physics Masters offered at this University - the other two being Theoretical Physics and Climate Physics. In the coming two years, you will be working in class and the lab with top researchers in the fields of Particle Physics, Photonics and Soft Condensed Matter, and at the end you will receive a degree from the best University in the Netherlands. No pressure!

During your studies we - that is Programme Director Prof. Raimond Snellings (top) and Programme Co-ordinator Dr. Gerhard Blab - will be your first points of contact for all small and not-so-small problems you may encounter. And while the structures and procedures of the programme are actually quite simple, or at least not much more difficult than solving a discrete logarithm, we want to provide you with some information about the programme and its research groups, the general layout of this master's programme, and get a head start answering some frequently asked questions!

About Experimental Physics

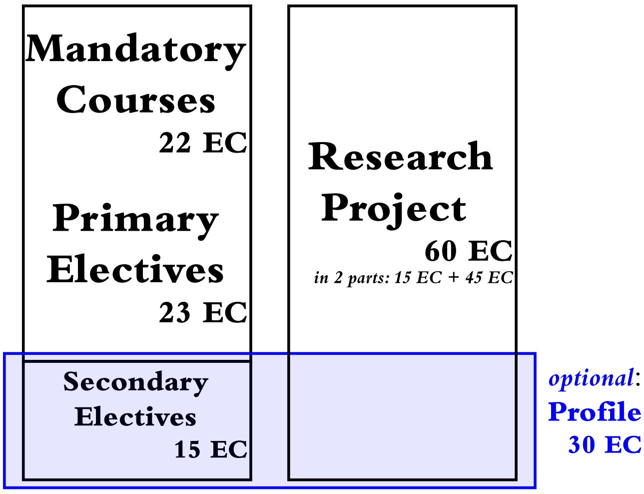
Experimental physics offers you the opportunity to explore an exciting range of topics at the extremes of modern science: from elementary particles to self-organizing complex (bio)systems, and from nano-Kelvin cold condensates to TeV hot plasmas. By following this challenging programme, you will develop an in-depth understanding of classical and quantum many-body systems, as well as the tool-set needed to study them with state-of-the-art experimental setups. The Experimental Physics courses will not only prepare you for a master's research project at the Debye Institute for Nanomaterials Science or the Institute for Subatomic Physics, but also give you the opportunity for internships outside the university with our industrial partners, at national research centres, or international research centres such as CERN.

General Layout

As you might infer from its name, the programme has a strong focus on the experimental aspects of physics and thus half of its 120 EC are used for a research project that you will undertake during your second year; But before you can go ahead working on your Nobel Prize-worthy work, you first have to master the theoretical foundations of Experimental Physics!

Required Reading

The largest chunk of your course work (45 EC) is meant to guide you towards one of the three directions embodied by the research groups in the programme: Particle Physics (PP), Atomic and Molecular Optics (AMO - also known as Nanophotonics), and Soft Condensed Matter and Biophysics (SCMB). The programme is not officially split into 'tracks,' but on the last page of this booklet you can find a table indicating to which of these tracks we think that the mandatory courses and primary electives belong.



Free Electives

An additional 15 EC of the programme consits of courses referred to as 'secondary electives.' You may chose *any* course offered by the Graduate School of Natural Sciences (GSNS) to deepen or widen your study. With permission from the programme director you can even venture outside our school to explore, for example, adjacent subject in the Geo- or Life sciences. If you have had enough of theoretical courses, you can also use these credits for a short (3 month) internship at another university or a company.

Secondary electives may also be used to make up for deficiencies (small gaps in basic proficiencies).

Research Project

The second half - and second year - of your master's study is dedicated to a research project in one of the research groups participating in the programme. The groups are introduced later in this booklet.
The project is split into two parts; at the end of the first part (20 EC) there is a intermediate evalution (pass/fail, or if you will go/no-go).

Profiles

If all those possibilities confuse you, then here is one more: for the last few year we have developped short (30 EC) 'profiles,' which are sets of theoretical and practical courses that will give you a chance to venture quite far outside the realm of physics, but which follow one common thread or concept. Successfully finshing a profile will be recorded on your diploma. There are currently three such profiles; these profiles have several things in common: (i) you need to apply and be accepted into the profile by its coordintaor, (ii) they are meant to be finished within the total course load of the programme - which essentially means that you lose the right to chose your secondary electives, and (iii) your thesis research is similarly shortened or modified to allow you to do interdisciplinary research or teach in a school.
We currently offer the following three profiles:

Complex Systems

Interdisciplinary profile for ambitious students from different Master's programmes, who want to work on modelling solutions within the field of Complex Systems. The profile gives you the opportunity to broaden your view and knowledge from an interdisciplinary angle and widens your opportunities for further development. It prepares you for a career in interdisciplinary fields at, for instance, financial companies.

Applied Data Science

Applied Data Science is a multidisciplinary profile for students who are not only interested in broadening their knowledge and expertise within the field of Data Science, but are also eager to apply these capabilities in relevant projects within their research domain. We investigate data science methods and techniques through case studies and applications throughout the life sciences & health, social sciences, geosciences, and the humanities. Therefore, students applying for this master's profile should have an affinity for this multidisciplinary approach.

Applied Data Science
Educational Profile

Educational Profile

If you are passionate about sharing your knowledge, and you would consider a career as a teacher in secondary education, this profile might be right for you.
If you have already completed an 'educational minor', or if you obtained a second degree (i.e., a limited teacher degree allowing you to teach until 9th grade) in teaching elsewhere, your educational profile will lead to a first degree teacher certificate.
The educational profile is primarily targeted towards teaching in the Dutch school system and, by default, the courses and the internships are in Dutch. However, there will be limited placement opportunities in bilingual or international schools.

Honor Programmes

In case you do not find the programme challanging enough, there is also the option to apply for our honours programme, which in effect is a three-year, double master's Experimental Physics & Nanomaterials. If you are interested, please make an appointment with the programme coordinator!

FAQ

I forgot to register for course XXX - *talk to the teacher of the course; if there is still room they will usually allow you to attend class and take the exam.*

The grade of course XXX is not yet in OSIRIS - *again, talk to the teacher of the course; if they claim to have submitted their grades, or if it is way more than 10 working days since the exam, please contact the programme coordinator!*

I am registered for the wrong course / OSIRIS contains incorrect information about a course or grade - *you should probably go directly to the study point for the master's programme (Buys Ballot Building, first floor); they can help with all kinds of OSIRIS related problems.*

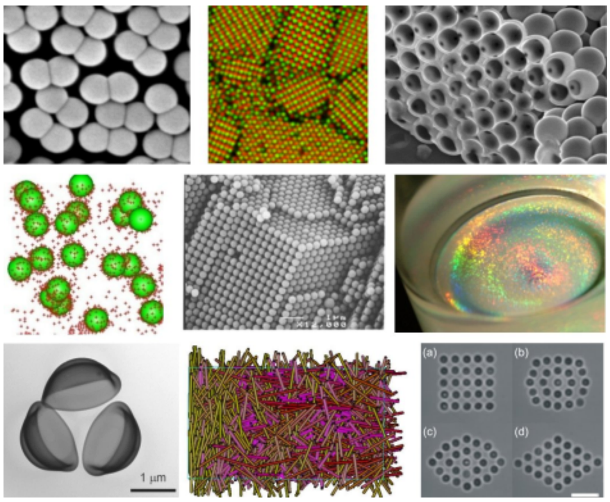
I want to take a course not on the electives list / outside GSNS - *the programme director can approve these courses as **secondary electives**. If you want to make larger changes (more than 15 EC) to your study program, make an appointment with the programme coordinator.*

Soft Condensed Matter & Biophysics

SCMBF are actually two groups - Soft Condensed Matter (SCM) and Molecular Biophysics (MBF) - located on the Ground Floor of the Ornstein Building. They are part of the Debye Insitute of Nanomaterials Science.

SCM

The emphasis in the Soft Condensed Matter group lies on the development and characterization of new model colloids and the quantitative 3D real-space analysis and manipulation of their self-assembly. Motivation comes both from the use of these systems as condensed matter model systems, and from their use as advanced materials in applications like photonic crystals and electronic-ink. In addition, we perform computer simulations and theory on soft condensed matter systems and try to bring these together with the experiments in a strongly synergistic approach.



One(of the many) research projects focusses on UV protection in consumer products. The main challenges faced within UV protective coatings, in particular, are enhancing protection over a broader spectrum of UV radiation and maintaining photostability. There is therefore a necessity for a flexible technology which allows the delivery of multiple sunscreens, with the possibility of pairing with antioxidants for photostabilisation. Therefore, in one line of research we are investigating biobased colloidal nanoparticles as vehicles for the delivery of multiple sunscreens and antioxidants.

We are specifically interested in designing these vehicles from water-insoluble polysaccharides and proteins (e.g. ethyl cellulose, zein), which are relatively unexplored when compared with their soluble analogues.

MBF

The Molecular Biophysics group has a strong multi-disciplinary character that is based on the group's long-standing background in fluorescence spectroscopy. About fifteen years ago, the first steps were made to extend the fluorescence spectroscopy work to the microscopic level. This resulted in the current programme that focuses on the application and development of novel fluorescence spectroscopy-based imaging methods as well as the characterization and development of luminescent labels. The mission of the group is to develop and exploit fluorescence spectroscopy-based techniques in microscopy. In our vision the future of fluorescence microscopy lies in the combination of fluorescence imaging and spectroscopic techniques. The novel imaging methodologies under development in the group utilize advanced light sources, non-linear excitation methods and contrast based on fluorescence spectroscopy.

The technical developments by the group are to a great extent driven by biological and biophysical problems which cannot be imaged with conventional techniques. Fluorescence spectroscopy relies on the ability to incorporate luminescent molecules in a chemically specific way into the sample. Moreover, the application of spectroscopic contrast techniques requires knowledge of their photophysical characteristics.

For these reasons the group also works on the characterization and development of luminescent labels. Conventional organic dyes are studied and characterized spectroscopically. Importantly, a number of collaborations were started to use novel luminescent particles such as quantum dots and dye-doped colloids as labels. Both types of luminescent particles offer interesting perspectives for use in imaging experiments.

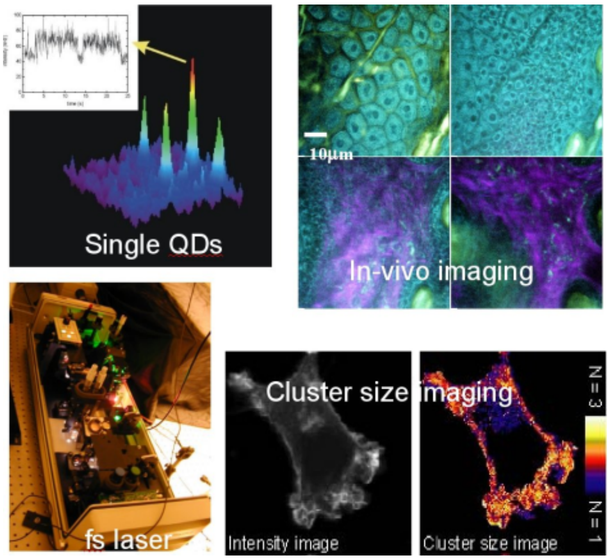
Nanophotonics

The present activities of the Nanophotonics research group, which is also part of the Debye Institute of Nanomaterials Reaearch - all take place in the field of experimental condensed matter

physics, with an emphasis on nanomaterials.
The central theme is the manipulation of electrons, atoms, and light in nanostructured materials. There are three sub-groups in Nanophotonics:

Atom Optics

The Atom Optics group (prof. dr. P. van der Straten) focuses on creating and understanding fundamental excitations in condensed matter model systems with many-body interactions.



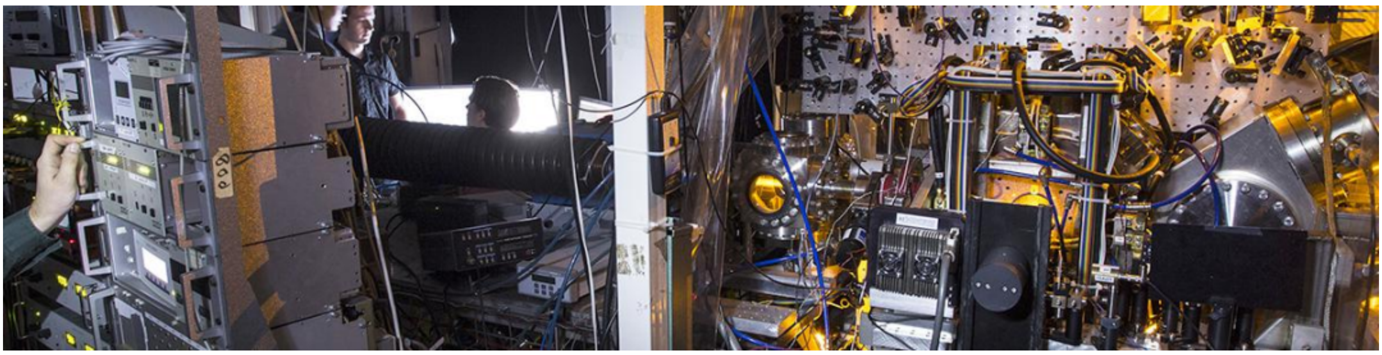
The key challenge of this group is to create the first atom laser producing a continuous matter wave, a potential work horse in modern condensed matter physics like the optical laser.

Physics of Light in Complex Systems (nanoLINX)

The Physics of Light in Complex Systems (nanoLINX) group (prof. dr. Allard Mosk and dr. Sanli Faez) aims to realise a new paradigm in imaging in scattering materials by integrating concepts from distinct fields such as space-time wavefront shaping, compressive sensing, adaptive optics and optical metrology.

Cold Atom Nanophotonics

The Cold Atom Nanophotonics group (dr. Dries van Oosten) investigates light-matter interactions at the nanoscale. Our main experimental effort in is the interaction between cold atoms and nanophotonic structures. We also ultrafast laser ablation at the nanoscale and the behaviour of light in large area photonic crystal cavities.



Sub-Atomic Particles

The research focus at the Institute for Subatomic Physics (SAP) is the topic of relativistic heavy-ion collisions. The main goal of the research is to understand Quantum Chromodynamics (QCD), the theory of the strong force, which is part of the Standard Model of Particle Physics.

The research area is experimental heavy-ion physics and our experimental setup, called ALICE (A Large Ion Collider Experiment), is located at the Large Hadron Collider (LHC) at CERN. The LHC is the world's most powerful particle accelerator, installed in a 27 km circumference underground ring straddling the border between Switzerland and France near Geneva.

The ALICE collaboration was established in 1992 and the Utrecht group joined in 1994. Currently ALICE consists of about 1,800 physicists (including about 300 PhD students), engineers and technicians from 174 institutes in 41 countries around the world. The Dutch ALICE group belongs to the 10 largest groups within ALICE. The main aim of the collaboration is to study a new state of matter, the Quark-Gluon Plasma (QGP), where quark and gluon degrees of freedom are not any more confined inside the hadrons. The QGP is studied using collisions of heavy nuclei, mainly lead on lead (Pb+Pb), with the ALICE detector at the top energy of the LHC. The ALICE detector stands 16 meters tall, 16 meters wide and 26 meters long, and weighs approximately 10,000 tons.

The Dutch ALICE group consists of physicists from Utrecht University and from Nikhef, the national FOM institute for subatomic physics.

External Research Institutes

In addition to the research groups above, you can choose other research facilities in the Netherlands (or even abroad) for your thesis research.

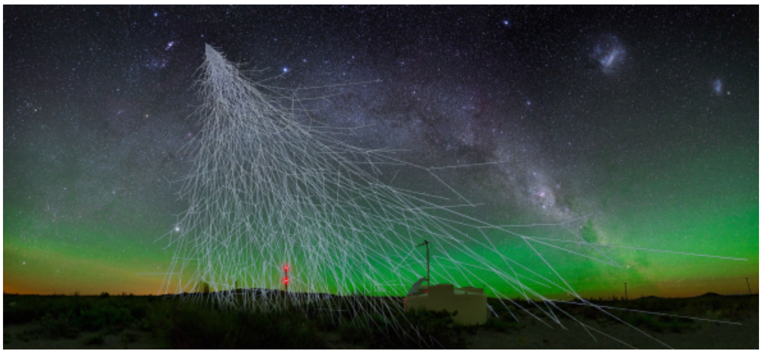
Debye Institute

At the Debye Institute for Nanomaterial(s) Science, chemistry and physics meet in the study of materials at the nanoscale. The institute specifically focusses on three themes: Catalysis, Colloid Science and Nanophotonics. The institute is named in honour of a true pioneer of the physical chemistry / chemical physics field: Dutch scientist and Nobel laureate Peter Debye (1884-1966).

Nikhef

In the world of elementary particles, there are three fundamental physical forces that describe the behaviour of particles. The electromagnetic force, together with the weak and strong nuclear force, determines how particles in the quantum world attract and repel each other, but also how new matter can be formed. The gravitational force – the force that describes the behaviour of large objects in the Universe – has a fundamentally different structure.

In particle physics, very large detectors are used to study elementary particles. Particles such as protons are accelerated in a particle accelerator, and made to collide with each other. The detectors record these collisions, which release a lot of energy to create new particles according to Einstein's E=mc2 In a way, detectors are microscopes; the smaller the details researchers want to see, the larger the microscope and its lenses need to be. Various detectors have been built, for example at CERN, DESY and Fermilab. Nikhef performs particle physics research at CERN's Large Hadron Collider (LHC) CERN.



Astroparticle physics combines physics and astronomy. In the cosmos, very strong magnetic fields create what can be considered a 'natural' particle accelerator. To perform astrophysics research, scientists 'just' need to build the right detectors. This is what astroparticle physicists at Nikhef are doing. Nikhef's research takes place at the research collaborations KM3NeT, XENON, Auger and (Advanced) Virgo.

AMOLF

Researchers at AMOLF are continuously searching for the fundamental relationship between the architecture and interactions of complex molecular and material systems, ranging from nanophotonic structures to multicellular organisms, and their properties and functions. AMOLF performs research within the following strongly connected themes.

In the area of nanophotonics, AMOLF researchers tame the flow, emission, and detection of light. They are seeking the absolute limits of what is possible. For example, they create structures with nanoscale dimensions, 100,000 times smaller than that of a human hair. They use these to study the interaction between light and matter down to the level of a single molecule. The measurements are also extremely accurate in terms of time. They are registered per femtosecond, one quadrillionth[1] of a second.

[1] or one billiardth, for people who still know how proper long-scale numbering works...

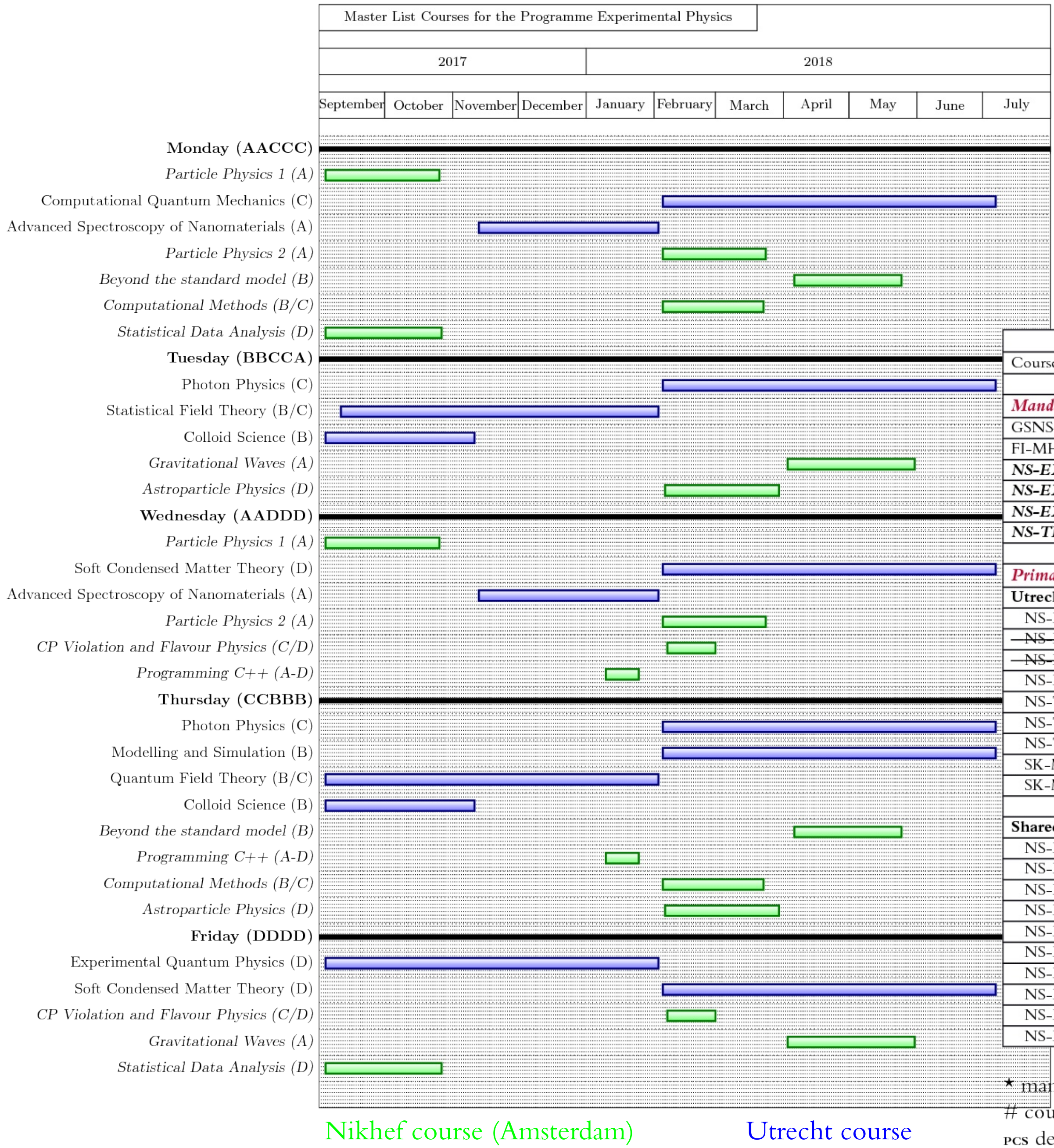
Light management in solar cells

There are many ways to improve solar cells. One way is to ensure that they catch as much sunlight as possible. AMOLF researchers are applying their expertise to manage light on solar cells. By capturing light in minute structures smaller than light's own wavelength, they can control the behaviour of light and keep it in the solar cell so it can be converted into energy. The researchers are 'stamping' nanostructures on conventional silicon solar cells, for example. Another route is to cover the solar cells with an organic layer in which the light can be easily managed. A third route is to develop a revolutionary new type of organic solar cell in which the nanostructures are naturally present

Designing novel materials

How to make new materials that do not occur in nature? Materials with completely new properties? For example, materials that become shorter when pulled, objects that assemble themselves just like your own body, or smart materials that observe and respond to their surroundings? With research into designer matter, AMOLF is pioneering a new area. Experiments, computer simulations and theoretical models are combined with 3D printing and nano-manufacturing. With this approach researchers are designing and constructing a wide range of designer materials: from crystal structures at the microscale via self-folding origami sheets to soft materials that can autonomously creep.

The discipline of designer matter is still in its infancy but could lead to revolutionary applications. For example, soft robots that respond to their environment, solar cells that automatically direct themselves towards the sun, or even a completely new type of medicine.



Nikhef course (Amsterdam) Utrecht course

Looking for a course?

Utrecht: OSIRIS http://tinyurl.com/3e9yo35

Amsterdam: Datanose http://tinyurl.com/yc7nz3gx

Questions or Complaints?

Coordinator: Gerhard A. Blab, Ornstein 057

030/253 2409 or coordinator.exph@uu.nl

Advisory Path →			PP	AMO	SCMB
Course ↓					
Mandatory Courses:					
GSNS-INTRO	Graduate school's master introduction	0.5 EC	⋆	⋆	⋆
FI-MHPSDIL	Dilemmas of the scientist	0.5 EC	⋆	⋆	⋆
NS-EX401M ⋆	***Experimental Quantum Physics***	***7.5 EC***	⋆	⋆	⋆
NS-EX418M ⋆	***Photon Physics***	***7.5 EC***	⋆	⋆	⋆
NS-EX403M ⋆	***Particle Physics 1***	***6 EC***	⋆		
NS-TP453M ⋆	***Soft Condensed Matter Theory***	***7.5 EC***			⋆
Primary Electives:					
Utrecht Courses:					
NS-EX404M	Particle Physics 2	7.5 EC	⋆		
~~NS-EX417M #~~	~~Physics of Light & Electron Microscopy~~	~~4.5 EC~~	⋆	⋆	⋆
~~NS-EX419M #~~	~~Application of Light & Electron Microscopy~~	~~3 EC~~	⋆	⋆	⋆
NS-EX431M #	Computational Quantum Mechanics	7.5 EC	⋆	⋆	⋆
NS-TP432M PCS	Modelling and Simulation	7.5 EC	⋆	⋆	⋆
NS-TP401M	Quantum Field Theory	10 EC	⋆	⋆	
NS-TP402M	Statistical Field Theory	10 EC	⋆	⋆	⋆
SK-MASPN	Advanced Spectroscopy of Nanomaterials	7.5 EC			⋆
SK-MCS	Colloid Science	7.5 EC			⋆
Shared NIKHEF Master Courses:					
NS-EX430M	Beyond the standard model	3 EC	⋆		
NS-EX415M	CP violation and Flavour Physics	3 EC	⋆		
NS-EX432M	Gravitational Waves	3 EC	⋆		
NS-EX428M	Particle Detection	6 EC	⋆		
NS-EX433M	Programming C++	3 EC	⋆	⋆	⋆
NS-EX405M	Computational Methods	6 EC	⋆	⋆	⋆
NS-EX427M	Astroparticle Physics	6 EC	⋆		
NS-EX434M PDS	Statistical Data Analysis	6 EC	⋆	⋆	⋆
NS-EX429M	Nikhef project	6 EC	⋆		
NS-EX406M	CERN Summer Student Programme	6 EC	⋆		

⋆ mandatory courses: choose 3 out of 4; Forth course can be taken as primary elective.

courses are given alternating every other year

PCS designated as course for profile "Complex Systems"

PDS designated as course for profile "Data Science"

PP – Particle Physics; AMO – Atomic and Molecular Optics; SCMB – Soft Condensed Matter and Biophysic