Faculty of Science

Prospectus 2010 - 2011

Physics and Astronomy

Master

Radboud University Nijmegen

Preface

This booklet is the prospectus for the masters programme of Physics and Astronomy. It contains information about the objectives, the goals and the contents of the programme. Furthermore a lot of practical information is given.

A small part of this prospectus is written in Dutch. This applies to the description of the course "Oriëntatie E-Variant" in chapter 4 and to the chapter on the examinational systems.

P.S. *This prospectus has been made with great care. However the authors are not responsible for inaccuracies. If you have comments or proposals for improvements don't hesitate to contact them.*

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Contents

1 Introduction......1
1.1 Admittance......1
1.2 Structure of the Masters programme......1
2 Aims and Attainment targets......4
2.1 Aims of the Master's programme......4
2.2 Attainment targets of the Master's programme......5
3 Programme......7
3.1 Research variant (O variant)......7
3.2 Communication variant (C variant)......14
3.3 Education variant (E variant)......15
3.4 Business & Management variant (MT variant)......16
4 Description of the Courses......17
Inleidingen, zelfstudieopdrachten, marktverkenningen, vaardigheidstrainingen, presentaties......27
5 Institutes for Education and Research......94
5.1 The Educational Department for Mathematics, Physics and Astronomy......94
5.2 Institute for Mathematics, Astrophysics and Particle Physics (IMAPP)......94
5.3 Institute for Molecules and Materials (IMM)......100
5.4 Donders Centre for Neuroscience (DCN)......113
6 Examinational Regulations......116
6.1 Interim examinations......116
6.2 Master's Thesis......116
6.3 The Master's examination......117
6.4 Regels en Richtlijnen van de Examencommissie......118
7 The Administrative Structure......122
7.1 The Educational Institute for Mathematics, Physics and Astronomy (WiNSt)......122
8 Student Facilities......123
9 Student Activities......127
9.1 Marie Curie......127
10 Appendices......128
10.1 Appendix A: Important departments and persons......128
10.2 Appendix B: Dates of Examinations 2010/2011......131
10.3 Appendix C: Teaching 2010/2011......131
Index of courses......133

1 Introduction

The Radboud University Nijmegen offers a Master of Science programme in Physics and Astronomy. This programme forms the connection between the Bachelors programme, taught in Dutch, and the state-of-the-art research that is being pursued at the different departments in the faculty. This Masters programme is of international standards and compatible with, e.g., the German Masters programme. It is therefore of particular appeal to students of any nationality who qualify in terms of their preceding studies and want to graduate as a Master of Science at the highest standards.

The Radboud University Nijmegen is a general university, offering almost all possible academic Programmes, ranging from Arts and Law, to Medicine and Science. This Masters programme allows a substantial choice of topics from all these areas, thereby offering the possibility to combine Physics and Astronomy with other studies.

A large part of the Masters programme is in the form of one or more traineeships, either in Physics and Astronomy departments at the Radboud University Nijmegen, or at an external institution, university or company. In this traineeship the student is confronted with current research and, moreover, actively takes part in ongoing frontier research. One of these traineeships results in a Masters thesis.

1.1 Admittance

The programme requires a Bachelors degree in Physics or Astronomy from the University of Nijmegen, or an equivalent degree. A Bachelors degree in Physics and/or Astronomy from any Dutch (technical) university qualifies. By exception, bachelor students with a maximum deficiency of 18 ec in the bachelor education, may already register for the Master Education (for students who started their education before September 1, 2002, this deficiency is 30 ec). In case of a deficiency, it is obligatory to complete the bachelor education in Physics & Astronomy within one year from the date of registration. In case of failure, students will be exluded from further participation to master course exams.

1.2 Structure of the Masters programme

The Masters programme at the Science Faculty of the University of Nijmegen is offered in four variants: a research (O) variant, a communication (C) variant, an education (E) variant, and a business and management (MT) variant. At this moment, only the research variant has a complete programme in the English language. The other variants are primarily aimed at the Dutch market and the Dutch educational system, and are therefore taught in Dutch.
The O-variant is intended as a preparation for admission as a research PhD Student in Physics and Astronomy. The other variants are not intended as such.

The O-variant of the Masters programme has 4 specializations:

- Biophysics and Neuroscience
- High Energy Physics
- Astrophysics
- Molecular and Condensed Matter Physics

These specializations are directly related with the pillars of research in Nijmegen, organized in the institutes: Donders Centre for Neuroscience (DCN), Institute for Mathematics, Astrophysics and Particle Physics (IMAPP), and Institute for Molecules and Materials (IMM).

Each specialization will be composed out of 4 elements:

- Common compulsory subjects for all physics students
- Specialization specific basic subjects
- Electives, specialization related and free
- Master's thesis

The master's thesis will be the reflection of a traineeship at one of the research departments.

Our research departments are specialized in the following fields:

- Theoretical Solid State Physics, notably band structure calculations where Nijmegen is the home of a national facility
- Theoretical Elementary Particle Physics, notably Standard Model and Minimal Supersymmetric Standard Model phenomenology
- Mathematical Physics (in association with the Mathematics department), notably diagrammatica and quantum probability theory
- Experimental Solid State Physics, notably in the areas of high magnetic fields (the High Field Magnet Laboratory, an international facility), scanning tunneling microscopy and spectroscopy, material surface spectroscopy and materials engineering
- Experimental Molecular Physics, notably in the areas of molecular dynamics and (bio)molecular structure trace gas facility based at the department
- Experimental Elementary Particle Physics, notably on experiments conducted at the leading facilities in the world, CERN and Fermilab, and a local facility for highest energy cosmic ray research
- Applied Molecular Physics, notably in materials science, neuro-imaging and turbulence
- Astro-(Particle) Physics, notably gamma ray bursts and the highest energy cosmic rays and
- Biophysics and Neuroscience, notably the biophysics of brain and behaviour and the study of artificial neural nets

The courses that are needed to prepare for the Masters thesis work are determined by the Masters thesis supervisor and the student together. It is therefore advisable to contact the prospective Masters thesis adviser(s) to discuss the content of these courses. These courses are deemed electives and are tailored to the needs and wishes of the student. To select a prospective Masters thesis adviser, please look at the descriptions of the different departments. The contact persons of the departments can be approached at any stage for information or to set up a programme in the electives section. In the last year of the bachelor programme, tours of the departments are organized for groups of students. This is a good occasion to visit all our departments and find out in detail what your possibilities are to do your Masters thesis work there.

Students may at any time enroll in supplementary courses and exceed the minimum of 120 study points (ec = european credits) required for the Masters degree.

2 Aims and Attainment targets

2.1 Aims of the Master's programme

The aims of the Master's (or doctoraal) programme in Physics and Astronomy have been laid down as follows in the Education and Examination Regulations (Art. 1.3):
The aims of the study programme are:

1. *To provide students with the knowledge, skills and insights pertaining to the fields of physics and astronomy that will enable them to practise their future professions independently, and to become eligible for the advanced programmes for scientific researchers or designers (O-variant), communication experts (C-variant),teachers (E-variant) or research managers in business organizations (MT-variant).*
2. *Academic education.*

Naturally, this description refers to professions for which a scientific education in physics and astronomy is either required or useful. This general aim is concretized in a number of detailed objectives.

Basically, prospective students are expected to possess all the knowledge, skills and insights mentioned in the attainment targets of the Bachelor's programme. Consequently, additional requirements may be set with regard to previous education, in individual cases, with regard to entrants from other institutions. Furthermore, the Master's programme pursues the following specific additional aims:

- Students acquire more specialized knowledge and insights pertaining to one or more sub-areas of physics and astronomy
- Students become acquainted with one or more disciplines outside the fields of physics and astronomy or with one or more sub-areas in physics and astronomy, other than the sub-area of specialization mentioned above
- Students learn how to analyse complex problems independently and how to formulate standard and innovative solutions
- Students learn how to test theories using concrete questions which they will have developed themselves
- Students who wish to obtain the Master's title in the Communication or Education variant will further deepen their knowledge of and insight into teaching and communication theories respectively, and will be able to apply this knowledge and these insights during practical training in the fields of communication or education
- Students in the Master's phase of the Management variant will further deepen their knowledge of and insight into management and organizational aspects, and will subsequently apply this knowledge and these insights during practical training in a business environment

2.2 Attainment targets of the Master's programme

The attainment targets of the Master's programme consist of:
General cognitive skills

1. Graduates will have acquired a way of thinking that will enable them to penetrate and solve problems, while maintaining a critical stance towards established scientific insights
2. Graduates will be able to formulate and analyse scientific problems at an abstract level by dividing them into testable sub-problems, differentiating between major and minor aspects
3. Graduates will be able to synthesize solutions to subproblems within a scientific framework and thus contribute to the formulation of general theories
4. Graduates will possess mathematical knowledge insofar as relevant in physics and astronomy at the Master's level
   Skills based on knowledge and insights pertaining to the fields of physics and astronomy
5. Graduates will possess sufficient skills in the fields of computing and computer science, which will enable them to design and implement computer programs and use current application programs
6. Graduates will have gained adequate knowledge and insights pertaining to the basic sub-areas of physics and astronomy. The scope of this basic knowledge will be sufficient to allow them to do practical training in one of the research groups
7. Graduates will possess sufficient skills in at least one sub-area of physics and astronomy to conduct scientific research under supervision
8. Graduates will be able to understand scientific articles on the chosen specialization. Furthermore, they will be able to follow the developments in the chosen specialization (level: Physical Review)
   Research methods in physics and astronomy
9. Graduates will be able to assimilate newly acquired knowledge of physics and astronomy and to integrate this knowledge with the knowledge they already possess. In addition, they will be able to orient themselves at specialist level in a sub-area of physics and astronomy that lies outside the chosen specialization
10. Graduates will be able to find relevant scientific sources relating to physical or astronomical problems that need to be solved
11. Graduates will be able to formulate new questions and hypotheses in the fields of physics and astronomy, and to select the appropriate pathways and research methods for solving these questions, taking into account the services and means available
    General communication skills
12. Graduates will be able to set up and perform experimental or theoretical scientific research, to systematically process and critically interpret the research results, and to formulate conclusions
13. Graduates will be able to communicate with colleagues in the same discipline about scientific knowledge, both at basic and specialist levels. They will be able to report orally and in writing, and to discuss a scientific topic, in Dutch as well as in English
    Reflection on society and societal problems
14. Graduates will be able to hold an oral presentation and to write a lucid article on the research conducted and modern concepts in physics and astronomy for a general, non-specialist public

Specific skills to be acquired in the C variant

15. Graduates will have gained sufficient knowledge of and insights into the role of physics and astronomy in society in order to function adequately in their future professions and reflect on societal problems
16. Graduates will have sufficient knowledge of various theories of communication that will enable them to reflect critically on the literature in the field of communication
17. Graduates will have gained insight into theories of communication and will be able to put a number of them into practice
18. Graduates will be able to reflect on the ways in which they put their communication skills into practice, efficiently applying communicative concepts
19. Graduates will have gained insight into factors that have a positive or negative effect on communication, and will have acquired the skills to identify and influence these factors in concrete communicative situations

Specific skills to be acquired in the E variant

20. Graduates will possess skills in the fields of scientific journalism and technical communication, and knowledge of recent developments in these fields
21. Graduates will have sufficient knowledge of various theories of education that will enable them to reflect critically on the literature in the field of educational counselling
22. Graduates will have gained insight into theories of education and will be able to put a number of them into practice
23. Graduates will be able to reflect on the ways in which they put their teaching skills into practice, efficiently applying educational concepts
24. Graduates will be able to indicate how scientific analyses and solutions to questions should be applied in concrete curricular and extra-curricular settings

Specific skills to be acquired in the MT variant

25. Graduates will be able to guide non-colleagues in mastering and practising the teaching profession
26. Graduates will have gained an overview of and insight into the various theories in the fields of management science and business administration
27. Graduates will have sufficient knowledge of these theories to reflect critically on the literature on counselling in these fields
28. Graduates will have gained insight into the various tools and strategies relating to the diagnosis and analysis of various types of complex management questions in science-related, knowledge-intensive organizations
29. Graduates will be able to use these tools and strategies in practice and to report on them orally and in writing, effectively applying theoretical concepts from management science and business administration

The above-mentioned attainment targets resulted in the Master's programme as described in Chapter 3.

3 Programme

3.1 Research variant (O variant)

Research variant (O variant)

The programme for the O-variant comprises 120 ec divided over

- mandatory courses, which depend on the chosen specialization
- electives, of which 20 ec can be chosen freely by the student. Within each specialization a number of electives are advocated and the most important ones are marked as "strongly recommended"
- a master thesis, amounting to 60 ec.

At the start of the Master's programme, the student is expected to contact the coordinator of the specialization of interest (see the table given below) to select a thesis supervisor. A more definitive choice is made after discussing optional programmes. When discussing these programmes the student and supervisor can agree to trade up to 12 ec of the time reserved for the master thesis project for electives, e.g. in order to prepare for the thesis work. It is also possible to select the course package from the C, E or M variants as electives. The individual programme is subsequently registered by the thesis supervisor and the student using a form, of which the student, supervisor and Examination Committee will all get a copy. The so-registered individual programme constitutes a commitment from both the student and thesis supervisor. Of course, changes can be made by mutual agreement between both parties. The Examination Committee provides a marginal check on the individual programme, and will contact student and thesis supervisor within three weeks after receiving the individual programme should a problem occur.

In the first half year the student is expected to follow courses to prepare for the thesis research. After that, the thesis project can be commenced. While the thesis work is being performed, the student still takes courses, usually the most advanced ones. Students are in particular encouraged to also have discussions about this material with the members of the department in which they are embedded.

In the table given below an overview of the various master specializations is presented, indicating the coordinator in each case.

Master of Science in Physics and Astronomy

Institute	**Specialization**	**Coordinator**
Donders Centre for Neuroscience (DCN)	Computational Neuroscience - Machine Learning	*Bert Kappen*
ROWSPAN	Experimental Neuroscience	*John van Opstal*
Institute for Mathematics, Astrophysics and Particle Physics (IMAPP)	Astrophysics	*Jörg Hörandel*
ROWSPAN	Experimental High-Energy Physics	*Frank Filthaut*
ROWSPAN	Theoretical High-Energy	*Wim Beenakker*

	Physics	
Institute for Molecules and Materials (IMM)	Experimental Condensed Matter Physics	*Alexey Kimel*
ROWSPAN	Theoretical Condensed Matter Physics	*Annalisa Fasolino*
ROWSPAN	Molecular Physics	*Wim van der Zande*

The individual master specializations are described in detail in the following subsections

Computational Neuroscience - Machine Learning

Coordinator: Bert Kappen

In the table presented below the mandatory, strongly recommended and elective courses are listed, with the amount of ec points given between parentheses.

Computational Neuroscience - Machine Learning

Fall semester	**Spring semester**
Mandatory	
Electrodynamics 1 (3) *1^{st} quarter*	Professional Preparation (1)
Computational Neuroscience (6)	Philosophy 2 (3) *3^{rd} quarter*
Machine Learning (6)	ROWSPAN
Electives, strongly recommended	
	Quantitative Brain Networks (6)
ROWSPAN	Stochastics Neuroscience Seminar (6)
Electives [1]	
Advanced Quantitative Brain Networks (3) *2^{nd} quarter* [2]	Data Analysis (3) *4^{th} quarter*
ROWSPAN	Computational Physics (6)
ROWSPAN	Advanced Computational Neuroscience (3) *3^{rd} quarter* [3]
Master thesis (60) [4]	

Footnotes:

1. An approval by the examination committee is required
2. First given in 2011
3. First given in 2012
4. Within the master thesis an additional industrial project (or comparable) can be incorporated

Experimental Neuroscience

Coordinator: John van Opstal

In the table presented below the mandatory, strongly recommended and elective courses are listed, with the amount of ec points given between parentheses.

Experimental Neuroscience

Fall semester	**Spring semester**
Mandatory	
Electrodynamics 1 (3) *1^{st} quarter*	Professional Preparation (1)
ROWSPAN	Brain and Behaviour 2 (6)
ROWSPAN	Philosophy 2 (3) *3^{rd} quarter*

Electives, strongly recommended	
Computational Neuroscience (6)	Quantitative Brain Networks (6)
ROWSPAN	Data Analysis (3) *4th quarter*
ROWSPAN	MRI Techniques in the Life Sciences (6)
Electives [1]	
Advanced Quantitative Brain Networks (3) *2nd quarter* [2]	Advanced Computational Neuroscience (3) *3rd quarter* [3]
Machine Learning (6)	ROWSPAN
Master thesis (60) [4]	

Footnotes:

1. An approval by the examination committee is required
2. First given in 2011
3. First given in 2012
4. Within the master thesis an additional industrial project (or comparable) can be incorporated

Astrophysics

Coordinator: Jörg Hörandel

Within the Dutch Astronomy Programme, the Nijmegen specialization is High Energy Astrophysics. In the table presented below the mandatory, strongly recommended and elective courses are listed, with the amount of ec points given between parentheses. Since several of the mandatory courses are given biennially, the astrophysics master students are advised to start their thesis project in time. The guidelines for astrophysics master students can be downloaded from http://www.astro.ru.nl/wiki/nl/education/curriculum

Astrophysics

Fall semester	**Spring semester**
Mandatory	
Electrodynamics 1 (3) *1st quarter*	Professional Preparation (1)
ROWSPAN	Philosophy 2 (3) *3rd quarter*
Black Holes in Active Galactic Nuclei (6) [2]	Compact Binaries (6) [1]
Cosmology (6) [1]	Astroparticle Physics (6) [2]
Electives, strongly recommended	
Astrophysics Seminar (3)	
Telescope Observing (2)	
	Interacademic Course Astrophysics (6)
Electives [3]	
Structure of Spacetime (6) [4]	Numerical Methods (3), *3rd quarter*
Nuclear Physics (6) [2]	ROWSPAN
Particle Physics Phenomenology (6)	Introduction to C++ (3)
Particle Detection and Acceleration (6)	ROWSPAN
Master thesis (60)	

Remarks:

1. Biennial courses, odd years
2. Biennial courses, even years
3. An approval by the examination committee is required. Apart from the specific electives

that are advocated in the table, a few more additional options can be pointed out. It is possible to follow any of the courses from the master programmes in experimental and theoretical high-energy physics and in addition it is possible to follow courses on astrophysics or astronomy at other Dutch universities
4. The course "Structure of Spacetime" will be given if a sufficiently large amount of students is registered. Please contact the lecturer about this

Experimental High-Energy Physics

Coordinator: Frank Filthaut

In the table presented below the mandatory, strongly recommended and elective courses are listed, with the amount of ec points given between parentheses.

For an optimal preparation the prospective master students in experimental high-energy physics are strongly recommended to take the Bachelor courses "Inleiding Groepentheorie" (introduction to group theory), "Subatomaire Fysica" (subatomic physics) and "Elektronica" (electronics), or equivalent.

Experimental High-Energy Physics

Fall semester	**Spring semester**
Mandatory	
Electrodynamics 1 (3) *1st quarter*	Professional Preparation (1)
Particle Detection and Acceleration (6)	Philosophy 2 (3) *3rd quarter*
Particle Physics Phenomenology (6)	ROWSPAN
Electives, strongly recommended	
	Astroparticle Physics (6) [2]
ROWSPAN	Introduction to C++ (3)
ROWSPAN	Particle Physics Experiment Analysis (6)
ROWSPAN	CERN Summer Student Programme [3]
Electives [4]	
NIKHEF Topical Lectures [5]	
Black Holes in Active Galactic Nuclei (6) [2]	Beyond the Standard Model (6) [1]
Cosmology (6) [1]	ROWSPAN
Machine Learning (6)	Introduction to String Theory (6) [2]
Introduction to Computer Graphics (6)	ROWSPAN
Nuclear Physics (6) [2]	Numerical Methods (3) *3rd quarter*
Quantum Field Theory (6)	ROWSPAN
Structure of Spacetime (6) [6]	Monte Carlo Techniques (6)
Theoretical Foundations of Elementary Particle Physics (6)	ROWSPAN
Master thesis (60) [7]	

Remarks:

1. Biennial courses, odd years
2. Biennial courses, even years
3. The number of ec points to be assigned to the CERN Summer Student Programme depends on the length of the programme, being given by the number of weeks in excess of four weeks. The full extent of the programme corresponds to 8 ec
4. An approval by the examination committee is required. Apart from the specific electives

that are advocated in the table, it is also possible to follow courses from the Nikhef Master of Particle and Astroparticle Physics. More information can be found on the website http://particles.nl/
5. 1 ec for each 3-day event, 3 times per year
6. The course "Structure of Spacetime" will be given if a sufficiently large amount of students is registered. Please contact the lecturer about this
7. Within the master thesis an additional industrial project (or comparable) can be incorporated

Theoretical High-Energy Physics

Coordinator: Wim Beenakker
In the table presented below the mandatory, strongly recommended and elective courses are listed, with the amount of ec points given between parentheses.

For an optimal preparation the prospective master students in theoretical high-energy physics are strongly recommended to take the Bachelor courses "Inleiding Groepentheorie" (introduction to group theory) and "Kwantummechanica 3" (many-particle and relativistic quantum mechanics), or equivalent.

Theoretical High-Energy Physics

Fall semester	**Spring semester**
Mandatory	
Electrodynamics 1 (3) *1st quarter*	Professional Preparation (1)
Quantum Field Theory (6)	Philosophy 2 (3) *3rd quarter*
Theoretical Foundations of Elementary Particle Physics (6)	ROWSPAN
Electives, strongly recommended	
	Introduction to String Theory (6) [2]
ROWSPAN	CERN Summer Student Programme [3]
Electives [4]	
NIKHEF Topical Lectures [5]	
Cosmology (6) [1]	Beyond the Standard Model (6) [1]
Particle Physics Phenomenology (6)	ROWSPAN
Structure of Spacetime (6) [6]	Introduction to C++ (3)
Advanced Statistical Physics (6)	ROWSPAN
Particle Detection and Acceleration (6)	Monte Carlo Techniques (6)
Lie Algebras (9)	ROWSPAN
Master thesis (60)	

Remarks:

1. Biennial courses, odd years
2. Biennial courses, even years
3. The number of ec points to be assigned to the CERN Summer Student Programme depends on the length of the programme, being given by the number of weeks in excess of four weeks. The full extent of the programme corresponds to 8 ec
4. An approval by the examination committee is required. Apart from the specific electives that are advocated in the table, it is also possible to follow courses from other fields in physics, at other faculties, and at other universities. A course that is particularly

interesting is the interacademic course "Field Theory in Particle Physics" at the University of Utrecht. A list of all master courses in theoretical physics in the Netherlands can be found in the DRSTP educational guide, which can be downloaded from http://www1.phys.uu.nl/drstp/
5. 1 ec for each 3-day event, 3 times per year
6. The course "Structure of Spacetime" will be given if a sufficiently large amount of students is registered. Please contact the lecturer about this

Experimental Condensed Matter Physics

Coordinator: Alexey Kimel

In the table presented below the mandatory, strongly recommended and elective courses are listed, with the amount of ec points given between parentheses.

For an optimal preparation the prospective master students in experimental condensed-matter physics are strongly recommended to take the Bachelor course "Vaste Stoffysica" (introduction to solid state physics), or equivalent.

Experimental Condensed Matter Physics

Fall semester	**Spring semester**
Mandatory	
Electrodynamics 1 (3) *1st quarter*	Professional Preparation (1)
Electrodynamics 2 (3) *2nd quarter*	Philosophy 2 (3) *3rd quarter*
Solid State Physics (6)	ROWSPAN
Electives, strongly recommended	
Advanced Statistical Physics (6)	Condensed Matter Theory (6)
Physics of Molecules and Molecular Aggregates (6)	Interaction of Light with Molecules and Materials (6)
ROWSPAN	Numerical Methods (3) *3rd quarter*
Electives [1]	
Experimental Techniques (6)	Advanced Spectroscopy (6) [2]
ROWSPAN	Data Analysis (3) *4th quarter*
ROWSPAN	Computational Physics (6)
ROWSPAN	Electronic Structure of Materials (6)
Scanning Probe Microscopy (6)	Lasers and Electro-Optics (6)
ROWSPAN	Material Science (6)
ROWSPAN	Nano Magnetism (6)
ROWSPAN	Quantum Transport (6)
Master thesis (60) [3]	

Remarks:

1. An approval by the examination committee is required
2. This course aims to give an overview of methods of modern spectroscopy employed within the IMM. The course is given by more than 5 lecturers. In order to obtain a deeper knowledge about a specific technique the students are strongly advised to follow a more specialized course. Please contact the lecturers for an advice about that
3. Within the master thesis an additional industrial project (or comparable) can be incorporated

Theoretical Condensed Matter Physics

Coordinator: Annalisa Fasolino

In the table presented below the mandatory, strongly recommended and elective courses are listed, with the amount of ec points given between parentheses.

For an optimal preparation the prospective master students in theoretical condensed-matter physics are strongly recommended to take the Bachelor course "Vaste Stoffysica" (introduction to solid state physics), or equivalent.

Theoretical Condensed Matter Physics

Fall semester	**Spring semester**
Mandatory	
Electrodynamics 1 (3) *1st quarter*	Professional Preparation (1)
Electrodynamics 2 (3) *2nd quarter*	Philosophy 2 (3) *3rd quarter*
Solid State Physics (6)	ROWSPAN
Electives, strongly recommended	
Advanced Statistical Physics (6)	Condensed Matter Theory (6)
Physics of Molecules and Molecular Aggregates (6)	Interaction of Light with Molecules and Materials (6)
ROWSPAN	Numerical Methods (3) *3rd quarter*
Electives [1]	
Experimental Techniques (6)	Advanced Spectroscopy (6) [2]
ROWSPAN	Data Analysis (3) *4th quarter*
ROWSPAN	Computational Physics (6)
ROWSPAN	Electronic Structure of Materials (6)
Scanning Probe Microscopy (6)	Lasers and Electro-Optics (6)
ROWSPAN	Material Science (6)
ROWSPAN	Nano Magnetism (6)
ROWSPAN	Quantum Transport (6)
Master thesis (60)	
Remarks:	

1. An approval by the examination committee is required
2. This course aims to give an overview of methods of modern spectroscopy employed within the IMM. The course is given by more than 5 lecturers. In order to obtain a deeper knowledge about a specific technique the students are strongly advised to follow a more specialized course. Please contact the lecturers for an advice about that

Molecular Physics

Coordinator: Wim van der Zande

In the table presented below the mandatory, strongly recommended and elective courses are listed, with the amount of ec points given between parentheses.

For an optimal preparation the prospective master students in molecular physics are strongly recommended to take the Bachelor course "Vaste Stoffysica" (introduction to solid state physics), or equivalent.

Molecular Physics

Fall semester	Spring semester
Mandatory	
Electrodynamics 1 (3) *1st quarter*	Professional Preparation (1)
Electrodynamics 2 (3) *2nd quarter*	Philosophy 2 (3) *3rd quarter*
Electives, strongly recommended	
Advanced Statistical Physics (6)	Numerical Methods (3) *3rd quarter*
Solid State Physics (6)	Interaction of Light with Molecules and Materials (6)
Physics of Molecules and Molecular Aggregates (6)	ROWSPAN
Electives [1]	
Experimental Techniques (6)	Advanced Spectroscopy (6) [2]
ROWSPAN	Data Analysis (3) *4th quarter*
ROWSPAN	Computational Physics (6)
ROWSPAN	Electronic Structure of Materials (6)
Scanning Probe Microscopy (6)	Lasers and Electro-Optics (6)
ROWSPAN	Material Science (6)
ROWSPAN	Nano Magnetism (6)
ROWSPAN	Quantum Transport (6)
Master thesis (60) [3]	

Remarks:

1. An approval by the examination committee is required
2. This course aims to give an overview of methods of modern spectroscopy employed within the IMM. The course is given by more than 5 lecturers. In order to obtain a deeper knowledge about a specific technique the students are strongly advised to follow a more specialized course. Please contact the lecturers for an advice about that
3. Within the master thesis an additional industrial project (or comparable) can be incorporated

3.2 Communication variant (C variant)

C-variant

Internship and Essay Master Communication	(30)
Track Science Communication*	(27)
Masters thesisproject	(30)
Electrodynamics 1	(3)
Professional Preparation	(1)
Philosophy	(3)
Physics or Astrophysics Electives	(20)
Electives	(6)

If you are interested in the interaction between science and the society, science communication might be an interesting way to go. Science communication is one of the graduation variants on the beta-faculty in Nijmegen. Among other things, it deals with perceptions, participation processes, knowledge production, interdisciplinarity and risks and uncertainties in science. Moreover, much attention is paid to writing skills (essay, columns), presentation skills and research methods. During your graduation project (30 ECTS), you link up theory from the courses with your beta background.

The job profile entails three fields: intermediary organisations between science and society (advisory bodies, interest groups and gouvernements), science communication research and science journalism. The Science Communication graduation variant is not only a very interesting new field of study for which there is a need on the labour market, it provides you with knowledge that may come in handy in every speciality!

* Track Science Communication includes: Framing Knowledge (3), Knowledge Society (3), Science & Media: strategies and trends (only in Dutch) (3), Introduction Science Communication (3), Science & Societal interaction (3), Risk Communication (3), Boundary-Work: The Tension between Diversity and Sustainability (3), Visible Scientists (3), Elective (3). More information can be obtained at:
http://studiegids.science.ru.nl/2010/en/science/prospectus/ects_science/contents/

and from:
Prof. dr H. Zwart
Room: HG 02.808
Tel. 3652038
E-mail: h.zwart@science.ru.nl

3.3 Education variant (E variant)

E-variant	
E-traineeships	(57)
Masters thesis project	(30)
Electrodynamics 1	(3)
Professional Preparation	(1)
Philosophy	(3)
Physics or Astrophysics Electives	(20)
Electives	(6)

This variant is intended as a preparation for a job in education. It gives admission to the postdoctoral Teacher Education of the ILS. Orientation on education at a Dutch High School during some weeks (3 ec) is possible. More information:
http://www.ru.nl/ils/onderwijs/masteropleiding

This variant is not intended as a preparation for admission as a research PhD student in physics or astronomy. More information can be obtained from:
Edith Verbeet - ILS (Instituut voor Leraar en School)
Rob van Haren - ILS (Instituut voor Leraar en School)

Erasmusgebouw, kamer 20.18
tel.: (024)3615573
e-mail: E.Verbeet@ils.ru.nl
e-mail: R.v.Haren@ils.ru.nl

3.4 Business & Management variant (MT variant)

MT-variant

MT-traineeship	(27)
Track Management and Technology*	(25+5)
Masters thesis programme	(30)
Electrodynamics 1	(3)
Professional Preparation	(1)
Philosophy	(3)
Physics or Astrophysics Electives	(20)
Electives	(6)

This variant is intended as a preparation for jobs in the field of management. It is not intended as a preparation for admission as a research PhD student in physics or astronomy.

* Track management and Technology includes: Business & Society (5 ec), Finance & Accounting (5 ec), Innovation management (5 ec), Organization Theory (5 ec), Strategy & Marketing (5 ec) and one optional subject for example: Research Strategy and Management (3 ec) or perhaps Science and Entrepreneurship (3 ec).

More information can be obtained at:
studiegids.science.ru.nl/2010/en/science/prospectus/ects_science/contents

Ms H. Vreugdenhil
Kamer HG 02.832
tel.: 36 53155
e-mail: Hannekev@science.ru.nl

4 Description of the Courses

Advanced Computational Neuroscience

Course ID: **NM085B** *3 ec* prof. dr. P.H.E. Tiesinga

Teaching methods
- 16 hrs student project
- 16 hrs question session
- 52 hrs individual study period

Prerequisites
Quantitative Brain Networks and Computational Neuroscience

Objectives
This course follows **Computational Neuroscience** and covers results from the recent literature to bring the student up to speed with the state of the art in the field. Each meeting period will have a presentation of a designated instructor or student followed by a discussion. The course is concluded with a written essay instead of an exam. At the end of the course the student should be able to understand, present and discuss papers from the technical literature and write a short report about one of the topics covered during the course.

Contents
Computational neuroscience aims to explain neural dynamics and cognition in terms of simple principles and models, thereby relating the structure of the central nervous system to function

Subjects
Journal publications on computational neuroscience, ranging from synaptic dynamics to single neuron dynamics to population activity, covering issues such as, but not limited to, neural coding and decoding, function and generation of rhythms, learning & memory, and attention

Literature
Journal articles assigned during the class

Examination
The final grade will be based on your class participation, your presentation and your term paper

Extra information
Co-instructor:
- Dr I. Bojak
- Dr R.-M. Memmesheimer
- Prof. dr B. Kappen

Advanced Quantitative Brain Networks

Course ID: **NM084B** *3 ec* prof. dr. P.H.E. Tiesinga

Teaching methods
- 16 hrs lecture
- 16 hrs student project
- 52 hrs individual study period

Prerequisites
Quantitative Brain Networks and Computational Neuroscience

Objectives
The brain is all about communication, between individual neurons as well as between brain areas comprised of billions of neurons. To study brain communication advanced new experimental and mathematical techniques have been developed, which require mathematical sophistication and a neurobiological background to fully comprehend. The goal is to discuss, in depth, recent technical papers in the area *Brain networks and neuronal communication*. At the end of the course the student should be able to understand, present and discuss papers from the technical literature and write a short report about one of the topics covered during the course.

Contents
This course covers the experimental methods to assess connectivity; data analysis methods to extract connectivity from dynamics; statistical models for connectivity and dynamical models that reproduce the observed coherent brain states

Subjects
Journal publications covering the following issues:
1. Genetic approaches to determine the anatomy of the local circuit
2. Genetic approaches to probing the dynamics of the local circuit
3. Laminar dynamics of cortical circuits
4. Cross-frequency locking from the single cell level to entire brain areas
5. Brain segmentation based on connectivity patterns
6. The importance and role of the default mode network
7. Current advances in statistical measures of association
8. Realistic connectivity for neural mass models
9. Current topics in large-scale brain networks

Literature
Journal articles assigned during the class

Examination
The final grade will be based on your class participation, your presentation and your term paper.

Extra information

Co-instructor:

- Dr I. Bojak
- Prof. dr R. Kotter
- Prof. dr D. Norris
- Dr D. Schubert

Advanced Spectroscopy

Course ID: **NM075B** *6 ec* second semester prof. dr. T.H.M. Rasing

Teaching methods
- 28 hrs lecture
- 28 hrs problem session

Prerequisites
Bachelor Physics, Natural Science or Chemistry, Recommended: Solid State Physics and Physics of Molecules and Molecular Aggregates.

Objectives
- The student is familiar with state of the art spectroscopic tools (radiation sources and external parameters like pressure, temperature and magnetic fields)
- The student knows about their possibilities, limitations (ground state properties and excited state properties) and fields of application
- The student knows what kind of experimental tool to use to addess a specific research problem

Contents
In this course students will learn about state of the art spectroscopic techniques to study the properties of molecules, molecular aggregates and materials. In particular, the spectroscopic tools within the Nijmegen Centre for Advanced Spectroscopy will be treated, covering Laser spectroscopy, Nuclear Magnetic Resonance, Spectroscopy in High Magnetic Fields and Nano/Single Molecule Spectroscopy.

Literature
Will be announced during the course

Advanced Statistical Physics

Course ID: **NM029B** *6 ec* first semester prof. dr. M.I. Katsnelson

Website
Blackboard

Teaching methods
- 30 hrs lecture
- 30 hrs problem session

Prerequisites
Bachelor Course 'Statistical Physics'

Objectives
The course is focused on the concepts of order parameter, broken symmetry and scaling, with applications to solid state and soft condensed matter physics. General methods of theoretical physics such as path integrals and renormalization group are considered in a context of statistical physics.

Subjects
- Landau theory of phase transitions and the concept of order parameter. Examples: structural phase transitions, magnetism, liquid crystals, superconductivity, superfluidity
- Ginzburg-Landau theory; the role of fluctuations. Correlation length
- Concepts of scaling for the second-order phase transitions and its qualitative justification ("Kadanoff decimation")
- Wilson theory of the phase transitions: renormalization group and Îµ-expansion
- Order parameter, broken symmetry and topological defects
- Fluctuations in low-dimensional systems and Mermin-Wagner theorem. Berezinski-Kosterlitz-Thouless transition
- Scaling concepts in polymer physics. Scaling properties of a single polymer chain
- Introduction to the statistical physics of membranes
- Percolation theory

Literature
- Shang-Keng Ma. *Modern theory of critical phenomena,* Perseus Books Group, ISBN 0738203017
- Gilles de Gennes. *Scaling concepts in polymer physics,* Cornell University Press, ISBN 080141203X

Examination
Oral exam

Extra information
More information: www.theorphys.science.ru.nl/people/katsnelson

Astroparticle Physics

Course ID: **NM076B** *6 ec* first semester dr. J.R. Hörandel

Teaching methods
- 32 hrs lecture
- 32 hrs problem session

Prerequisites
Bachelor degree in (astro)physics with Observational techniques (e.g. 'Radioastronomy or Observational Astrophysics')

Objectives
- The student will master the physics behind ultra-high energy particles from space, especially their acceleration and propagation through interstellar space
- The student will master the physics behind collisional interactions of ultra-high energy particles, especially with atmospheric atoms and molecules
- The student will master the electromagnetic radiation properties emitted by accelarated elementary particles, especially low-frequency synchroton radiation
- The student will master the (astro)physics of possible sources of ultra-high energy particles, including supernova remnants, compact binaries and massive black holes
- The student will understand the observational techniques used to detect ultra-high energy astroparticles and ultra-high energy gamma-rays
- The student will familiarize him/herself with the newest observatories connected with astroparticle physics

Contents
Astroparticle physics is a quickly growing field, where charged particles (cosmic rays), neutrinos, and very high energy gamma-rays (> 100 GeV) are used to probe the Universe. An overview will be given of the current state of the field, on the current views of accelerating particles to energies in excess of 10^19 eV, on the physics of the propagation of these particles through interstellar space and the interactions these particles will have with the Earth's atmosphere and magnetosphere. A particular focus will be put on the observations of ultra-high energy cosmic rays with LOFAR and the Pierre Auger Observatory.

Literature
- T. Stanev, *High Energy Cosmic Rays*, Springer
- T.K. Gaisser, *Cosmic Rays and Particle Physics*, Cambridge University Press
- M.S. Longair, *High Energy Astrophysics, (Volume 1+2)* , Cambridge University Press
- V.S. Berezinsky, *Astrophysics of Cosmic Rays*, Elsevier Science, North-Holland

Examination
Written examination

Extra information
This course will be given odd-biennial in autumn; next time 2011/2012

Astrophysics Seminar

Course ID: **NM072B** *3 ec* first semester dr. G.A. Nelemans

Teaching methods

- 10 hrs personal study counseling

Objectives

- The students can critically read scientific articles
- The students can present scientific articles
- The students gain an understanding on how scientific articles are written
- The student broaden their scientific background by attending the colloquia

Contents

Astrophysics is an international discipline. It is important to know what research is done in other places. Therefore regular talks (Colloquia) are held by Astronomers from all over the world.
In addition masters students will give student seminars in which they critically discuss a recent article, present the results and lead a discussion on the topic of the paper.
See Prof. Falcke at the start of the academic year to choose an article and get a date assigned.
Each Astronomy master student will have to give a presentation each year in which he/she is doing his/her masters.

Literature

http://www.astro.ru.nl/wiki/news/seminars

Examination

Attendance and quality of the seminars.

Extra information

Compulsory for masters students Astrophysics

Beroepsorientatie

Vakcode: **FNWI001** *3 ec* eerste semester drs. J.G.J. van den Broek

Werkvormen

Inleidingen, zelfstudieopdrachten, marktverkenningen, vaardigheidstrainingen, presentaties.

Vereiste voorkennis
De cursus is toegankelijk voor studenten uit de masterfase van alle bètaopleidingen.

Leerdoelen
Studenten
- krijgen meer inzicht in hun eigen competenties en ambities
- kunnen hun competenties en ambities relateren aan de eisen van het werkveld
- verzamelen op een interactieve manier informatie over relevante ontwikkelingen binnen hun zoekrichting
- verkennen de mogelijkheden om een passende baan te verwerven
- leren om zich in woord en geschrift te presenteren als "academisch professional"

Beschrijving
De cursus bestaat uit de volgende onderdelen:
- Zelfverkenning en zelfanalyse (wie ben ik, wat kan ik, wat wil ik?)
- Arbeidsmarktoriëntatie en actieve verkenning van de zoekrichting
- Vaardigheidstrainingen (met o.a. afstudeerplan) en sollicitatietrainingen (brief, c.v. en sollicitatiegesprek).

Literatuur
Ondersteunend cursusmateriaal wordt ter plekke uitgereikt.

Bijzonderheden
In verband met de vaardigheidstrainingen is aanwezigheid verplicht. Er is plaats voor 16 deelnemers per cursus. Schriftelijke opdrachten, mondelinge presentaties en eindverslag.

Tijdens de cursus "Beroepsoriëntatie" richten we ons in eerste instantie op de arbeidsmarkt voor afstuderende bèta's in Nederland. Omwille van de diepgang en de nuances in de persoonlijke reflecties, analyses en feedback is taal vereist op het niveau van "native speaker". Bij dit keuzevak gebruiken we daartoe de Nederlandse taal.
De cursus wordt twee keer per jaar aangeboden: in het najaarsemester op dinsdagmiddag (13.45 - 17.30 u.)
in het voorjaarsemester op vrijdagmiddag (13.45 - 17.30 u.).

Beyond the Standard Model

Course ID: **NM022B** *6 ec* second semester prof. dr. A.N.J.J. Schellekens

Teaching methods
- 32 hrs lecture

Prerequisites
Theoretical Foundations of Elementary Particle Physics

Objectives
- The student understands the main outstanding problems of the Standard Model and some possible solutions

Contents
In this course a selection of new ideas for extending and improving the Standard Model of particle physics will be discussed. Depending on the theoretical and experimental status of these ideas and the interest of the students, topics may include neutrino masses and oscillations, supersymmetry, Grand Unification, composite quarks and/or leptons, extra dimensions and 'brane worlds' and others.

Literature
Necessary:
- Lecture notes 'Beyond the Standard model' available at www.nikhef.nl/~t58

Examination
Oral examination

Extra information
This course will be given even-biennial

Black Holes in Active Galactic Nuclei

Course ID: **NM018B** *6 ec* first semester prof. dr. P.J. Groot

Teaching methods

- 16 hrs computer course
- 24 hrs lecture
- 24 hrs problem session

Prerequisites

Bachelors in Physics and Astronomy

Objectives

- The student masters methods from high-energy astrophysics and is able to apply these to Active Galactic Nuclei and Black Holes
- The student is able to model these processes numerically in a simplified setting
- The student understands the physics of accretion disks around black holes
- The student understands the physics of jets and how we can estimate physical conditions around the black hole from them

Contents

Accretion is the Universe's powerhouse: over the lifetime of the Universe most electromagnetic radiation has been produced by the accretion if gas onto the supermassive black holes in the centers of galaxies. These so-called Active Galactic Nuclei (AGN) host a range of physics phenomena that are not only important for understanding the physics in the direct environment of these black holes, but, e.g. through the generation of supersonic jets, also on the structure and evolution of the galaxies surrounding these active nuclei. After a general introduction to AGN, we focus on relativistic jets and compact radio sources, synchrotron radiation, shock acceleration, black hole basics, standard accretion discs, advection-dominated accretion flows, the emission-line region of AGN and a unified view of AGN.
Students will be trained in modeling some of these phenomena with relevant physics on the computer.

Literature

- Lecture notes

Examination

Grading will be based on presentation and assignments

Extra information

This course will be given even-biennial in autumn.
The course is taught by dr. Elmar Körding

Brain and Behaviour 2

Course ID: **NM050B** *6 ec* second semester prof. dr. C.C.A.M. Gielen

Website
Blackboard

Teaching methods
- 28 hrs lecture

Prerequisites
Brain and Behaviour 1

Objectives
- The student is familiar with the main problems in the field of visual perception and motor control
- The student is familair with Information Theory (Mutual information and maximum log likelyhood estimator) to estimate information transfer
- The student can apply deterministic optional control (including Hamilton-Jacobi-Bellman equation and Pontryagin Maximum Principle)
- The student has the mathematical skills to develop advanced models to explain recent experimental data in a unified conceptual frame work

Contents
This course will present general principles of neuronal information processing. These principles are illustrated by discussing the functional characteristics of the visual system and motor system in man.

Subjects
- Control Theory
  - Conditions of stability of nonlinear systems
  - Conditions for stable control
  - Algorithms for optimal control
- Information Theory
  - Entropy; mutual information
  - Efficiency of information coding
  - Parameter estimation principles
- The visual system
  - Organisation of the visual system
  - Efficiency of visual information processing
- The motor system

- Organisation of the motor system
- Optimal control of the motor system
- Control of redundant manipulators

Literature
Necessary:
- Lecture notes (For sale at secretary's office of Biofysica room 0.20 M244, Geert Groteplein-Noord 21)

Examination
Written exam

Extra information
More information: www.mbfys.ru.nl/~stan/

Compact Binaries: Physics and Evolution

Course ID: **NM024C** *6 ec* second quarter prof. dr. P.J. Groot
dr. G.A. Nelemans

Teaching methods
- 10 hrs computer course
- 30 hrs lecture
- 30 hrs problem session

Prerequisites
Bachelor degree in (astro)physics with Stellar evolution ('sterevolutie').

Objectives
- The student will be have a working knowledge of the equation of state of compact objects
- The student will be able to explain the formation of compact binaries
- The student will master the physics of accretion and be able to relate this to observed phenomena.
- The student will understand how compact binaries can be observed at all electromagnetic wavelenghts and in gravitational waves

Contents
Binary stellar systems containing at least one compact object (a white dwarf, neutron star or black hole) are ideal place to study physics under extreme conditions: strong gravity, high energy, supranuclear densities, strong radiation fields, 'naked' fusion. Compact binaries host most of the observed high energy physics phenomena as observed in the X-ray and gamma-ray sky: X-ray bursts, X-ray pulsars, novae, Supernovae Type Ia, radio and X-ray jets, accretion disks and perhaps even gamma-ray bursts. The course will give an overview of the formation of the compact binary. The (interior) physics of compact objects will be explained (supranuclear densities, degenerate matter, quark-gluon plasmas, superfluidity and superconductivity). In most systems accretion of matter is reponsible for the observed phenomena. The physics of accretion will be detailed and a relation will be made with the observed phenomena.

Literature
Recommended:
- Lewin & Van der Klis, *Compact Stellar X-ray Sources*

Examination
Exercises and a presentation on a relevant topic in a concluding 'mini-symposium'.
Computer programming exercise

Extra information

INLEIDINGEN, ZELFSTUDIEOPDRACHTEN, MARKTVERKENNINGEN, VAARDIGHEIDSTRAININGEN, PRESENTATIES.

This course will be given even-biennial, in quarter 2 and 3!

Computational Neuroscience

Course ID: **NM047B** *6 ec* first semester prof. dr. H.J. Kappen
prof. dr. P.H.E. Tiesinga

Website
Blackboard

Teaching methods
- 30 hrs lecture
- 30 hrs problem session

Prerequisites
Inleiding Biofysica; neurophysics

Objectives
After successful completion of the course
- the student is able to calculate the response of a neuron or of a network of neurons to various inputs, both analytically and by computer simulations
- the student should be able to apply basic principles from Information Theory and Non-linear Systems analysis to quanitfy information processing by networks of neurons and to determine the attraction domain and stable states of a network of neurons.

Contents
The aim of this course is to give a theoretical description of the neuronal dynamics at the level of a single neuron and at the population level. The theoretical model will be used to explain the information processing and the storage and retrieval of information by populations of neurons.
The course consists of two parts. The first part is given by Kappen and consists of the following topics: Integrate and fire neurons, networks of binary neurons, synaptic plasticity, supervised and unsupervised learning, classical conditioning, reinforcement learning, control theory

This course deals with the mechanisms underlying the communication by and between cells in the central nervous system. It begins with the dynamics of changes in the configuration of proteins that are responsible for the transport of ions (sodium, potassium, chloride, etc.) through the outer cell membrane, and a biophysical model of the nerve cell is developed. Then, neuronal information processing and information storage within the CNS is treated, and how self organisation of the CNS can be understood from basic principles about development and learning.

Subjects
For part Kappen, see http://www.snn.ru.nl/~bertk/comp_neurosci/

For the part Gielen, see www.mbfys.ru.nl/~stan

Literature
Necessary:
- Reader with chapters from *Handbook of Biological Physics*, Vol.4: Neuro-Informatics and Neural Modeling. Editors: Gielen and Kappen, Elsevier, 2001 (For sale at secretary's office of Biofysica, room 020 M244, Geert Grooteplein-Noord 21)

Recommended:
- Theoretical Neuroscience, Computational and Mathematical Modeling of Neural Systems, by Dayan and Abbott, MIT Press, paperback version, (2005) is highly recommended.

Examination
Written exam

Extra information
The course relies on active student participation. The students will present most of the material.
The examination is based on these presentations, the regular and computer assignments, and on an essay that summarizes the recent developments on a particular neuroscience topic.

Computational Physics

Course ID: **NM015B** *6 ec* second semester prof. dr. A. Fasolino
prof. dr. H.J. Kappen

Teaching methods
- 60 hrs lecture

Prerequisites
Knowledge of a programming language and the course numerical methods

Objectives
- The student can use computer simulations to address a variety of problems in physics. This ability makes possible either to gain a deeper understanding of physics already studied in other courses or to address a broader class of problems than traditionally studied in undergraduate courses
- In the module on Artificial Intelligence the student has learned that for a class of artificial intelligence problems, the required computations are similar to problems in statistical mechanics. Therefore, similar approximation techniques can be used. The student is able to apply these techniques on actual expert systems that are built at the RU

Contents
This course introduces prototypical models and computational methods developed to deal with complex physical systems and phenomena, particularly in statistical mechanics and artificial intelligence.

Subjects
- Review of Statistical physics:
  - Relation between microstates and observables
  - Deterministic and stochastic simulations
- Random processes:
  - Random walk, percolation
  - Critical exponents, finite size scaling
- Monte Carlo simulations:
  - Crude and importance sampling, Metropolis algorithm, non-Boltzmann sampling
  - Ising model
- Molecular dynamics:
  - Description of interatomic forces, integration of equations of motion
  - Microcanonical, constant temperature simulations
  - Simulated annealing
- Artificial intelligence:

- graphical probability models for expert systems
- approximate inference with MCMC and belief propagation
- combinatoric optimization with simulated annealing and belief propagation

Literature

Relevant books are present in the library and do not have to be bought. For the AI part, the book by David Mackay: Information theory, inference and learning algorithms (see www.inference.phy.cam.ac.uk/mackay/itila/ for online version) will be used as background material.

Examination

For each topic students carry out a computer project which is then summarized in a short report. A final task is chosen in agreement with the teacher, either on one of the course topics or in other relevant fields.

Extra information

This course will be given odd-biennial

Condensed Matter Theory

Course ID: **NM068B** *6 ec* second semester prof. dr. M.I. Katsnelson

Website
www.theorphys.science.ru.nl/people/katsnelson

Teaching methods
- 30 hrs lecture
- 30 hrs problem session

Prerequisites
Bachelor Courses 'Quantum Mechanics' and 'Statistical Physics'

Objectives
The course is focused on the concept of quasiparticles and many-body effects in condensed matter theory (including magnetism, superconductivity, superfluidity, metal-insulator transitions, etc.)

Subjects
- Types of condensed matter. General quantum-mechanical problem of a crystal. Adiabatic approximation
- Lattice dynamics. Phonons as prototype quasiparticles. Scattering by the lattice and correlation functions. Anharmonic phenomena
- Conduction electrons in solids. The effect of external electric and magnetic fields on the Bloch states. Zener breakdown. Quantum oscillation phenomena (de Haas-van Alphen, Shubnikov-de Haas effects). Quantum Hall effect
- Plasma phenomena in solids. Plasmons as an example of collective excitations. Landau theory of Fermi liquids. Mott transitions and the restrictions of the band theory of crystals
- Magnetism, exchange interactions, spin waves. Types of magnetic ordering, quantum theory of ferro- and antiferromagnets. Interaction of conduction electrons with spins. Kondo effect
- Superconductivity. Phenomenological theory of superconductivity. Flux quantization. Josephson effect. Cooper pairing and the BCS theory
- Bose-Einstein condensation and superfluidity. The model of nonideal Bose gas. Feynman variational approach to the superfluidity of He^4

Literature
Recommended:
- S.V. Vonsovsky and M.I.Katsnelson, *Quantum solid state physics*
- C. Kittel, *Quantum theory of solids*

Examination
Oral examination

Cosmology

Course ID: **NM026C** *6 ec*

dr. G.A. Nelemans
prof. dr. P.J. Groot
drs. M.T.B. Nielsen

Teaching methods
- 32 hrs lecture
- 3 hrs student presentation
- 32 hrs problem session

Objectives
The students masters the most important methodes in non-electromagnetic and emerging fields of astrophysics, in particular:
- The student understands the physics of gravitational radiation
- The student understands the measurements, implications and physical settings the Cosmic Microwave background, in particular in the context of general relativity
- The student understands the physics of gravitational lensing, both in the case of microlensing, as well as on galaxy cluster scales

Contents
The early Universe is, par excellence, the area where astrophysics and high energy physics come together. Relevant topics that find their origin in this overlap regions are:

- The formation of elementary particles,
- the origin of density variations as seen in the micro-wave background,
- the nature and evidence for dark matter,
- the nature and evidence for dark energy
- observations of distant supernovae Type Ia
- the theory and use of gravitational lensing (strong, weak and microlensing)

Literature
Recommended:
- Peacock, *Cosmological Physics*, Cambridge University Press, ISBN 0-521-42270-1
- http://www.astro.ru.nl -> studiemateriaal

Examination
Grading will be based on the assignments, a presentation and a computer programming excercise

Extra information
This course will be given odd-biennial in autumn; first time again in 2011-2012

Data Analysis

Course ID: **NM067B** *3 ec* fourth quarter dr. A.V. Kimel

Teaching methods
- 16 hrs lecture

Prerequisites
Numerical Methods. The basics of MATLAB

Objectives
The students will understand basic principles, assumptions and limitations of statistical data analysis. They will be capable to apply statistical method for analysis and interpretation of experimental results.

Contents
The course will introduce basic statistical principles and approaches for analysis and interpretation of experimental data in physics and other sciences

Subjects
The course will cover the following topics:

- ***Describing outcome of an experiment as a random variable*** (Central limit theorem, Law of large numbers)
- ***Parameter estimation***(Criteria of quality of parameter estimation, Estimation of expected value and variance from experimental data (direct and indirect measurements), Moments of probability law and sample moments, Method of moments, Maximum likelihood)
- ***Fit of experimental data***(Least squares and linear least squares, Assessing quality of fit and Ï‡^{2}-distribution)
- ***Testing hypothesis***(Probability plots, Null hypothesis, Comparison of two normally distributed samples, Student's t-distribution)
- ***Signal processing***(Fourier transformation, Spectra of periodic and pulsed signals, Fourier transformation of discrete (experimental) data, Sampling, Temporal profile of signals with bandwidth limited spectra (sampling theorem))

Literature
- Lecture notes

Recommended:
- R.J. Barlow, *Statistics: A guide to the Use of Statistical Methods on the Physical Sciences* (John Wiley & Sons, Chichester, 1989)
- F. James, *Statistical Methods in Experimental Physics* (World Scientific, Singapore, 2006) 2nd edition
- J.A. Rice, *Mathematical Statistics and Data Analysis* (Belmont, CA: Thomson Brooks/Cole, 2006) 3rd edition

Examination
Oral examination is combined with take-home problem of data analysis

Electrodynamics 1

Course ID: **NM001B** *3 ec* first quarter dr. ir. G.A. de Wijs

Teaching methods
- 14 hrs lecture
- 14 hrs problem session

Prerequisites
Bachelors course electromagnetism or equivalent.

Objectives
- The student has a thorough understanding of classical radiation theory
- The student is capable to solve the exercises of the treated subjects at the level of Jackson's 'Classical Electrodynamics'

Contents
The subject of this course is electromagnetic radiation. The course opens with short review of Maxwell's equations and the potentials, followed by the conservations laws for energy, momentum and angular momentum and a derivation of the retarded Green function from Maxwell’s equations. This Green function is the basis for the treatment of radiation, starting with the radiation of an oscillating charge distribution in the multipole expansion up to and including the quadrupole term. A further application is Rayleigh scattering and the structure function of a material. This Green function is also used to derive the potential (Lienard-Wiechert) and radiation from an accelerated charge. The special case of a constant velocity larger than the speed of light in a medium leads to a qualitative description of Cerenkov radiation. The case of uniform circular motion is worked out to the point of a qualitative treatment of the power spectrum of cyclotron and synchrotron radiation. Other important examples that are treated in the course are radiation from scattering of light to a free electron. (Thomson and Compton scattering) and radiation from a collision of two charges (Bremsstrahlung). Level: Introduction to Jackson: 'Electrodynamics'

Literature
Necessary:
- J.D. Jackson, *Classical Electrodynamics,* 1998, ISBN 0-4713-0932-X
- A syllabus will be distributed during the course.

Examination
Written examination

Electrodynamics 2

Course ID: **NM002B** *3 ec* second quarter dr. ir. G.A. de Wijs

Teaching methods

- 16 hrs lecture
- 16 hrs problem session

Prerequisites

Electrodynamics 1

Objectives

- The student understands the concepts/topics outlined at "Contents" below.
- The student is capable to solve and answer the exercises and questions concerning the treated subjects at the level of Jackon's '*Classical Electrodynamics*'.

Contents

The topics covered in this course are (a) the Lagrange and Hamilton formalism for a charged particle in an electromagnetic field, both non-relativistically and relativistically, (b) a complete but concise treatment of multipole radiation, (c) the classical connection between macroscopic fields D and H and the macroscopic fields E and B, (d) birefringence, (e) (model) dielectric functions of metals and non-metals and their role in, e.g., optical response and EELS, and (f) the Kramers-Kronig relations. (c-e) all relate to electro-magnetic phenomena in matter. Also a quantum excursion into (c) is made, where the connection between polarisation/magnetization of crystals and the microscopic Bloch functions becomes apparent in the so-called ``modern theory of polarisation and (orbital) magnetization", dating from respectively the 1990s and the current decade.

Literature

Necessary:
J.D. Jackson, *Classical Electrodynamics,* 1998, ISBN 0-4713-0932-X
Additional syllabus (will be made available during the course)

Examination

Written examination

Electronic Structure of Materials

Course ID: **NM038B** *6 ec* second semester prof. dr. R.A. de Groot

Teaching methods

- 32 hrs lecture

Objectives

- To acquire basic knowledge and understanding of modern electronic structure methods
- To acquire basic knowledge and understanding of (crystallographic) group theory
- To perform electronic structure calculations on simple model systems independently
- To abstract physical properties and understanding from the calculations defined under 3

Contents

Tutorials involve the calculation of electron structure of:

- Simple metals
- Magnetic metals
- A semiconductor
- A relativistic material

all with the use of existing computer programs.

Subjects

- Reciprocal space, Brilliouin zones and group theory associated to electron structure calculations
- Basic sets, pro's and con's
- Density functional theory
- APW, ASW and LSW methods in some detail

Literature

- Lecture notes and references given during the lectures

Examination

Oral exam

Experimental Techniques

Course ID: **NM004B** *3 ec* first semester dr. S.A.J. Wiegers

Teaching methods
- 12 hrs lecture
- 12 hrs problem session

Prerequisites
- Bachelor Program Laboratory Courses

Objectives
- The student understands the experimental and physical background of achieving high vacuum, of operating lasers, achieving low temperaturs and using electronic lock-in signal techniques
- The student is able to translate a scientific question into an experimental design/realisation

Contents
Modern physics depends heavily on advanced experimental techniques. The technological fields of vacuum technology, laser technology, cryogenic technology and electronics are essential when translating a scientific question into an instrument including the collection and use of the observations. In this course, we want to stay close to the technology, pumps, lasers, coolers, lock-in amplifiers explaining their physical and practical operating principes. Next to making series of problem sets on the different topics, a self-chosen scientific problem and its experimental solution will be described and presented.

Literature
Heighly recommended:
J.H. Moore, C.C. Davis and M.A. Coplan, *Buiding Scientific Apparatus,* 4^{e} edition, Cambridge University Press, ISBN 978-0-52187858-6

Examination
- Take home experimental construction problem
- Oral presentation

Interacademic Course Astrophysics

Course ID: **NM063B** *6 ec* second semester prof. dr. P.J. Groot

Teaching methods

- 32 hours lecture
- variable hours (group)assignments

Contents

In the framework of a Dutch national astrophysics master at least one course a year will be given nationally, at the Utrecht University. The topic of each year's course is changing, and will mostly cover topics outside of the Nijmegen astrophysics Masters curriculum. The topic of the year 2010/2011 will be announced as soon as it is known.

Literature

www.uu.nl/uupublish/homeuu/deuniversiteit/wiewatwaar/1137main.html

Extra information

The course will be given in Utrecht on Wednesdays from 11h to 16h.
Morning (11 am-13 pm) lectures will be followed by practical work, tutorials, and guest lectures on specific topics in the afternoon.
The morning lectures will be held in the Minnaert building.
You can reach the Uithof from Utrecht CS with bus 11 or 12, leaving the station every 3-5 min. Allow for about 25 min to reach the Minnaert building from the station. Maps and directions can be found at the the university webpage. In case of major group delays (trains or weather) you are asked to inform the lecturer. Coffee, tea and lunch are available in the Minnaert canteen (chipcard required). A prepaid card can be bought at the entrance hall.

Interaction of Light with Molecules and Materials

Course ID: **NM074B** *6 ec* second semester dr. A.V. Kimel

Teaching methods

- 16 hrs lecture
- 16 hrs problem session

Prerequisites

Inleiding Vaste Stof Fysica, Inleiding Atoom- en Molecuulfysica, Quantummechanica 1a,1b

Objectives

Bridging the gap between Bachelor Courses and Specialized Capita Courses, Broad Introduction to Optical Techniques in Research

Contents

We will present the quantum mechanical description of the interaction of light with quantum systems, introducing incoherent and coherent interactions and their non-intuitive consequences. Where abstract quantum systems are isotropic, solids and interfaces are not. The optical response of these systems requires vector and tensor descriptions. The course will explain why different solids (insulators, semiconductors, metals, super-conductors) have different optical responses. A special attention will be paid to non-linear optical processes, which allow changing the colour of light, ultrasensitive diagnostic of surfaces and interfaces. It will be shown that at the shortest most intense pulses, processes change. The special position of NMR (or MRI) will be explained.

Subjects

At the end of the course the student is expected to obtain knowledge on the following issues:

Interaction of Light with Matter

- Quantum treatment of atom-radiation interaction
- Two-level and few-level systems
- Rabi frequency
- Bloch vector, optical Bloch equations
- Principles of Coherent control
- Introduction to quantization of the optical field
- Excitation by intense laser fields (guest speaker)

Optics of Molecules and Atoms

- Linear optics (line shapes, the role of collisions)
- Non-linear optics in atoms and molecules (multi-photon excitation, (stimulated) Raman scattering, AC Stark shifts)
- Ultra fast spectroscopy
- Examples of coherent control
- The few level system, description of NMR/MRI

Optics of Materials

- Linear optics (approximations, dielectric permittivity, magneto-optical effects)
- Tensor representation of optical phenomena

• Nonlinear optics (approximations, optical rectification, second harmonic generation, photo-refraction, stimulated Raman scattering)
• Ultra-fast optics of solids (optical Bloch equation, semiconductor Bloch equations, ultra-fast transient processes in solids)
• Optics of dielectrics, semiconductors, metals and superconductors (approximations, specific spectral features and their correlation with transport properties)

Literature

- Lecture notes

Recommended:

- R. Loudon, *The Quantum Theory of Light* (Oxford University Press, USA, 2000).
- L. D. Landau, E. M. Lifshitz, *Electrodynamics of Continuous Media.* (Pergamon, Oxford, 1984).
- R. R. Birss, *Symmetry and Magnetism* (North-Holland,Amsterdam, 1966).
- Y. R. Shen, *The Principles of Nonlinear Optics* (John Wiley & Sons, 2003).

Examination

Open book oral examination

Introduction to C++

Course ID: **NM073B** *3 ec* second semester dr. F. Filthaut

Teaching methods

- 14 hrs lecture

Prerequisites

Basic programming skills (*e.g.*, experience with C or Fortran)

Objectives

- knowledge of basic C++ syntax
- knowledge of object orientation using C++
- ability to code algorithms using C++

Contents

C++ has become the *lingua franca* of modern computer programming, especially where large software projects are involved and efficiency is an issue.
The aim of this course is to provide students with sufficient basic skills for them to be able to participate in such projects. The course is slightly biased (in its examples and exercises) towards high-energy physics but is meant to be accessible to others, too.

Subjects

1. basic language features
2. modularity and structured programming
3. basics of classes
4. design features of classes
5. I/O using the Standard Library
6. templates
7. the Standard Template Library
8. inheritance and polymorphism
9. exception handling

Literature

Lecture notes will be available
Recommended literature:

- B. Stroustrup, *The C++ Programming Language*, 3rd edition, Addison Wesley, ISBN 0-201-88954-4
  This book by the creator of C++ contains a wealth of information, which makes it worth having for everyone dealing with C++ on a regular basis. However, it is not very suitable

as a tutorial

- J.J. Barton and L.R. Nackman, *Scientific and Engineering C++: An Introduction with Advanced Techniques and Examples*, Addison Wesley, ISBN 0-201-53393-6
  Though slightly outdated, this book provides one of the best tutorial introductions to C++

Examination
Through exercises

Extra information
Computer access is essential

Introduction to Computer Graphics

Course ID: **NM058B** *6 ec* first semester drs. P.F. Klok

Teaching methods
- 84 hrs computer course
- 28 hrs lecture

Prerequisites
Required is programming experience at the level of Programmeren (NB021B) or equivalent

Objectives
- Familiarize with basic terms and techniques used in computer graphics and image processing.
- Familiarize with implementation of various techniques in both fields.
- A well-funded judgement on graphics matters should be obtained.
- A quick mastering of graphics software should be obtained.

Contents
During the lectures the basics of computer graphics and image processing are covered. The assignments of the practical course follow the topics of the lecture text. A written examination about the topics of the lecture text concludes the course.

Subjects
- **General:**
  basic notions, synthetic camera, windows, viewports, clipping, coordinate systems, graphical standards
- **Interactive Graphics:**
  windows, graphical objects, input classes, user interface
- **2D and 3D Graphics:**
  transformations, projections, graphics pipeline, hidden-line and hidden-surface removal
- **Raster Graphics:**
  frame buffers, scan conversion, colour models
- **Rendering:**
  ray tracing and ray casting, reflections, shading, splines
- **Image Reconstruction**:
  fourier transforms, backprojections
- **Image Enhancement:**
  filtering, histogramming
- **Visualization:**
  pseudo colour, lookup tables

Literature
Necessary:

- Website http://www.hef.ru.nl/~pfk/education/icg/

Strongly recommended:
- Foley, van Dam, Feiner, Hughes, Phillips, *Introduction to Computer Graphics*, Addison Wesley, 1993, ISBN 0-201-60921-5.

Examination
Exercises and preliminary examination.

Extra information
Lectures followed by practical work to elaborate on lecture topics
The graphical package OpenGL is used with programs written in the C programming language

Introduction to Neuroimaging techniques

Course ID: **MOL074** *3 ec* kwartaal 11 prof. dr. D.G. Norris

Teaching methods
- 18 hrs lecture
- 18 hrs problem session

Prerequisites
Inleiding Magnetische Resonantie. Basic knowledge of electric and magnetic fields.

Objectives
The primary aim of the course is to give students insight into the main methods of cognitive neuroimaging and the underlying biochemistry and biophysics. At the end of the course the students should be able to understand:
1. The basic biochemistry of brain activation
2. How metabolic activity can be measured with magnetic resonance spectroscopy
3. Image formation in MRI
4. The mechanisms of fMRI
5. The origin of the EEG and MEG signals
6. The rudiments of analysis in the source and sensor domains

Contents
The course is divided into three parts:

1. Magnetic resonance spectroscopy and brain kinetics. The biochemistry of brain activation will be explained, and methods of measuring metabolic activity with magnetic resonance spectroscopy described.
2. functional Magnetic Resonance Imaging (fMRI). This will start with a short review of some of the material covered in the course 'Inleiding Magnetische Resonantie'. It will then move on to examine the role of pulsed magnetic field gradients in imaging techniques. This will culminate in the k-space description of imaging and the echo planar imaging experiment. We will then study the physiologogy and biophysics associated with brain activation studies.
3. The physiological processes responsible for producing EEG and MEG signals will be explained. There will be a demo of data acquisition in the MEG laboratory. After it will be explained how the data are analyzed both in the time and frequency domains. It will be demonstrated how the neuronal sources producing the signals can be identified. Finally different examples will be covered showing how EEG and MEG data can been used to answer cognitive neuroscience questions.

Literature
- D. W. McRobbie, E. A. Moore, M. J. Graves and M. R. Prince, *MRI - from picture to*

proton. Cambridge University Press, Cambridge, 2003, pp. 359 paperback, ISBN 0-521-52319-2.
- D.G. Gadian, *NMR and its applications to living systems*, 2nd edition 1998, Oxford Science Publications, ISBN 13978-0-521-68384-5

These will be available in the library.

Examination
Each part of the course will consist of lectures, assignments and 'werkcolleges'. Performance of the assignments and attendance at the 'werkcolleges' is compulsory in order to pass the course. At the conclusion of each block a short open book test will be available for performance in the three open book tests, a minimum of 70% will be given for a closed book written exam at the end of the course. The scores from the open book tests will only be included if they improve the total score.

Introduction to Partial Differential Equations

Course ID: **WB046B** *6 ec* second semester prof. dr. H.T. Koelink

Teaching methods

- 32 hrs lecture
- 32 hrs problem session

Prerequisites

Calculus 1-4, Analysis 1-2, Ordinary Differential Equations (or Applied Mathematics 1)

Objectives

Te student is to able to work with partial differential equations, as well as to distinguish between various classes of pde's. For such classes the student is able to discuss solution methods as well as theoretical considerations.

- The student is acquainted with partial differential equations and classical and weak solutions;
- The student is able to classify partial differential equations according to classification schemes;
- The student is able to solve simple first order partial differential equations explicitly using the methods of characteristics;
- The student is acquainted with a few classical partial differential differential equations such as the Laplace, heat and wave equation;
- The student is acquainted with maximum principles and the energy method

Contents

A partial differential equation describes a relation between the partial derivatives of an unknown function and given data. Such equations appear in all areas of physicsan engineering. More recently the use of PDEs in models in biology, pharmacy, imageprocessing, finance etc. have increased strongly. Since the origin of these models is very diverse and the results should be applicationdriven, the analysis of PDEs has many facets. The classical approach focused on finding explicit solutions. Since numerical methods and fast computers became available, the modern approach is more oriented to the application of functional analytic methods in order to find existence and uniqueness results and to show that solutions depend continuouslyon the given data. Having existence, uniqueness and stability under perturbations, a numerical method may be implemented to find an approximation of the solution one is interested in. The present course will be an introduction to the field. The elementary classical results will be explained and we will touch some of the more modern aspects.

Subjects

- Introduction: some elementary models will be explained and different types of PDEs will be classified.
- First order equations: the method of characteristics, conservation laws and shock waves.
- Linear second order equations: the heat equation, the laplace equation and the wave equation are classical second order models.
- The wave equation for one space dimension: The Cauchy problem and d'Alembert's solution.
- Seperation of variables. For special domains and special PDEs one may split the problem into a set of ODEs.
- Sturm-Liouville equations. Parameter dependent boundary value problems for ODEs.
- Elliptic equations. The maximum principle and uniqueness.
- Integral representations. For some special cases Green functions give an almost explicit solution.
- Equations in higher dimensions: the classification in parabolic, elliptic and hyperbolic equations. Some explicit solutions.
- Variational methods. Introducing the weak formulation

Literature
Lecture notes, which will be made available via Blackboard.
Secundary literature 'An Introduction to Partial Differential Equations' by Y. Pinchover, J. Rubinstein, Cambridge University Press.

Examination
Schriftelijk tentamen.

Introduction to String Theory

Course ID: **NM059B** *6 ec* second semester prof. dr. A.N.J.J. Schellekens

Teaching methods
- 32 hrs lecture

Prerequisites
Theoretical Foundations of Elementary Particle Physics

Objectives
Student understands main goals of Superstring Theory and the present status

Contents
In this course an introduction to string theory will be given. At this moment string theory is the most important candidate for a quantum theory of gravitation, describing at the same time strong, weak and electromagnetic interactions as we know them. Over the past thirty years string theory developed to an extended web of new ideas in theoretical and mathematical physics.
In this course a number of basic concepts are treated. In addition a not too detailed overview of the field is given addressing also recent developments.

Literature
Necessary:
- Lecture notes, available at www.nikhef.nl/~t58

Background material:
- B. Zwiebach, *A first course in String Theory*

Advanced:
- M. Green, J. Schwartz and E. Witten, *Superstring Theory (I+ll)*, Cambridge University Press, 1987
- J. Polchinski, *String Theory (I+II)*, Cambridge University Press, 1998

Examination
Oral exam

Extra information
This course will be given odd-biennial

Lasers and Electro-Optics

Course ID: **NM008B** *6 ec* second semester dr. F.J.M. Harren

Teaching methods
- 30 hrs lecture
- 30 hrs problem session

Prerequisites
Completed B.Sc. programme

Objectives
- The student is able to describe the physics of lasers
- The student is able understand the various types of laser systems
- The student is able to understand and describe non-linear
- The student is able to engineer electro-optical devices

Contents
This course provides a detailed introduction to the basic physics and engineering aspects of lasers, as well as to the design and operational principles of a wide range of optical systems and electro-optic devices. Throughout, important derivations and results are given, as are many practical examples of the design, construction and performance characteristics of different types of lasers and electro-optical devices. The lecture deals with the fundamentals of laser physics, the characteristics of laser radiation, and discusses individual types of laser, including optically pumped insulating crystal lasers, atomic gas lasers, molecular gas lasers and semiconductor lasers. The electro-optic part deals with topics such as fundamentals of non-linear optics, parametric processes and electro-optic and acousto-optic devices.

Literature
Necessary:
- Davis, *Lasers and Electro-optics, Fundamentals of Engineering,* Cambridge Univ. Press 2002, ISBN 0-521-48403-0

Examination
Open book examination

Lie Algebras

Course ID: **NM028C** *9 ec* first semester prof. dr. G.J. Heckman
prof. dr. H.T. Koelink

Teaching methods
- 42 hrs lecture
- 14 hrs problem session

Prerequisites
Symmetry or Introduction Group Theory

Objectives
- The student becomes familiar with Poisson algebras Universal enveloping algebras.
- He also knows the representation theory of SL(2) Representations via constructions of linear algebra Reductive Lie algebras.
- The student knows Verma representations and the representation theory of SL(3) Physical applications: Spin and quarks.
- The student knows the Weyl character formula Spherical harmonics.
- The student knows SO(n) Physical application: The Kepler problem.

Contents
In this course we discuss the mathematics of Lie algebras and their representations. The basic examples are the Heisenberg algebra, the special linear algebra SL(n) and the orthogonal algebra SO(n). For each of these algebras we discuss the physical relevance which lie mainly in the realm of particle physics. We also discuss the link with invariant theory, an important subject in geometry. The course is interesting for students in both physics and mathematics, and standard for students in mathematical physics. The material of the course is useful for the courses "Beyond the Standard Model" and "Introduction to String Theory" of Prof. dr. B. Schellekens.

Literature
Lecture notes will be made available electronically via blackboard.

Examination
Oral exam

Extra information
The course will only be taught given a sufficient number of participants. Please register via blackboard.

Machine Learning

Course ID: **NM048B** *6 ec* first semester prof. dr. H.J. Kappen
dr. W.A.J.J. Wiegerinck

Teaching methods
- 40 hrs lecture

Prerequisites
- Neural Networks and information theory

The following courses are useful but nor required: Voortgezette Kansrekening , Markov ketens, Toegepaste wiskunde 1

Objectives
The aim of the course is to familiarize the student with the modern concepts of machine learning at the international research level. In particular:
- The student understands the concepts of Bayesian inference and use it to derive a number of different machine learning methods, such as regression models, kernel methods, classification models, graphical models
- The student is familiar with stochastic networks of interacting variables, thermodynamic concepts, and sampling methods
- The student is familiar with a number of approximate inference methods, such as the variational method, belief propagation
- The student is capable to write computer programs to implement the above methods

Contents
This course is an advanced course on machine learning and neural networks from a probabilistic point of view. Starting in 2010/2011, the course is a continuation of the course Neural Networks and information theory and will contain advanced topics. The course is intended for master students in physics and mathematics. Students with a background in computer science, AI or cognitive science are recommended to follow the course Introduction to Pattern Recognition instead.
The course provides a good preparation for a Masters' specialisation in Theoretical Neuroscience or Machine Learning.
See http://www.snn.ru.nl/~bertk/machinelearning/ for futher information.

Subjects
See the course website: http://www.snn.ru.nl/~bertk/machinelearning/

Literature
- David MacKay, *Information Theory, Inference and Learning Algorithms*, Cambridge University press. The entire book can be viewed on-screen at http://www.inference.phy.cam.ac.uk/mackay/itila/book.html

- several handouts will be distributed during the course

Examination
Oral exam

Extra information
Part of the course will be presented by the students. Part of the course will make use of videolectures.
Examination is weighted average of oral exam, homework assignments and presentations.

http://www.snn.ru.nl/~wimw/collegeML.html

Materials Science

Course ID: **NM020B** *6 ec* second semester dr. P.R. Hageman

Teaching methods

- 30 hrs lecture
- 30 hrs problem session

Prerequisites

This course aims at master students physics, chemistry or natural sciences

Objectives

- The student has knowledge of the concepts and theory from material science as presented in the course
- The student can apply the presented concepts and theory in order to interpreted correctly scientific literature in the area of material science
- The student is capable to reduce the information from the scientific literature to the core problems
- The student is capable to solve these core problems using the presented theory and concepts or can present a different solution method

Contents

Understanding of the fundamental nature of materials during the last century has led to the development of materials science and engineering. Within this field traditionally the relation between the microscopic structure and macroscopic properties of bulk materials such as metals, semiconductors, ceramics and polymers is studied. Recent developments concentrate on the processing and performance of materials in the form of thin films, as these have become increasingly important in our daily life.
This material science course handles the relationship between material structure and the resulting mechanical, electrical, chemical, optical and magnetic properties of materials in general and thin films in particular. Enveloping this relation special emphasize is given to methods for thin film deposition (MOCVD, MBE, Sputtering) and their final performance. The processing -> structure -> properties -> performance interactions will be illustrated by the discussion of recently developed materials such as gallium-nitride and synthetic diamond coatings as well as specialized applications such as high efficiency solar cells and magnetic multi-layers.

Literature

Hand outs will be distributed during the course. No specific book is required.

Examination

The students write independently a paper about a subject dealing with materials science on basis of distributed scientific literature. In this paper the student has to apply the knowledge learned in the course.

Mechanical engineering; designing and manufacturing instruments

Course ID: **NM079B** *2 ec* 3 times a year dr. ing. S.M. Olsthoorn

Teaching methods
- 64 hours within two week period
- Instruction and practical training

Objectives
At the end the student will be able to:

- translate a theoretical idea into a experimental set-up
- interpret mechanical drawings and possibilities
- communicate on a technical level with mechanical engineers
- understand all possibilities of the mechanical workshops

Contents
This is an 8-day course in which the student is trained in learning to think as a mechanical engineer. The student learns how to start an experiment. What are the possibilities when designing and manufacturing a scientific set-up.
The student learns to read all details of technical drawings and an introduction to designing programs. After a theoretical introduction, the students will learn to make a simple mechanical drawing of an instrument or an experiment.
The student learns to work with mechanical tools. After a good introduction the student will work under supervision with all kinds of mechanical tools including a lathe and a milling machine.

Subjects
- The student learns the basics of mechanical engineering
- The student learns how to design an instrument or a simple experiment

Examination
During the course students have to manufacture a brench-screw.
At the end students have to deliver a good technical drawing (made in Autocad, Inventor, or by hand) including the necessary side- front- and top- views.

Extra information
This course is open for master students and for PhD students in Physics and Astronomy. (http://www.ru.nl/fnwi/technocentrum). The course will be offered three times per year and accepts three students per course. Students from other disciplines may be accepted dependent on the available capacity. After this course students have a good practical background in designing and manufacturing an instrument, however they have not yet the skills to work on their own in the mechanical workshop.
Registration: Dr. G. Swart, HG 01.832, email: g.swart@science.ru.nl

Monte Carlo Techniques

Course ID: **NM042B** *6 ec* second semester prof. dr. R.H.P. Kleiss

Website
www.hef.ru.nl/~kleiss/

Teaching methods
- 40 hrs lecture

Prerequisites
Theory of probability, some programming experience

Objectives
- The student undeerstands the principles of the Monte Carlo method and the quasi-MC method
- The student can construct algorithems for the generation of sequences of quasi- or pseudo-random numbers
- The student can apply variance-reduction techniques
- The student can design and execute Monte Carlo studies on physical systems

Contents
The course is an introduction to solving problems using random numbers. As primary example, the problem of multi-dimensional integration is treated. This course is mainly intended for people confronted with numerical integration and Monte Carlo simulation, such as in the phenomenology of elementary particle physics.

Subjects
- Theory of Monte Carlo integration: probability calculations and the construction of estimators
- Techniques of variance reduction: stratification, importance sampling, multichanneling
- Algorithms for the generation of (pseudo)random numbers
- Tests of randomness of number series
- Algorithms for the generation of non-uniform number sets
- Discrepancies and Koksma-Hlawka type inequalities
- The Wozniakowski theorem
- Principles of quasi-Monte Carlo
- Generating quasi-random number sets
- The problem of many-particle phase space integration: RAMBO, MAMBO and SARGE algorithms

Literature
Announced during the course

Examination
By arrangement

Nano Magnetism

Course ID: **NM044B** *6 ec* second semester dr. A.I. Kiriliouk

Teaching methods
- 28 hrs lecture

Prerequisites
Quantum mechanics; Introduction to Solid State Physics

Objectives
- The student has a knowledge about the basic magnetic interactions
- The student can apply the acquired knowledge to solve basic problems
- The student should be able to understand the recent discoveries in the area of magnetism
- The student is able to read and understand the articles in leading scientific journals

Contents
Magnetism is a phenomenon that has intrigued mankind since millennia and has found a large variety of applications ranging from the compass to hard disks. Modern preparation techniques have allowed the fabrication of magnetic structures with typical dimensions that are small compared to fundamental**length scales** such as exchange length, mean free paths or spin diffusion length, which have led to exciting new effects like giant magneto-resistance and spin injection. The importance of such phenomena has been recognized in the Nobel prize 2007.
This course will cover several topics of magnetism in **nanodimensions**, starting from basics. Special attention will be on the formation of the magnetic moments as well as on various aspects of magnetization dynamics. It will also include a review of experimental approaches.

Subjects
- quantum mechanics: spin-spin and spin-orbit interactions
- exchange and anisotropy
- magnetic order: ferro-, ferri, and antiferromagnets - dimension dependence
- superparamagnetism
- spin waves in nanoelements
- magnetization dynamics: domain wall, spin precession, spin heating, etc.
- magnetic quantum phenomena
- preparation and magnetic and structural characterization techniques
- magneto-optics as important tool for ultrafast dynamics studies
- utilization: are we going to have a magnetic computer?

Literature
Lecture notes are handed out at every lecture; blackboard will also be used for the lecture notes and extra material

As extra reading:

- S.V. Vonsovskii, *Magnetism,* John Wiley & Sons, New York, 1974
- S. Chikazumi, *Physics of Ferromagnetism,* Clarendon Press, Oxford, 1997
- D. Craik, *Magnetism: Principles and Applications,* John Wiley & Sons, New York, 1995
- D.C. Mattis, *The theory of magnetism,* Harper & Row, New York, 1965
- J. Stöhr and H.C. Siegmann, *Magnetism: from fundamentals to nanoscale dynamics*, Springer, 2006

Examination

Combination of a written short report, 15 minutes oral presentation on a selected subject, oral exam, and the work during the semester

NIKHEF Topical Lectures

Course ID: **INDC** *1 ec* 3 times per year prof. dr. S.J. de Jong

Website
www.nikhef.nl/pub/onderzoekschool/

Teaching methods
- 24 hours lecture

Contents
These topical lectures typically comprise three full days and need some preparation. Participation in the NIKHEF topical lectures should be reported a priori to the IMAPP secretariat (HG 03.380, tel: 52099, email: secr@hef.ru.nl) or to Prof.dr. S.J. de Jong. For dates and topics of upcoming NIKHEF topical lectures, please consult the web-site.

Examination
Aanwezigheidplicht

Nuclear Physics

Course ID: **NM016B** *6 ec* first semester dr. A.C. König

Teaching methods
- 40 hrs lecture

Prerequisites
Quantum Mechanics 1a, 1b en 2

Objectives
Thorough knowledge of:
- Nuclear structure, instability and reactions
- Interaction of radiation with matter
- Detectors and instrumentation
- Biological effects of radiation and nuclear medicine
- Nuclear power

Subjects
- Semi-empirical mass formula, Shell model, Single-particle aspects, Collective aspects
- Nuclear decays: Gamma, beta and alpha decay
- Nuclear reactions:, Compound nucleus, Optical model, Direct reactions
- Interactions of radiation with matter: Fundamentals
- Detection methods for radiation
- Biological effects of radiation
- Nuclear medicine: CT-scan, PET-scan, MRI-scan, Radiotherapy
- Nuclear power generation: Fission and fusion

Literature
Necessary:
- John Lilley, *Nuclear Physics, Princples and Applications*, John Wiley & Sons Ltd.

Examination
Written or oral examination

Extra information
This course will be given even-biennial

Numerical Methods

Course ID: **NM066C** *3 ec* third quarter Dr. W. Hundsdorfer

Teaching methods
- 14 hours lecture
- 14 hours tutorial

Prerequisites
Basic knowledge Linear Algebra and Calculus

Objectives
- The student will become femiliar with properties of some numerical methods and their implementations

Contents
Theoretical properties and practical aspects of basic numerical methods for
Linear and nonlinear algebraic equations
Polynomial interpolation and approximation
Numerical integration
Ordinary differential equations

Subjects
- Root finding: bisection, Newton-Raphson
- Numerical diffentiation
- Numerical integration: trapezoid, Simpson, Monte Carlo
- Ordinary differential equations: Euler, Runge-Kutta, Verlet
- Interpolationand polynomial approximation; special functions

Literature
Lecture notes, downloadable from Blackboard

Examination
Programming tasks with written exam

Extra information
This course is given at master-physics and bachelor-mathematics

Oriëntatiestage E-variant

Course ID: **NM061B** *3 ec*

Teaching methods

- 60 uur stage in het voortgezet onderwijs
- 20 uur voorbereiding / stage-opdrachten / verslag

Prerequisites

- CEM-cursus
- **Alleen toegankelijk voor Nederlands sprekende studenten**

Objectives

De Oriëntatiestage E-variant biedt studenten de mogelijkheid om (na de CEM-cursus in de bachelorfase) zich tijdens de masterfase verder te oriënteren op de Educatieve variant. Deze snuffelstage is niet verplicht maar zeer aan te raden voor iedereen die de eerstegraads bevoegdheid leraar wil halen. De stage kan flexibel worden ingeroosterd.

Contents

De scholen bieden twee mogelijke periodes voor de snuffelstage, te weten van 1 oktober tot 1 december of van 1 februari tot 1 april. Deze periodes zijn ruim genomen om de student en de school de gelegenheid te geven om de stage flexibel in te roosteren in het vierde studiejaar. De schoolstage bestaat niet alleen uit meelopen en observeren, maar ook uit zelf lesgeven (8 lesuren) en de eigen lessen nabespreken met de begeleidende schooldocent. De ervaring leert dat men 4 à 5 weken lang 2 dagen per week op school aanwezig moet zijn om de verlangde hoeveelheid ervaring op te doen. Het staat de student echter vrij om in overleg met de stageschool een ander rooster te maken.

Begeleiding

De begeleiding vanuit de universiteit wordt verzorgd door een vakdidacticus van het Instituut voor Leraar en School (ILS). Deze instituutsdocent verzorgt een inleidende bijeenkomst, onderhoudt de contacten met de scholen, levert literatuur en opdrachten, en beoordeelt het verslag. De instituutsdocent komt in principe één keer naar de stageschool voor overleg ter plekke, al dan niet aangevuld met een lesobservatie.

Informatie en aanmelding

Stageplaatsen worden geregeld door het stagebureau van het ILS op basis van inschrijvingen voor de cursus. Houd er rekening mee dat het gebruik van een OV-weekkaart nodig kan zijn. Neem voor verdere informatie contact op met het Secretariaat Instituut voor Leraar en School, Gymnasion, tel. 024-3530093 of 3530094.

Extra information

Exclusivy for Dutch speaking students

Particle Detection and Acceleration

Course ID: **NM081B** *6 ec* first semester dr. A.C. König

Teaching methods
- 40 hours lecture
- Student presentations
- Homework

Prerequisites
Bachelor courses 'Quantum Mechanica II' and 'Inleiding subatomaire fysica' or equivalent

Objectives
- The student is knowledgeable about the basics of accelerator techniques and properties
- The student is aware of the physical principles used in the detection, measurement, and identification of high energy particles, as well as of the most important aspects of data handling in large experiments
- The student is able to participate in research activities, without further general prior knowledge

Subjects
- Concepts: cross sections, decay rates and lifetimes
- Accelerators: history of particle accelerators
- Acccelerator physics: focusing, acceleration, cooling
- Detection principles and their applications
- Interactions of charged particles
- Charged particle tracking
- Scintillation
- Cherenkov radiation
- Calorimetry
- The shell model of modern particle detectors
- Triggering and data acquisition
- Reconstruction of physics objects

Literature
- **Required**

Lecture Notes

Examination
Oral exam

Particle Physics Experiment Analysis

Course ID: **NM077B** *6 ec* second semester prof. dr. S.J. de Jong

Website
blackboard

Teaching methods
- 32 hrs lecture
- 32 hrs problem session

Prerequisites
Particle Physics Experiments

Objectives
After the course the student should be able to analyse data from high energy physics experiments under supervision of a senior physicist.

Contents
The analysis of data for particle physics experiments is explained.
Special emphasis lies on the statistical treatment of the data, fitting techniques, event classification, significance, exclusion limits, and systematic uncertainty treatment.

Literature
To be decided

Examination
By arrangement

Particle Physics Phenomenology

Course ID: **NM010C** *6 ec* first semester prof. dr. N. de Groot

Teaching methods
- 30 hrs lecture
- 30 hrs problem session

Prerequisites
Bachelor courses 'Kwantum Mechanica 2' and 'Structuur der Materie'

'Inl. Subatomaire Fysica' or 'Kwantum Mechanica' 3 are a bonus.

Objectives
- The student will be able to describe the production and detection methods of elementary particles
- The student will be able to name the elementary particles, their properties and describe the history of their discovery
- The student will be able to apply Feynman diagrams to fundamental processes and calculate their cross-sections or decay rates
- The student will be able to apply symmetries and conservation laws
- The student will be able to describe the Standard Model

Contents
Introduction to the elements of the Standard Model of elementary particle physics

Subjects
- Introduction to the production and detection of elementary particles
- Historical introduction to the elementary particles: featuring leptons, quarks and gauge bosons
- Feynman diagrams: fundamental interactions in pictures
- Symmetries and conservation laws
- The Standard Model of Elementary Particle Physics

Literature
- David Griffiths, *Introduction to Elementary Particles*, John Wiley & Sons Inc., 2008 (new edition), ISBN: 978-3-527-40601-2

Examination
Take home assignment

Philosophy 2 (for Physicists)

Course ID: **FFIL211A** *3 ec* third quarter dr. M.A.M. Drenthen
S.A.J. Segers

Teaching methods
- 20 hrs lecture
- 2 hrs personal study counseling
- 58 hrs individual study period

Prerequisites
students are expected to have completed the bachelor course 'Inleiding in de filosofie'

Objectives
After this course the student:
- is able to read and analyze a philosphical text, to present a text, to lead a group discussion
- understands the epistemological shift from classical physics to quantumphysics and is familiar with the major positions in the debate between scientific idealism, realism, instrumentalism and positivism
- is aware of the specific nature of the scientific appraoch, and is able to demarcate the boundaries between physics and other fields of intellectual activity

Contents
The development of quantum mechanics has given rise to a number of epistemological, cultural historical, and philosophical debates. In this course, we will read some texts from the founding fathers of quantum mechanics. The main focus is on the relation between physical models and reality. What is the status of physical knowledge? What is the role of aesthetic judgments in the development of theoretical physics? What are the boundaries of the scientific approach? What can a theory of everything imply? What is the relation between scientific insights and religious or ideological outlooks on life?

This course will be taught in English. However, if there are less then 2 foreign students, it will be held in Dutch. In that case, non-dutch speaking students will get an alternative assignment.

Students who wish to follow this course have to SIGN UP AT LEAST 4 WEEKS BEFORE THE START OF THE COURSE. Please conform your subscription in Blackboard by pressing the 'group activation' button.

Students who do not speak Dutch are requisted to make themselves known as such AT LEAST 4 WEEKS BEFORE THE START OF THE COURSE, by sending an e-mail to: m.drenthen@science.ru.nl. This way, that the lecturer can decide in time if the course will be held in Dutch, or if it has to be taught in English.

Literature
Papers will be distributed.

Examination
During this course, student will have to read and analyze, present and discuss philosophical texts.
Students will be assessed on their home assigments, their presentation and their contributions to the discussions in class. There will be no final exam.
Attendance is mandatory.
Students who wish to follow this course have to SIGN UP AT LEAST 4 WEEKS BEFORE THE START OF THE COURSE.
Please conform your subscription in Blackboard by pressing the 'group activation' button.

Students who do not speak Dutch are requisted to make themselves known as such AT LEAST 4 WEEKS BEFORE THE START OF THE COURSE, by sending an e-mail to: m.drenthen@science.ru.nl. This way, that the lecturer can decide in time if the course will be held in Dutch, or if it has to be taught in English.

Physics of Molecules and Molecular aggregates

Course ID: **NM082B** *6 ec* first semester prof. dr. W.J. van der Zande

Teaching methods
- 32 hrs lecture
- laboratory tour
- 24 hrs combining exercise classes, modern literature discussions

Prerequisites
- bachelor in physics or chemistry or natural sciences
- quantum mechanics on bachelor level
- structure of matter on bachelor level or analogous course

Objectives
At the end of the course the student is expected to be able to:
- Describe the strength and structure of molecules
- Describe the spectral response of molecules over the full electromagnetic spectrum
- Understand intramolecular dynamics
- Understand the relation between molecular forces and chemical reactivity
- Describe the physical and optical properties of large molecules
- Understand the experimental tools for the study of molecular physics

Contents
In this course we will present the quantum description of molecules and introduce the tools to appreciate molecular properties as structure, bond strengths, ionization energies, etc. The consequences of structure and symmetry on molecular absorption and emission will be explained. The response of molecules to the different parts of the electromagnetic spectrum (X-ray to far IR) will be treated. Chemical reactions involve breaking and making of bonds. This process happens in collisions between molecules, the general properties of these reactive collisions will be discussed. The transition from ‘small’ molecules to ‘large molecules’ will be explained in the form of heterogeneous broadening and intramolecular dynamics processes. Examples will be given of large molecules, individual as well as aggregates and their mechanical and optical behavior with references to properties of the solid state and soft solid state. Throughout the course examples will be given of modern research tools to determine, and to manipulate molecular properties.

Literature
To be determined

Examination
(1) small report based on literature
(2) written or oral exam depending on the number of students enrolled

Extra information

The course is part of the eductaional program of the Reserach Institute for Molecules and Materials
The course will be given by various teachers

Professional Preparation

Course ID: **NM019B** *1 ec* second semester prof. dr. S.J. de Jong

Website
Blackboard

Teaching methods
- 16 hrs problem session

Prerequisites
Bachelor exam Physics and/or Astronomy

Objectives
The student will be able to:
- reflect on her/his professional abilities
- reflect on her/his preferences for employment
- compose her/his CV
- write a letter to apply for a professional position
- present her-/himself to a selection board

Contents
This course prepares for the transition from being a student to physicist or astronomer on the job.
It comprises four half-day sessions in which the student is trained to reflect on her/his own abilities, preferences for employment and on matching these. Under the guidance of the trainer a CV and a letter of application will be composed and commented on in a group process. Presentation as a job candidate to a selection board will be practised with students both in the role of the applicant and member of the selection board.
The course will be lead by a professional trainer from the RU Student Affairs Office.

Examination
Presence and active participation is required for all four lectures

Extra information
This course will occupy four half-day (3,5 - 4 hour) session at dates that will be announced by email in early 2011

Quantitative Brain Networks

Course ID: **NM080B** *6 ec* second semester prof. dr. P.H.E. Tiesinga

Teaching methods

- 40 hrs lecture
- 20 hrs personal study counseling

Prerequisites

(Physics master*) Inleiding biofysica, Brain & Behavior 1, Neural Computation
(Research master CNS) Advanced mathematics or equivalent.

Objectives

The brain is all about communication, between individual neurons as well as between brain areas comprised of billions of neurons. To study brain communication advanced new experimental and mathematical techniques have been developed, which require mathematical sophistication and a neurobiological background to fully comprehend. The goal is to provide the neurobiological background and the mathematical/computational skills necessary to understand current technical publications in the field of *Brain networks and neuronal communication*.

Contents

This course covers the experimental methods to assess connectivity; data analysis methods to extract connectivity from dynamics; statistical models for connectivity and dynamical models that reproduce the observed coherent brain states.

Subjects

1. Local circuit structure: experimental methods to extract connectivity, results of rodent and primate experiments, and theoretical methods for describing connectivity
2. Local circuit dynamics: interpreting the local field potential, dynamical measures for the connectivity, results from primate experiments
3. Large-scale brain structure: neuroimaging methods to determine anatomical and functional connectivity
4. Large-scale brain dynamics: brain oscillations, mean field models, dynamic causal modeling.

Literature

A reader will be made available at cost during the course.

Examination

The final grade will be based on your class/practice hours participation, handed-in homework and a final exam

Quantum Field Theory

Course ID: **NM040B** *6 ec* first semester dr. W.J.P. Beenakker

Teaching methods
- 30 hrs lecture
- 30 hrs problem session

Prerequisites
Bachelor courses on Quantum Mechanics

Objectives
- The student has a good understanding of the fundamental aspects of quantum field theory in the canonical formulation
- The student is able to derive and use Feynman rules
- The student is familiar with the salient details of calculating radiative corrections within perturbation theory
- The student is familiar with the concept of gauge symmetries and its implications

Contents
This course provides an introduction to the modern concepts of quantum field theory, formulated in the canonical framework. Special attention is devoted to the explicit calculation of physical observables, like scattering cross-sections and decay widths. It is shown how such calculations can be performed within perturbation theory by employing Feynman rules. The resulting higher-order perturbative corrections turn out to be infinite and therefore require a careful treatment. In this context it will be investigated whether the predictive power of the theory can be restored if the infinities are regularized properly. A further aim of the course is to introduce the concept of local gauge symmetries, which plays a crucial role in the description of the interactions between fundamental particles. As an example it is shown how the electromagnetic interactions can be described by invoking the gauge principle and how the corresponding gauge symmetry enables us to get a handle on the infinities of the perturbative corrections.

At the end of the lecture series an extra two-week crash course is offered to the interested student. In this crash course it is shown how to adequately describe electromagnetic, strong and weak interactions by means of Abelian, non-Abelian, as well as spontaneously-broken symmetries. As a particular application, the Standard Model of electroweak interactions is constructed from basic experimental observations and basic physical requirements (like unitarity and predictability).

Literature
Necessary:

- Michael E. Peskin and Daniel V. Schroeder, *An introduction to Quantum Field Theory* (Westview Press, 1995)

Recommended (not mandatory):

- Claude Itzykson and Jean-Bernard Zuber, *Quantum Field Theory*, Dover Edition (Dover Publications, 2006)

Examination

Written exam

Quantum Transport

Course ID: **NM083B** *6 ec* second semester dr. U. Zeitler

Contents
Course information will be announced after the summerholidays

Research Labs

Course ID: **NM003B** *6 ec* first semester ir. R.A.H.M. van Haren

Teaching methods

- 2 day preparation (literature), 6 day laboratory work and 2 day report writing up to 10 days per experiment

Prerequisites

Bachelor lab classes

Objectives

- The student can perform experiments independently
- The student can work out problems and have malfunctioning apparatus repaired
- The student can analyse the obtained data
- The student can give a concise oral and written presentation of the work

Contents

This course is the final preparation before working in a real experimental environment. 'Research Labs' tries to simulate the environment which students will experience in a real Research Laboratory.
Up to 3 experiments can be chosen from a list of available subjects. Each experiment brings 3.0 ec. The experiments are located in the experimental researchgroups of the faculty. The following experiments are available (with some restrictions):

- A3:Laser Induced Fluorescence (Harren)
- B2: De Haas van Alphen Effect (Zeitler)
- B3: Femtoseconde spectroscopie (Kirilyuk)
- B4: Magneto-optica (Kirilyuk)
- B5: 2D Electron Gas (Zeitler)
- B6: Scanning Probe Microscopy (Gerritsen)
- C1: Radio Interferometer (Groot)
- D1: Biofysica (Gielen)
- E1: Muondetection (Timmermans)
- E2: Dradenkamer (Timmermans)
- T2: Photo Acoustic Detection (Harren)
- T4: Chemical Vapour Deposition of Diamond (Schermer)

The student him/herself should be mainly responsible for the proper execution of the work. There is enough time available for working out eventual problems and debugging. The analysis of the obtained data plays an important role, as well as concise presentation.
More general information on the objectives and the organization of this course is available from the coordinator.

Examination

Oral and written presentation

Scanning Probe Microscopy

Course ID: **NM070C** *3 ec* first semester prof. dr. S.E. Speller
dr. B.L.M. Hendriksen

Teaching methods
- 30 hrs lecture

Prerequisites
Solid State Physics

Objectives

This course is an introduction to Scanning Probe Microcopy. It is recommended to students who are interested in nanoscopic phenomena and wish to gain insight in local probing and imaging methods used in nanoscience research. After successfully completing this course you
- understand how the physical and chemical properties of a material change when their size is reduced to the nanometer scale.
- understand the nano-scale physical and (bio)chemical interactions between the probe and a nanostructure on a surface.

- can recognize the instrument components of a scanning probe microscope and you understand their operation.
- are able to design experiments based on scanning probe microscopy, which target a given nano-scale question.
- have a general overview of applications of scanning probe microscopy in nanoscience research, you can read and comprehend scientific literature about scanning probe microscopy and you can actively participate in discussions on the topic.

Contents
This course is an introduction to:
- Scanning Tunneling Microscopy
- Atomic Force Microscopy
- Nano-Optical Microscopy

Scanning probe microscopes are widely used in nanoscience. A scanning probe microscope (SPM) can visualize atomic, molecular and nano-scale structures on solid surfaces by detecting atomic-scale interactions between a probe tip and the studied material. In this course we discuss the relevant probe-sample interactions (e.g. electron tunneling, nano-scale forces, near fields), we treat the electrical and mechanical components of the SPM instrumentation, we discuss the various operation modes of SPMs and provide a broad overview of applications of SPM in nanoscience. Examples from physics, chemistry and biology include: atom manipulation, electron confinement, nano-scale friction, magnetism, molecular-scale chemistry, protein unfolding.

Literature
On website during the course.

Examination

Oral presentation on a dedicated scanning probe microscopy mode. A support package is provided.

Seminar Stochastics Neuroscience

Course ID: **WM081B** *6 ec* second semester prof. dr. F.H.J. Redig

Prerequisites

Contents
In this research seminar joinlty between mathematics and the Donders centre for cognitive neuroscience, we explore the interface stochastics/neuroscience.

Subjects
People present recent research results and background material in the following subjects

- stochastic control theory and large deviations
- stochastic integrate-and-fire models
- dynamical systems and excitability of neurons

Literature
Books and papers will be made available during the seminar

Examination
Evaluation is on the basis of participation and presentation of a recent research paper or chapter of a recent book on neuroscience

Solid State Physics

Course ID: **NM009B** *6 ec* first semester prof. dr. ir. J.C. Maan

Teaching methods
- 30 hrs lecture
- 30 hrs problem session

Prerequisites
Inleiding in de Vaste Stof Fysica and/or Structuur der Materie

Objectives
- The student will have an understanding of formal transport theory
- The student will have an understanding of mesoscopic phenomena
- The student will have an understanding of semiconductor and heterojunctions
- The student will have an understanding of superconductiviy
- The student will have an understanding of magnetism in solids
- The student will have an understanding of important quantum phenomena of solids in magnetic fields

Contents
This course assumes a working knowledge of key concepts and methods in solid state physics: the consequences of crystal symmetry, the notion of quasi-particles and the Fermi-particle character of the electrons, as obtained in a course like 'Inleiding Vaste Stof Fysica', and/or 'Structuur der Materie' and the student should have cursory understanding of energy bands and Fermi surfaces, and the consequences of band filling for metals, semiconductors and insulators.
The importance electron-electron interaction and the concept of quasiparticles to describe important phenomena like superconductivity and magnetism will be emphasized. Furthermore the effect of the discrete electron charge and wave character electron for small systems (mesoscopic physics) will be treated. The course aims at building a bridge bridge between the basis concept developed in the last fifty years to understand solid state physics and the new phenomena discovered in the last decades which are based upon this understanding.

The course material roughly covers chapters 8-13, 17 and 18 from Kittels book.

Subjects
- Formal transport theory in bulk and low dimensional (semiconductor) systems where mesoscopic phenomena play a role. Semiconductors and heterostructures will be treated

more thoroughly than in the introductory course
- Superconductivity which from a phenomenological point of view while also an introduction to the BCS theory is given
- Magnetism (paramagnetism, diamagnetism and ferromagnetism) both from an experimental as a theoretical point of view
- Important quantum effects in magnetic fields, like the Shubnikov-deHaas, deHaas van Alphen, Magnetic resonances, Quantum Hall effect and fractional quantum Hall effect will be presented

Literature
Necessary:
- Charles Kittel, *Introduction to Solid State Physics*, Wiley 2005, ISBN 0-471-680057-5, (8th edition or later)

Recommended:
- Luth and Ibach, *Solid State physics*, 2nd edition, Springer Verlag

Examination
Written exam and 1 point credits by joining the tutorial

Telescope Observing

Course ID: **NM027C** *2 ec* Throughout the year, on individual basis prof. dr. P.J. Groot

Teaching methods
- 100 hrs personal study counseling

Prerequisites
Astronomisch Practicum I and/or II.

Objectives
- Gaining insight into the working of professional observatories
- Gaining knowledge on the preparation, execution and analysis of observing runs
- Gaining deeper insight into the working of spectrographs, wide field cameras or radio interferometers
- Understanding the basics of astronomical data reduction.

Contents
Astronomical observations are obtained on large scale international observing facilities. The student will spend a number of nights at an observatory obtaining observations and doing first line data reductions. The data will be obtained as part of running observing programs of the staff of the Department of Astrophysics. Possible observatories where the observations will be conducted include the Westerbork Synthesis Radio Telescope, the optical telescopes at the Anglo-Dutch Isaac Newton Group of Telescopes at La Palma and the telescopes of the European Southern Observatory (ESO) in Chile. In preparation for these observing trips, students will be required to operate the optical and radio telescopes at the University of Nijmegen.
This course is only open to students of the masters track 'Astrophysics', and who have started their Masters Research project. Contact prof.dr. P.J. Groot to start the project.

Literature
Depends on the project and will be handed out during the course
More information: www.astro.ru.nl/studiemateriaal

Examination
Essay on the basis of an observing run.

Extra information
Only open for Master students in Astrophysics. The course will be done during the Masters thesis research project.

Theoretical Foundations of Elementary Particle Physics

Course ID: **NM014B** *9 ec* first semester prof. dr. R.H.P. Kleiss

Website
http://www.hef.ru.nl/~kleiss

Teaching methods
- 60 hrs lecture

Prerequisites
Bachelor course 'Kwantummechanica 2' and 'Inleiding subatomaire fysica' or equivalent

Objectives
- Working knowledge of the priciples and methods of perturbative quantum field theory
- The capability of computing simple phenomenological predictions by diagrammatic means
- Insight into the construction of quantum field theories
- Working knowledge of the Standard Model

Contents
For a complete overview of particle physics, this course can be combined with the course 'Experimental Foundations of Elementary Particle Physics'.

Subjects
- Diagrammatica: the art of Feynman diagrams
- Particle scattering theory predicting interaction rates and lifetimes
- Particle spin: making the world turn
- Gauge invariance and its profound implications
- The Standard Model of elementary particle physics

Literature
Discussed during the course

Examination
By arrangement

The Structure of Spacetime

Course ID: **WM058B** *6 ec* first semester dr. W.D. van Suijlekom

Teaching methods
- 28 hrs lecture
- 28 hrs tutor session

Prerequisites
Tensoren en Toepassingen; Inleiding Algemene Relativiteitstheorie

Objectives
- The student has a conceptual understanding of the mathematical structure of General Relativity.
- Is familiar with the basic definitions and results in differential and Riemannian geometry.
- Is familiar with the classical tests of GR and the Friedmann-Lemaitre-Robertson-Walker cosmological models, as well as black hole physics.
- Is able to read the research literature on gravitational physics.

Contents
We introduce the mathematical techniques necessary for applying Einstein's general theory of relativity. These include the concepts of manifolds, curvature, symmetries, differential forms, and conformal/causal structure. Using these, we will cover singularity theorems, integral theorems, and applications to cosmology and the death of stars.

Literature
R.M. Wald, General Relativity, University of Chicago Press, 1984, ISBN 9780226870335

Examination
Oral exam

5 Institutes for Education and Research

Research is an integral part of the master education. Faculty staff members are generally appointed in a research institute. Giving lectures is one of their tasks. Research in the Faculty of Science occurs in 6 multidisciplinary research institutes. Faculty involved in master education of Mathematics, Physics and Astronomy are recruited from 3 different research institutes:

- Institute for Mathematics, Astrophysics and Particle Physics (IMAPP)
- Institute for Molecules and Materials (IMM)
- Donders Centre for Neuroscience (DCN)

The educational institute for Mathematics, Physics and Astronomy (WiNSt) is responsible for the coordination and organization of the master education.

5.1 The Educational Department for Mathematics, Physics and Astronomy

Head:	Dr G.W.M. Swart
Staff	Dr T. Smits, Ms Drs I. de Vries, Ir R. van Haren, Ing. P. van Rijsingen, Ir W. Szweryn, Drs T. Asselbergs
Secretariat	Ms J.Th.M. Vos - van der Lugt (secrons@science.ru.nl), Ms M. van Megen (m.vanmegen@science.ru.nl) room HG 01.831; tel.: (36)52739;
Website:	www.ru.nl/winst

The Educational Department 'WiNSt' is responsible for the coordination and organisation of education in the discipline of Physics and Astronomy. The implementation of improvements and innovations is also part of the job, as is the managing of the Student Laboratories. Besides, the department informs and recruits future students. Finally the department keeps in contact with high-school teachers in order to improve the relation between secondary and tertiary education.
The tasks of the department are partly executive, partly initiating and preparatory. There is a strong interaction between the education-committee, the exam-committee and the PR-committee.

5.2 Institute for Mathematics, Astrophysics and Particle Physics (IMAPP)

Institute for Mathematics, Astrophysics and Particle Physics (IMAPP)

The Research Institute for Mathematics, Astrophysics and Particle Physics (IMAPP) comprises research in the areas of mathematics, astrophysics and elementary particle physics.

In addition to research in the disciplinary areas, the institute fosters research that connects these areas, such as mathematical physics and astroparticle physics. Research at the institute also connects to research areas outside the IMAPP domain, such as computer science via algebra and logic, neuroscience via stochastics and solid state physics via semiconductor detector R&D.

To summarise the mission of the institute: it performs research on the fundaments of mathematics and (astro)particle physics to push the boundaries of the known, where e.g. the question of the origin and evolution of the universe is central

Astrophysics (IMAPP)

Astrophysics (IMAPP)

Chair:	Prof. Dr P. Groot
Scientific staff:	Prof. Dr H. Falcke, Dr J. Hörandel, Dr G. Nelemans, Dr E. Körding, Prof. Dr J. Kuijpers, Ms Prof. Dr C. Aerts, Prof. Dr C. Dominik
Secretariat:	Mrs C. Custers, Mrs E. Gebhardt, Mrs. D.Maurits (secr@astro.ru.nl) room: HG 03.720, tel. (36)52804
Website:	http://www.astro.ru.nl
Research:	

- Detection of ultra-high energy cosmic rays
- Physics and populations of (ultra)compact binaries in our Galaxy
- Cosmic magnetohydrodynamics, extremely relativistic plasmas and astroparticle physics
- Asteroseismology
- Formation of planetesimals in proto-planetary disks

The Master's programme focuses on high-energy astrophysics and particle astrophysics. Core subjects are the physics of compact objects (white dwarfs, neutron stars, radio pulsars, and black holes), the origin of our universe and nucleosynthesis in the context of the Big Bang and the Standard Model, and the development of new observational methods (neutrino, gravitational and cosmic ray detectors). These areas are at the forefront of physics and the students will be given the opportunity to explore (and extend) these frontiers. The student is expected to go on at least one observing trip either to the Westerbork Synthesis Radio Telescope, the new radio telescope array LOFAR, to the optical telescopes at La Palma or at ESO, Chile, or to the Pierre Auger Observatory in Argentina. The Department of Astrophysics participates in the Netherlands' School for Research in Astronomy (NOVA), a collaboration of the astronomical institutes of the Universities of Amsterdam, Leiden, Utrecht, Groningen and Nijmegen which constitute one of the six national 'topscholen'. The Department participates in the Institute for Mathematics, Astrophysics, and Particle Physics (IMAPP).

Description of research:

Detection of ultra-high energy cosmic rays
The research of the Department is focused on theoretical and observational high-energy and particle astrophysics. The research in the group of Prof.dr. Heino Falcke and Dr. Jörg Hörandel is focused on astroparticle physics, in particular the detection of ultra-high energy cosmic rays through their low- frequency radio emission that can be detected with telescope arrays such as LOFAR and Auger. Prof.dr. Falcke is furthermore interested in jets from black holes, in particular the supermassive black hole in the center of our own Galaxy.

Population of (ultra)compact binaries in our Galaxy
The group of Prof.dr. Paul Groot and Dr. Gijs Nelemans focuses on the population of (ultra)compact binaries in our Galaxy. In these binaries a stellar remnant (white dwarf, neutron star or black hole) accretes matter from a companion, which, in the ultracompact binary setting, is also an evolved object. Determining space densities from massive wide field surveys, understanding the physical characteristics of known systems, combining observations with theory in population synthesis techniques and determining the strongest sources of low-frequency gravitational wave radiation are some of the aims of the research group.

Cosmic magnetohydrodynamics, extremely relativistic plasmas and astroparticle physics
The adjunct professors Kuijpers, Aerts and Dominik spend part of their research time in the Department. Their specialisations are cosmic magnetohydrodynamics, extremely relativistic plasmas and astroparticle physics (Kuijpers), asteroseismology of single and binary (subdwarf) B stars (Aerts) and the formation of planetesimals in proto-planetary disks (Dominik).

Opportunities for students:
For student training and research, the Department owns an extensive suite of telescopes: a 20 cm optical refractor, a 35 cm optical reflector, a two disk radio interferometer and a few LOFAR antennae. The Department also participates in the HISPARC detector for cosmic rays. Students are encouraged to use these facilities for their own research. The research of the Department is focused on theoretical and observational high-energy and particle astrophysics. Usage is made of optical telescopes worldwide (in particular the ING telescopes on La Palma and the ESO telescopes), the Hubble Space Telescope, the LOFAR array and its predecessors and the Pierre Auger Observatory in Argentina. The research is done in close collaboration with researchers within and outside of the Netherlands.

Location:

The departement of Astrophysics is located in the Huygens building, on the third floor in wing seven. This is the top-floor of the north-western wing (above the crossing of the Heyendaalseweg & the Kapittelweg).

Websites:

- **http://www.astro.ru.nl/: Nijmegen Department of Astrophysics**
- http://www.astronomy.nl/: Dutch School for Astrophysical Research (NOVA)

- http://www.astron.nl/: Westerbork Synthese Radio Telescoop
- http://www.eso.org/: European Southern Observatory
- http://www.ru.nl/IMAPP: IMAPP
- http://www.ing.iac.es/: Isaac Newton Group of Telescopes, La Palma
- http://www.lofar.org/: LOFAR
- http://www.stsci.edu/: Hubble Space Telescope Science Institute

Experimental High Energy Physics (IMAPP)

Experimental High-Energy Physics (IMAPP)

Head:	Prof. Dr N. de Groot
Scientific staff:	Prof. Dr S.J. de Jong, Prof. Dr D. Froidevaux, Dr F. Filthaut, Drs P.F. Klok, Dr A.C. König, Dr Ch. Timmermans
Secretaries:	Ms M. van Wees-Mobertz, Ms G. Koppers-Janssen (secr@hef.ru.nl) room: HG 03.830; tel. (36)52099
Website:	www.hef.run.nl/ehef

Research:

- The search for the Higgs particle
- New phenomena beyond the Standard Model
- High energy cosmic rays
- Detector development

The department performs experimental research in the fields of elementary particle physics and astroparticle physics.

Description of research:

The search for Higgs particle.

The Standard Model (SM) is a very succesful quantum field theory of leptons and quarks as the most fundamental building blocks of matter. The interactions between these building blocks are described in terms of an exchange of quanta of the electro-weak and colour forces. Besides the quarks, leptons and field quanta, which have all been discovered by now, the SM predicts the existence of a so-called Higgs particle, with gives mass to all the other particles in the model. This Higgs particle, sometimes described as the holy grail of particle physics, has not yet been observed.

The DØ detector at the Tevatron proton-antiproton collider at Fermilab is recording data since 2001. The ATLAS detector at hte LHC at CERN, currently the most powerful acceleration on the world has been designed to find the Higgs particle. And if the Higgs particle is light enough, it can be observed at Tevatron. Our group is focusing on the Higgs search in these experiment.

The phenomena beyond the Standard Model

Even though the Standard Model agrees extremely well with the experimental results, a number of observations is not explained by this model. For example the number of different species of quarks and leptons and their masses cannot be predicted by the SM. We expect that a high enough energy, the Standard Model gets superseded by another model. This could manifest itself in the production of new particles. Because of the high energy of the LHC collider, the ATLAS detector, will be an excellent place to look for signatures of 'new physics'. We are preparing for this analysis.

High energy cosmic rays
Together with the astrophysics department we investigate various aspects of high energy cosmic rays. The NAHSA initiative (Nijmegen Area High School Array) has been followed nationally as HiSPARC. In this experiment high-school students install, maintain and analyze data from cosmic ray detectors at their own school, with the aim to observe extremely high energy cosmic rays (with an energy of more than 0.01 J). The origin of such radiation is unknown and the observed rate worldwide is higher than expected.
We have joined the Pierre Auger observatory in Argentina. We investigate the origin of the cosmic rays with the highest energies that can be measured on earth. The LOFAR project (Low Frequency Array of Radio telescopes) uses radiowaves to detect cosmic airshowers. We are installing LOFAR-like detectors at Auger to improve the energy measurement and pointing resolution of cosmic rays.

Detector and accelerator development
Although the start of data taking for the ATLAS experiment is about to begin, people are already planning the next generation of accelerators and their detectors. One idea is to increase the number of particles and therefore the number of collisions in the LHC. Another is to have a linear collider of electrons and positrons. We are involved in the development of precision tracking detectors for both accelerator technologies.

Opportunities for students:
Within the topics and experiments described above and supervised by staff and PhD students returning from CERN and FNAL, students can do excellent work on topics like:

- Experimental physics analysis and theoretical interpretation:
  - analysis of the DØ data (Higgs)
  - analysis of the ATLAS data (Higgs, supersymmetry)
  - analysis of AUGER and HiSPARC data
- Numerical physics:
  - physics and detector simulation with Monte-Carlo techniques
  - software for the reconstruction of particle collisions and their graphical reproduction
  - neural network techniques for particle reconstruction
- Applied physics:
  - development of semiconductor detectors
  - development of fast read-out electronics
  - development of cosmic radiation detectors for high school application

The research is carried out in teamwork with PhD students, post-docs and staff, but on an individual topic. It is expected to lead to a masters thesis.

In principle, students can be sent for short periodes to CERN (Geneva) or Fermilab (Chicago). Furthermore, the Department can help with applications for summer student fellowships at CERN or Fermilab.

Theoretical High Energy Physics (IMAPP)

Theoretical High-Energy Physics (IMAPP)

Head:	Prof. Dr R.H.P. Kleiss
Scientific staff:	Prof. Dr A.N.J. Schellekens, Dr W.J.P. Beenakker
Secretariat:	Ms A.M.J. van Wees-Mobertz and Ms G. Koppers-Janssen (secr@hef.ru.nl) room: HG 03.830; tel. (36)52099
Website:	www.ru.nl/thef/

Research:

- Phenomenology of electron-positron and hadron-hadron collisions
- Monte Carlo techniques
- Baryon-(anti)baryon interactions
- The landscape of string vacua

Description of research:

Phenomenology of electron-positron and hadron-hadron collisions
The goal of the research is to work out precise theoretical predictions for experimentally measured observables at existing and future collider experiments. Examples are:

- Production and decay of Higgs particles at the hadron colliders Tevatron (Fermilab, Chicago) and LHC (CERN, Geneva), aimed at studying the mechanism by which particles acquire mass
- Production and decay of supersymmetric particles at the hadron colliders Tevatron and LHC, aimed at studying the theoretical idea of unifying the fundamental forces in nature
- The study of scattering processes at a future linear electron-positron collider, aimed at gathering information on the physics that governs the ultra-high energy scales where gravity starts to play a prominent role

In this work, heavy reliance is put upon perturbative techniques in quantum field theories, embodied in Feynman diagrams.

Monte Carlo techniques
The previously mentioned research strongly involves algebraic and numerical techniques. The results often appear as Monte Carlo codes suitable for use by the experimental community. The Monte Carlo method enables the calculation of complex multi-dimensional integrals as well as the simulation of very nontrivial processes. This is made possible by the use of computer-generated sequences of (pseudo)random numbers. Generating sequences of such numbers is a fundamental and challenging field of both pure and applied mathematics. The possible use of different, quasi-random number sequences, which give numbers that are

distributed more uniformly than (pseudo)random ones, poses a host of fundamental as well as practical questions.

Baryon-(anti)baryon interactions
Baryons are fermionic particles composed of three light quarks. In addition to the common nucleons proton and neutron, which consist of up and down quarks, the baryon family also contains the more exotic hyperons, which consist of at least one strange quark. When these particles are collided they all interact with each other via the strong nuclear force. The research programme aims at describing and elucidating the present and future experimental baryonic data. This involves partial-wave analysis of nucleon-(anti)nucleon scattering data and the construction of nucleon-nucleon, nucleon-hyperon and hyperon-hyperon potentials, using theoretical concepts such as chiral symmetry and effective Lagrangians. A spin-off of this programme is the study of nuclear and hyperonic matter in the context of neutron stars.

The landscape of string vacua
String theory is a model of fundamental physics whose building blocks are one-dimensional extended objects called strings, rather than the zero-dimensional point-particles that form the basis for the Standard Model of particle physics. The goal of the research is to find among all the possible string vacua the ones that incorporate the known laws of physics. The idea of the landscape of string vacua is based on the anthropic principle, which states that fundamental constants may have the values they have not for fundamental physical reasons, but rather because such values are necessary for life to exist. The research has a strong mathematical component, involving conformal field theory and topology.

Opportunities for students:
The department of Theoretical High Energy Physics offers several theoretical research projects at the Bachelor and Master level. Students are advised to contact the head of the department or one of the members of the scientific staff for more details. In addition, the department can help students with applications for summer-student fellowships at CERN.

5.3 Institute for Molecules and Materials (IMM)

Institute for Molecules and Materials (IMM)
The Institute for Molecules and Materials (IMM) covers a wide range of research topics that aim at understanding the fundamental physics of molecules and materials in order to be able to control their properties and design new functionalities. IMM combines theoretical, experimental and computational approaches under one roof. The Institute offers the students an internationally oriented, multidisciplinary, high-level Master Program in Molecular and Condensed Matter Physics. The program is firmly embedded in a consortium of several research departments and designed to create a unique training environment to educate a new generation of highly motivated and ambitious people seeking their career in fundamental and applied research as well as high-tech industry. The first stage (year) of the Master Program is devoted to participation in courses. The second year comprises some optional courses, but is mainly devoted to a large research project, forming the subject of the MSc thesis. The combination of the advanced research facilities of the institute such as High Field Magnet Lab, Laser Lab, NanoLab and THz free electron laser make our institute a world-unique

center with an emphasis on the spectroscopy of complex molecular and solid state systems. All the state-of-the-art equipment of the IMM is available to the students.

The students may choose between two tracks of the master program: Molecular Physics and Condensed Matter Physics. However the differences between these two tracks are minor since one of the main goals of the program is to train students in a multidisciplinary environment and thus to broaden their choice of future careers. The lecturers are all world-recognized experts or leaders in their research areas. Scientific achievements of IMM are often published in the most prestigious journals for fundamental physics such as *Physical Review Letters*, *Nature* and *Science*. The ambition of the lectures is to enrich the classical content of university physics education with the latest concepts of modern physics. The interdisciplnarity and multidisciplinarity of IMM provide the students a unique opportunity to choose a research project either purely in fundamental physics or at the junction of physics with chemistry and biology. The intense involvement of IMM in rapidly developing research areas of modern science allows IMM to offer a PhD position to all students with sufficiently high marks. For quite exceptional students, it may be even possible to combine a part of their MSc with the first year of PhD.

Applied Materials Science (IMM)

Head:	Prof. Dr E. Vlieg
Scientific staff:	Dr P.R. Hageman, Dr Ir J.J. Schermer
Secretariat:	Ms A.L.A.M. Hendriks (ams-secr@science.ru.nl) room: HG 03.527; tel. (36)53353
Website:	www.ru.nl/ams
Research:	

- Solar cells
- Wide bandgap semiconductors

Research is aimed at the formation (growth and processing) and the study of thin-film materials and devices. For this purpose the AMS department has a state of the art clean room facility with all the required equipment for the deposition, processing and analyses of the thin-films. Of particular interest are the so-called III-V and III-nitride semiconductors. These are compound materials based on elements from the third (Al, Ga, In) and fifth (N, P, As) group of the periodic table. The physical and chemical properties of these materials can be tuned at will by variation of the element composition. Therefore, these materials are used to produce opto-electronic components of extremely high quality. Related to this, the research is generally conducted in close cooperation with companies, large institutes and other universities such as Philips, NXP, ESA, Dutch Space, ECN and the Technical University Eindhoven.

Description of research:

Solar cells

The III-V materials GaAs and InGaP are applied for the production of high efficiency solar cells. These cells are produced at crystal wafers. Due to the high cost of these wafers, the III-

V solar cells are presently only utilised for spacecraft. At the AMS department an Epitaxial Lift-Off (ELO) technique is being developed by which the solar cell layer with a thickness of about 2 μm can be released from the wafer on which it was formed. In this way the wafer can be reused, resulting in a large reduction of costs so that the cells can also be utilised for the generation of electric energy on Earth. Single junction solar cells produced with the ELO technique have already reached a world record efficiency of 24.5% and approach their theoretical maximum. Further developments aim for multi-junction solar cells and the use of lenses and mirrors to concentrate the light before it is converted into electricity. In this way theoretically efficiencies above 50% can be achieved.

Wide bandgap semiconductors
The recently developed group III-nitride materials (AlN, GaN and InN) have ideal properties (wide bandgap, high break-down voltage and electron mobility, etc.) to be used in high power opto-electronic components. As a result the application of these materials in e.g. LED-lamps and multi-media lasers increases rapidly. Because presently there are no wafers with a 'matching' crystal structure, the nitrides are produced on 'non-matching' wafers of sapphire. As a result of this, the nitride layers contain many defects which have a large influence on the performance of the electronic components made from these materials. At the department the formation and behaviour of these defects are studied with the aim to minimise their concentration. This has resulted in the realisation of High Electron Mobility Transistors with a European record power density. On the other hand the possibility to develop matching wafers is being investigated. Application of such wafers would reduce the defect density of the nitride layers with several orders of magnitude and further boost up the efficiency of the components produced from these materials.

Opportunities for students:
The department offers many possibilities for students to conduct scientific research. Together with a supervisor the student defines a project assignment that he/she can conduct independently after a short introduction period. The research is completed with a colloquium at the department and a final report (master thesis). Dependent on the result the project can lead to a publication in a scientific journal.

Condensed Matter Science and HFML (IMM)

Head:	Prof. Dr Ir J.C. Maan
Scientific staff:	Dr J.A.A.J. Perenboom, Dr P.C.M. Christianen, Dr S.A.J. Wiegers, Dr U. Zeitler, Dr H. Engelkamp, Dr A. McCollam, Ir. A. den Ouden, Dott. G. Pettinari
Secretariat:	Ms H.E.M. Verhaegh-Peeters (hfmlsecr@science.ru.nl) room: HFML 02.15; tel. (36)52087;
Website:	www.hfml.ru.nl/
Research:	

- Connection with high magnetic fields
- Interdisciplinary research

Description of research:

Connection with high magnetic fields
In condensed matter physics the application of high magnetic fields is widespread. A (high) magnetic field changes the thermodynamic state of any system and a study of this change provides new and unique information. In some cases new states of matter (suppression superconductivity, quantum Hall effects, etc.) are discoverd.
In the area of the fundamental properties of matter the main emphasis is on nanostructures ranging from, those made from lithographically etched semiconductor to self-assembled supramolecular structures. Pioneering scientific discoveries are often done in the highest magnetic fields, which are available at HFML.

Interdisciplinary research
Magnetic fields also find applications in chemistry or biology related research. These applications comprise instrumental developments like high field Electron or Nuclear Magnetic Resonance (ESR and NMR) but also ordering of mesa molecular systems in high magnetic fields.
Finally there are also research activities in magnet technology.

Opportunities for students:
Many experiments can be done in the laboratory. Ranging from low temperature (mK) experiments, laser spectroscopy, far infrared spectroscopy, magnetostriction, magnetisation, susceptibility and transport experiments. Much research is performed in collaboration with other groups both within the university and other (European) research departments. This open and international character provides a broad orientation for the students. Research done at HFML provides an excellent training as experimental physicist, which is highly appreciated on the labor market (both in academia as in industry).

Electronic Structure of Materials (IMM)

Head:	Prof.Dr. R.A. de Groot
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Website	www.ru.nl/esm

Research is related with:

- Anionogenic ferromagnets. Ultra relativistic Dirac compounds
- Half-metallic materials and spin-electronics
- Materials for hydrogen storage
- Electronic, optic and mechanical properties of organics and refractory superalloys
- Photovoltaics
- Electrocatalyses
- Materials and Solar-energy

Description:

The main goal is to understand and design the physical properties of various new materials, including artificial nanostructures, from ab initio calculations.

Modern quantum-mechanical computations within Density Functional Theory (DFT) and extensions like GW and Bethe-Salpeter schemes allow to investigate the electronic, magnetic, optical and mechanical properties of interesting materials.

Although the work is theoretical in nature, and mainly involves large scale computer work, we aim for a close collaboration with experimental groups.

Opportunities for students:
Several oppertunities exist for students to participate in the ongoing research of the group. A master student works on an identifiable subject. Subjects range from "theoretical" to quite applied. Usually his/her work results into a publication in an international journal. For qualified students industrial apprenticeships are possible.

Molecular and Laser Physics (IMM)

Head:	Prof. Dr D.H. Parker
Scientific staff:	Dr F.J.M. Harren
Secretary:	Ms M. Speijers (m.speijers@science.ru.nl) room: HG 01.719; tel: (36)52025
Website:	http://www.ru.nl/mollaserphys/

Research:

- Molecular dynamics of atmospherically relevant processes
- Development of new lasers and molecular beam techniques
- Trace Gas Research

Description:

Molecular dynamics of atmospherically relevant processes
Many processes are possible during a collision between a molecule and another molecule, electron or photon. Most simply, elastic scattering can take place, where the molecular internal energy remains the same but the velocity changes. Inelastic scattering is more interesting - here the rotational and vibrational energy changes, which can lead to non-equilibrium population distributions and even laser or maser action. Chemical reaction, the most complicated and important collision process, can also occur, often via a short-lived transition state complex. The same sort of transition state complex is directly prepared and probed in photodissociation studies of so-called 'half-collision' reactions.

In recent years quantum mechanical theory has been able to quantitatively describe a few of the simplest reactive and inelastic scattering processes. For the more complicated 'real-world' scattering systems laboratory work is essential. Experimental research on molecular scattering dynamics has blossomed worldwide in the last years due to new powerful laser-and molecular beam-based techniques, especially the velocity map imaging technique developed here in our group in Nijmegen.

A general theme of our research centers on the dynamics of molecular processes relevant to atmospheric processes. The central molecule in this theme is molecular oxygen. We continue to deepen our understanding of the surprisingly complex molecule and, most recently, of Van der Waals clusters containing molecular oxygen. Another related species of interest is the hydroxyl radical. We have an active and synergetic collaboration with the Theoretical Chemistry Institute in Nijmegen in all of these studies.

In our current research on molecular scattering we use velocity map imaging and also the laser induced fluorescence technique in studies of photodissociation, inelastic scattering and most recently, reactive scattering. We are studying, for example, inelastic collisions between the OH and CO molecules, which is a key process in atmospheric chemistry and in combustion. Molecular beams of the reactants are formed and cross each other in a small region that is probed using laser induced fluorescence. With laser spectroscopy the precise quantum state distributions of both species can be obtained before and after collision. The results obtained are used to improve the theoretical potential energy surfaces describing the collision complex. In another related project the photodissociation dynamics of OH are studied using velocity map imaging. In this technique a laser is used to selectively photoionize the O and H atom dissociation products without changing the energy obtained from the initial photodissociation step. Carefully designed ion optics guides the ions onto a two-dimensional detector in a way that uniquely 'maps' the nascent product velocity. The full three-dimensional product velocity distribution can then be calculated from the experimental two-dimensional ion image. Up to now no such measurements have been possible for OH, despite it being the most important free radical in atmospheric chemistry. In collaboration with Prof. Ubachs of the Free University of Amsterdam we plan to chart out OH dissociation pathways for the ultraviolet to extreme ultraviolet (300-100 nm) spectrum.

Development of new lasers and molecular beam techniques
Progress in both fundamental and applied experimental research relies on increasingly better diagnostic techniques. Technique development is thus an important research line on its own in the group. As an example, two-dimensional velocity map imaging of ions and electrons has been improved over the last years and applied to the study of bimolecular collisions and photodissociation, surface scattering and chemical reactions.

An important drawback of present lasers systems in the infrared wavelength region is their lack of laser power and ability to generate every laser frequency in the infrared. The use of novel non-linear materials and the technique of parametric oscillation offer the possibility to avoid this and to generate continuous-wave, continuous tunable, narrowband radioation with high output powers at wavelengths between 2.5 and 10 micrometers.

Another state-of-the-art method under development includes proton transfer mass spectrometry with ion cyclotron trapping for signal enhanchement.

Trace Gas Research
The reliable sensing of minute quantities of trace gases in complicated gas mixtures is an

innovative, highly important and most exciting task in practically all technical and life sciences. The Trace Gas Research Group is focused on the development and application of trace gas detection methods with lasers and mass spectrometers. For this we use laser spectroscopical methods such as photoacoustic spectroscopy, frequency modulation spectroscopy and cavity ring down spectroscopy, while within mass spectrometry proton transfer reactions are used to gain high sensitivity for volatile organic compounds. The focus is, thereby, on state-of-the-art detection of substances at sub-part per billion (volume) concentrations, on-line, non-invasive, with high selectivity and detection speed. See also www.ru.nl/tracegasfacility

Next to the research group we operate a Life Science Trace Gas Facility, in which scientists from Biological, Chemical and Medical fields are supported to perform trace gas research for which 'conventional' equipment lacks adequate sensitivity. The facility operates unique state-of-the-art trace gas detectors that allow real time measurements at unprecedented detection levels. Research areas are covered ranging from plant-pathogen interaction to the effect of smoking on the lungs and the study of the effect of tuberculosis.

Opportunities for students:
There are opportunities for students in fundamental molecular reaction dynamics, the development of new instrumental techniques with lasers and molecular beams or the trace gas research with applications in medical sciences. Much of the research is in cooperation with our research groups in Europe and the USA, at University level or with industry.

Molecule and Biophysics (IMM)

Professor:	Prof. Dr W.J. van der Zande
Scientific staff:	Prof. Dr W.L. Meerts, Prof. Dr Marc J.J. Vrakking (FOM-Institute AMOLF)
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Website:	www.ru.nl/molphys

Research:

- Biomolecular structure and function.
- Molecular detection and recognition.
- Electrons and molecules.
- Instrumental developments

Description:

Biomolecular structure and function
Structure and functionality of biological molecules are strongly related. Biophysical processes take place at a well defined temperature. These molecules often change in structure during their reactions; hence stiffness and flexibility have to be accurately tuned. Laser spectroscopy and in particular high resolution laser spectroscopy is the most accurate tool to determine the structure of the molecules. Also the flexibility of these molecules is encoded in their spectra as a consequence of the rules of nature imposed by quantum mechanics. We use high resolution laser techniques to find very precise answers on the structure and flexibility of

small size biomolecules with the long term aim to explore the limits of these techniques in the direction of 'real' biomolecules. Experiments are performed in close collaboration and in an exchange program with the Heinrich Heine University in Düsseldorf and in collaboration with the theoretical chemistry program at this university.

Molecular detection and recognition
Small molecules such as atmospheric species are easily recognized by their spectral structures. However, also these molecules have spectral features that are extremely weak, while at the same time these properties are highly relevant to atmospheric problems as a consequence of the enormous amounts of these molecules in our atmosphere. Using cavity ring down spectroscopy, absorption characteristics of small molecules are quantified in order to understand the effects of collisions and improve the use of these data. In the mid-infrared and far-infrared, large molecules reveal not only structure but also their internal flexibility. The study and generation of these spectra is a growing field in the group.

Electrons and molecules
In our upper atmosphere, molecules are often present as ions. The reaction of these ions with electrons is experimentally studied in a large scale storage ring experiment in Stockholm in collaboration with the University of Stockholm while we develop instrumentation and determine the properties of these reactions that are directly related to airglow and auroral phenomena in our upper atmosphere.

Instrumental developments
The group MBf is respossible for the design ansd constructor of a FIR or THz radiator source based on a free electrolaser. A large and ambitious project.

Opportunities for students:
The world around us contains molecules in all shapes, forms and size. Molecular processes dominate daily life. The understanding of molecular behavior, the detection and recognition of molecular behavior and in particular the interaction between the molecular world and electromagnetic radiation is central in the research themes of this group.
Therefore all students are welcome to perform or to join the scientific program in the department in all phases of their university program.

Scanning Probe Microscopy (IMM)

Head:	Ms Prof. Dr S. Speller
Scientific staff:	Dr. J.A.A.W. Elemans, dr.ir. B.L.M. Hendriksen
Secretariat:	Ms M.L. Beenen(mailto:r.gommers@science.ru.nl) room HG 01.074; tel. (36)52121
Website:	wiki.science.ru.nl/spm/Main_Page

Research

- Nanoprobing
- Molecular electronics and mechanics

- Nanoscale chemistry
- Bio-electronic coupling
- NanoLab Nijmegen

Scanning Probe Microscopy enables visualization of nanoscopic objects. Our interdisciplinary group is dedicated to the development of new modes operation to address nanoscale systems which couple physics, chemistry, and biology.

Description

In our research group Scanning Prob microscopy we are interested in phenomena on very small length scales. The long-term aim is to unravel mechanisms and processes which couple physical, chemical and biological structures. For this purpose advanced scanning probe microscopy methods are developped and applied. We are an interdisciplinary team of physicists, chemists, natural scientists, engineers, and biologists. We collaborate with the molcular cluster, the computational and theory groups, the biochemistry groups within the Institute for Molecules and Materials of the Faculty of Science. In addition, collaborations exist with a large number of international laboratories and industries.

Scanning Probe Microsocpy (SPM) methods represent a unique toolbox to study and manipulate systems locally and to address nano-objects individually. To some extent device-like conditions can be realized on nano-scale. Our aim is to enhance the applicability and selectivity of scanning probe microscopy methods. In our group we develop SPM modes for complex systems and environments. This includes functionalization of nanoprobes, correlative nano-probing, and local tunneling and ion currents in liquids and electrolytes, allowing us to explore heterogneneous systems, (spin)electronic and transport properties of nanoscale structures, correlation of structural and functional properties, and chemical reaction mechanisms.

Molecular electronics and mechanics

"How do molecules conduct electricity? " That is the central question of this research theme. Understanding the transport mechanisms of change carriers in organic molecules is relevant to molecular electronics, organic electronics and electron transport in biology. We use STM and conducting tip AFM to study charge transport (electrons/holes) through single molecules and between molecules in molecular assemblies. We focus on the coupling between the charge carriers transport with the mechanics of the molecules and the structure of the molecular assemblies.

Nanochemistry

During the past decades Scanning Probe Microscopy studies of molecular layers in ultra-high vacuum have provided substantial insight into chemical processes at the nanoscale. However, chemistry in industry and in the laboratory occurs under far more realistic conditions: often in a liquid, and under a controlled atmosphere. We have developed a sophisticated Liquid Scanning Tunneling Microscope, which allows the study of molecular layers under these practical conditions. In this setup we focus on studying dynamic processes at a surface, such as the step-by-step monitoring of chemical reactions in real-space. These studies can provide unique new insights in reaction mechanisms, since information is obtained about single molecules instead of at the ensemble level, where the behavior of millions of molecules is averaged. It is important to extend the apolar liquids we use to electrolytes, and it is our aim to combine the microscopy with advanced spectroscopy and optical techniques. The interdisciplinary research is done in a joint collaboration with the chemistry groups in the Molecular Cluster.

Interaction forces of individual biological structures

Interactions between biomolecules are of eminent importance in biology. For instance for improving and finding ways to cure diseases induced by viruses such as HIV and Hepatitis we need the physical knowledge of specific binding between protein and nucleic acids. Since in biology energetics of processes is close to kT, single molecule approaches are quite insightful. Atomic force microscopy modes have been developed to a powerful tool to assess biologic interaction. Individual biologic bonds can be exposed to organic agents and drugs and their effect can be assessed directly by the force characteristics. Also at the level of viruses and live cells force spectroscopy can reveal mechanisms of interaction.

Bio-electronic coupling

- Magnetite nanocrystals and their role in magneto reception

Magneto reception allows animals to navigate in the geomagnetic field. We study magnetite nanocrystals in the tissue. Our aim is to unravel transduction mechanisms of magneto reception in fish. Recently we achieved the correlation of Magnetic Force Microrscopy-Atomic Force Microscopy, transmission electron microscopy, and staining of neighboring epithelium slices. This allowed us to determine the distribution of nanoparticles among cells. We also study model systems such as Ferro fluids by Magnetic Force Microscopy.

- Ion current imaging of live cells

Cells are a stage of sparkling activity including numerous biochemical reactions and migratory processes. Typical examples are protein synthesis and regulation, repair, replication, molecular transport, export, and initiation of programmes such as division, activation and differentiation. Processes can be triggered or modified by internal and external stimuli and are accompanied by substantial fluctuations of analytes. We investigate local changes of ion concentrations in live cells using Scanning Ion Conductance Microscopy.

Opportunities for students

For students, there is ample opportunity to participate in the research of basically all the subjects mentioned above. Supervision is usually done by more experienced group members such as Phd students, postdocs and faculty staff. There are also excellent possibilities for interdisciplinary internships.

Spectroscopy of Solids and Interfaces (IMM)

Head: Prof. Dr Th. Rasing

Scientific staff: Dr A. Kirilyuk, Dr A. Kimel
Secretariat: Ms M.L.G. de Wit
(marilou.dewit@science.ru.nl)
room HG 01.074; tel. (36)53141
Website: www.ru.nl/imm/ssi
Research topics:

- Nanomagnetism
- (Sub)nanosized magnetic clusters
- Ultra fast carrier and spin dynamics, coherent control
- Nanophotonics
- Supramolecular structures
- Liquid crystals and polymers
- Applications

Mission: to understand the relation between properties and structure of condensed matter, in particular of nanoscopic, magnetic and molecular materials with a focus on phenomena occurring on ultra short time scales (femto seconds) and ultrasmall length scales (nanometers). In this regime quantum mechanical principles and surfaces and interfaces play a dominant role and may lead to surprising new results. For this research novel, advanced optical and scanning probe techniques are being developed and applied.

Description:

Nanomagnetism
This field of research includes magnetic surfaces and interfaces and electronic and magnetic properties of low dimensional objects such as nano-wires, ultra thin films and multilayers. This exciting area combines fundamental challenges with a high potential of practical applications like sensors (Nobelprize 2007) and datastorage. We use new Scanning Probe and Nonlinear Optical techniques that were partly pioneered in Nijmegen like Magnetization induced Second Harmonic Generation. New future developments are the combination of these approaches to allow the study of matter with the highest spatial (in-plane as well as out of plane) and temporal resolution.

(Sub)nanosized magnetic clusters
The goal is a comprehensive study of nanosized clusters of various oxides, both free and deposited on surfaces, that form the building blocks of new materials. Special attention is on the correlation between crystallographic structure, electronic states and magnetic properties. The combination of structural (infrared vibrational spectroscopy, SEM), electronic (UV ionization spectroscopy for free clusters, STM spectroscopy for clusters on a surface) and magnetic (Stern-Gerlach experiments for free clusters, magneto-optics and spin-polarized STM for the deposited ones) information will provide an unprecedented insight into the properties of these interesting strongly-correlated materials. Part of the research is done using the free electron laser FELIX at Rijnhuizen, while collaborations exist with various theoretical groups (including prof. M. Katsnelson).

Ultra fast carrier and spin dynamics, coherent control

The dynamics of electrons and holes in semiconductors and metals (in the presence of electric and magnetic fields) can be studied using ultrashort femto-second (fs) laser pulses. In this way electron-electron, electron-phonon and electron-magnon interactions can be probed directly, in contrast to standard transport experiments that only probe time - averaged quantities. For example, an intriguing question is: how fast can the magnetization of a magnetic system be changed (reversed)? This is an exciting area of fundamental research with far reaching practical consequences for opto-electronics, spintronics and magnetic recording. We have pioneered novel methods to create very fast controllable magnetic field pulses (Th. Gerrits, Nature **418** (2002) and A. Kimel et al, Nature **435** 2005) and have also demonstrated the possibility to observe and exploit the ultrafast spin dynamics in anti-ferromagnetically ordered materials (A. Kimel et al, Nature **429** (2004). A. Kimel et al Nature Physics ...)). We have recently demonstrated that magnetic domain can even be switches with a 40 fs optical pulse (D. Stanciu et al, Phys.Rev.Lett. (2007)) and discovered a completely new linear reversal mode for the magnetic moment (K. Vahaplar et al Phys.Rev.Lett. 2009). This work profits from strong collaborations with many experimental as well as theoretical groups worldwide. Theoretical work is done in collaboration with Prof. Katsnelson.

We are further exploring complete coherent optical control of spins in magnetic media and in atoms to understand and exploit the interaction of photons, spins and angular momentum transfer (in collaboration with Prof. W. van der Zande).

Nanophotonics

The goal is to achieve the control of electronic and magnetic properties at femtosecond time scales with nanometer spatial resolution, where usual optical tools fail. Scattering-type near-field scanning-probe microscopy is being developed to achieve a resolution down to 10 nm. This, combined with femtosecond laser pulses, will allow the real-time observation of ultrafast nanometer-scale dynamics. On the other hand, plasmonic structures will be developed and used to concentrate electromagnetic optical waves in a sub-wavelength volume and achieve modification and amplification of opto-magnetic effects.

Supramolecular structures

In collaboration with the Organic Chemistry groups (Nolte, Rowan, van Hest) that are responsible for the synthesis of increasingly complex systems with tailor made properties, the physical properties of individual molecules and molecular aggregates are being studied with scanning probe and nonlinear optical techniques. This highly interdisciplinar field is a strongly growing research area with connections to biology.

Liquid crystals and polymers

These fascinating materials combine a large variety of interesting fundamental phenomena with a huge potential for application (LCD's: Liquid Crystal Displays and Biosensors). Topics of current research are light induced ordering, nano patterned surfaces, phase transitions and dynamics in very thin films. A new development is the exploration of the hierarchy of ordering in LC-cells (from the molecular nanoscale to the macroscopic scale of the LCD) for the application of LC cells as biosensors. This work is done in collaboration with Organic Chemistry (Nolte, Rowan, Kouwer), Philips and several European groups.

Applications

Many of the topics described above are at the interface between fundamental and applied research (a distinction that is often rather arbitrary). This is illustrated by the industrial collaboration with for example Philips, NXP, Seagate and others, often within European projects. Some of these applied research projects are monitored by an external advisory/user committee where researchers from industrial laboratories play an important role. This allows students to have contacts with industry and their approach to research at a quite early stage, which gives extra opportunities for students who desire a career in industry. There are also possibilities to do (part of) a research project in an industrial laboratory, both in the Netherlands and abroad.

Opportunities for students:

The research is mostly done by PhD students and postdocs in collaboration with undergraduate students. The senior scientists supervise the various PhD and undergraduate projects and are also involved in short time pilot projects, that if succesfully, will later be integrated in the research programme.

For students, there is ample opportunity to participate in the research of basically all the projects mentioned above. Our philosophy however is that the students should have their own, individual projects, that can but not necessarily have to be part of a larger project. Though not a necessary condition, the past experience shows that most of these student projects lead to one or more publications in international journals. There are also possibilities of joint projects (with other graduate or Phd students) and often the undergraduate projects may lead to a PhD project. Part of the research internship can be done abroad as part of the Socrates Programme (for example Leuven, Oxford, Marseille) or within one of the many collaborations (Japan, Germany, UK, France, USA, Sweden, Switzerland, Austria).

Theory of Condensed Matter (IMM)

Head:	Prof.Dr. M.I. Katsnelson
Scientific staff:	Ms Prof.Dr. A. Fasolino
Secretariat:	Ms J.P.M. Föllings-Reuvers (a.follings@science.ru.nl); room HG 03.050; tel. (36)52981
Website:	www.ru.nl/tcm

Research

- physical properties of solids
- physical properties of liquids
- essentially many-body properties

Description of research

The aim of condensed matter theory is an explanation of physical properties of solids and liquids on the base of fundamental physical principles. A broad class of phenomena, from strength, plasticity, friction, to magnetism, superconductivity, and superfluidity, can be explained in terms of laws of quantum mechanics. However, in practice it is an extremelly difficult problem, first of all, due to its essentially many-body character. The Theory of Condensed Matter group deals with this problem on different levels, such as model considerations of basic many-body effects for quantum and classical systems, realistic simulations of physical properties of specific materials, and phenomenological description of complicated phenomena such as equilibrium and nonequilibrium phase transitions.

Opportunities for students

The department of Theory of Condensed Matter offers several theoretical and/or computational research projects at the Bachelor and Master level. Students are advised to contact the head and members of the department to choose a project of mutual interest at the right level. Master projects are in general related to one topic of current interest of the group and aim at reaching some original scientific result.

5.4 Donders Centre for Neuroscience (DCN)

Donders Centre for Neuroscience (DCN)

All research groups from the Faculty of Science and the University Medical Center St. Radboud, working in the field of Neuroscience, collaborate within the Donders Centre for Neuroscience (DCN). The research groups, most relevant for physics, are the Dept.of Biophysics (van Opstal, Kappen, Gielen) and the new research group on NeuroInformatics (Professor currently recruited) within FNWI and the dept. of Clinical Neurophysiology (Stegeman) within the UMCN. The DCN collaborates with the Center for Cognitive NeuroImaging on advanced NeuroImaging techniques (EEG, MEG, fMRI) and data-analysis. The research activities closely related to physics concentrate on experimental and theoretical approaches to

- Understanding localization and identification using auditory, visual and vestibular information
- Motor control and robotics
- Computational Neuroscience
- Natural and Artificial intelligence.

Contact information:

Secretary: Mw. J.I.M. (Judith) Fontaine
T: (+31) (0)24 3614244
E: neuroscience@donders.ru.nl
or
Prof. Dr C. Gielen (Director DCN), tel 024 3614242
Dr A. Vink (Managing Director DCN), tel. 024 3668578
www.ru.nl/dcn/current/vm/donders_centre_for/

Biophysics

The Biophysics group is funded both by the Faculty of Science and the University Medical Centre and collaborates with the Dept. of Biophysics of the University Medical Centre.
Head: Prof. Dr. A.J. van Opstal

Scientific staff: Prof. Dr H.J. Kappen, Dr H.H.L.M. Goossens (UMC), Dr T.F. Oostendorp (UMC)

Secretariat: Ms J. Fontaine and Ms I. Helsen (mbfys@science.ru.nl), room GG 21.16.0.20; tel.: (36)14244

Website: www.ru.nl/mbphysics

Research:

- Brain and behaviour
- Machine learning and artificial intelligence

Description of research:

Brain and behaviour

The research focuses on neuronal information processing by the central nervous system, in particular on the sensory coding of visual, auditory and vestibular information and on sensorimotor transformations that map the sensory information into goal-directed motor commands (eye, head, and arm movements) for appropriate action. The studies include experimental and theoretical approaches. With regard to experiments the group collaborates with researchers in the Donders Institute (http://www.ru.nl/fcdonders/), which houses advanced equipment for measuring and imaging of neuronal activity, and with research groups in the University Medical Centre St. Radboud.

The topic of neuronal information processing is addressed from different perspectives:

- Experimental research based on a systems-theoretical approach. By presenting a variety of complex stimuli and their associated responses, we aim to elucidate and characterise the functional properties and hierarchical structure of processes involved in perception and action.
- Electrophysiological studies in which we record neuronal activity in primates and humans.
- Characterization of source location of brain structures that contribute to neuronal activity using the bioelectricity of the brain (electro-encephalography, EEG and magneto-encephalography MEG) in collaboration with the department of Neurology and the Donders Center for Cognitive Neuroimaging.
- Theoretical research modelling biological neurons and the information storage and retrieval by networks of neurons.

The theoretical research aims to gain insight in information processing in neurobiological systems as well as on applications of knowledge using artificial neural networks and machine learning algorithms. We develop models for complex biological neurons and investigate learning and communication in neuronal circuits, as well as the dynamics of self-organization and information storage by networks of neurons.

Machine learning and artificial intelligence

Although still far in the future, one day we will have computers and robots that can think and learn like humans. Nevertheless, artificial intelligence research is producing useful methods that provide solutions in many branches of industry. At the department of Biophysics, there is a group of physicists that develop novel machine learning methods and that apply these methods to AI applications. In particular, methods that have a close resemblance to methods from statistical physics, such as mean field and Bethe approximations and Monte Carlo sampling, are developed by the group and are among the best methods world-wide. Applications are in the areas of medical expert systems, genetics, multi-agent control problems, and time-series forecasting. Soms of these applications are commercialized through spin-off companies or with industrial partners. For more information see www.snn.ru.nl/nijmegen/. Students that are interested to write their Master's thesis in this research direction are adviced to follow courses as described in the master track computational neuroscience - Machine Learning.

Opportunities for students:
The department of Biophysics offers several experimental and theoretical research projects for a Bachelor or Master project. Students from Physics, Natural Science, Mathematics, Informatics and Biology can follow dedicated bachelor courses in the Minor Neuroscience, and a Master program that is tailored to their specific interests in the field of Neuroscience. Students are advised to contact the head of the Biophysics department, or one of the members of the scientific staff for further details.

6 Examinational Regulations

The examination regulations have been laid down in two documents. The Education and Examination Regulations (OER) govern the general organization and scope of education and examinations. More specific regulations can be found in the Rules and Guidelines of the Examination Committee.

This chapter first discusses a number of points from these regulations plus a number of practical aspects. The full text of the OER can be found on the internet, the Rules and Guidelines of the Examination Committee can be found below.

The study programme of Physics and Astronomy includes a propaedeutic examination, a Bachelor's examination, a Master's examination and a Doctoraal examination. Each examination comprises a number of interim examinations.

All interim examinations are administered at least twice a year: the first time shortly after the last lecture given; re-sits are scheduled later in the year. In some subjects, students are given a third opportunity to take an interim examination. A student can sit an interim examination up to a maximum of 3 times, provided he or she is registered as a regular student, external student (student who is entitled to sit examinations, but may not attend lectures and receives no grant) or institutional student (student who is not entitled to a grant and pays the institution fee instead of the legal tuition fee). If an interim examination has been taken more than once, the highest score will count. If, after three sittings, a student has not been able to pass the examination, he or she may request the examination committee in writing for permission to take the examination once more. The regulation stating the maximum of three examination sittings came into force as of 1 September 1999 and applies to interim examinations for which students have registered for the first time since that date, and all following interim examinations.

Some interim examinations may only be taken when certain components have been completed successfully. See OER: www.ru.nl/ons/onderwijszaken/onderwijs-_en/

6.1 Interim examinations

Students need to register for all interim examinations in the Master's phase. They can do so via KISS, which can be accessed on the computer terminals located at various places in the building. Each student will receive a personal password. Through KISS, you can register for interim examinations, look up your examination results, change your address, etc. Make sure you register before the closing date (5 working days before the date of examination).

Practical exams are also examination components for which students should register.

A few weeks after the examination, the results can be looked up via KISS. For privacy reasons, results are not disclosed over the telephone!

6.2 Master's Thesis

The procedure for assessing the master's thesis results is more stringent than the procedure for assessing other study components. The report is read by the graduation supervisor and a second staff member. The procedure is as follows:

- The graduation supervisor (supervising professor) is responsible for the dissertation and mark

- The graduation supervisor nominates a scientific staff member from outside his/her branch of learning as a second assessor, by letter or e-mail to the secretariat of the institute, at least 5 weeks before the date on which the mark is to be submitted
- The secretariat of the institute communicates the nomination to the chairman of the examination committee or, in case the chairman is not present, to the secretary or other deputy designated by the chairman
- When approved, the nomination will be communicated by letter or e-mail to the graduation supervisor
- The dissertation will be submitted to the second assessor at least 3 weeks before the date on which the mark should be known
- The second assessor will have 10 working days to assess the work placement results
- Within those 2 weeks, the graduation supervisor will inform the second assessor of the mark awarded for the work placement
- Within those 10 days, the second assessor will state whether or not he/she agrees with the mark given
- If the second assessor does not agree with the mark given, this will be reported to the graduation supervisor and the secretariat of the institute
- The secretariat will keep anonymous records of the dissertations the second assessor has assessed otherwise
- The graduation supervisor and second assessor will jointly determine the final mark. In the event that they cannot come to an agreement, the graduation supervisor will determine the mark and will report the matter to the examination committee

6.3 The Master's examination

Students should register for the Master's (Doctoraal) examination in Physics and Astronomy no later than the closing date (see appendix B for dates).
To register for the Master's (Doctoraal) examination, students **must** submit the following documents:

- valid student card
- valid passport or identity card
- last obtained certificate (if obtained outside the RU)

Only for students who were registered as external students during part of their study:

- a confirmation of external student status. This is a statement from the institute confirming that the student in question did not receive any education during the period that he/she was registered as an external student.

The Student Administration/Examination Office will **only** register students for the Master's examination if all the results of the interim examinations are in the possession of and have been processed by the Student Administration/Examination Office.

The regulations governing the examinations in August are somewhat different. For these, students can register up to the end of May, and may do so even if several marks have not yet been obtained. These marks have to be delivered before August 31, 2011; 12:00 a.m.

There are approximately 10 examinations scheduled each year (see appendix). The diplomas are presented once every three months. If students need proof of graduation before the date of presentation (e.g. when applying for a job), they can obtain written proof of graduation from the chairman of the examination committee. Students may also enquire at the Student Administration/Examination Office whether the examination committee has already signed the Master's certificate. If this is the case, the Student Administration/Examination Office will supply a certified copy of it.

6.4 Regels en Richtlijnen van de Examencommissie

REGELS & RICHTLIJNEN van de EXAMENCOMMISSIE 2010/2011
Artikel 1: Toepassingsgebied

Deze regels en richtlijnen zijn van toepassing op de tentamens in de opleiding Natuur- en Sterrenkunde, hierna te noemen: de opleiding.

Artikel 2: Begripsomschrijving

In deze regels en richtlijnen wordt verstaan onder:

1. examenregeling: de onderwijs- en examenregeling voor de in artikel 1 genoemde opleiding;
2. examinandus: degene die zich onderwerpt aan een tentamen of examen;
3. tentamen: het onderzoek naar en de beoordeling van kennis, vaardigheden en inzicht, ongeacht de vorm waarin dit onderzoek plaatsvindt;
4. student: degene die als zodanig is ingeschreven voor de opleiding;
5. examinator: examinator als bedoeld in artikel 7.12 lid 3 WHW.

Artikel 3: Dagelijkse gang van zaken examencommissie

De examencommissie wijst uit haar midden een lid aan dat belast is met de behartiging van de dagelijkse gang van zaken van de examencommissie.

Artikel 4: Vaststelling uitslag examen

   1. Alle beoordelingen op hoogstens één na zijn voldoende, dat wil zeggen tenminste 6.0, respectievelijk voldaan, gevolgd of vrijstelling. Er zijn geen beoordelingen lager dan 5.
   2. Het gemiddelde van alle beoordelingen is ten minste 6.

6. De kandidaat is geslaagd voor het propedeutisch examen als de beoordelingen die hij/zij ontvangen heeft voor de onderdelen van het propedeutisch examen voldoen aan de volgende voorwaarden:
7. De kandidaat is geslaagd voor het bachelorexamen als hij/zij de propedeuse heeft behaald en de beoordelingen die hij/zij ontvangen heeft voor de onderdelen van de postpropedeuse, voldoen aan de volgende voorwaarde: alle beoordelingen zijn voldoende, dat wil zeggen tenminste 6.0, respectievelijk voldaan, gevolgd of vrijstelling
8. De kandidaat is geslaagd voor het masterexamen als de beoordelingen die hij/zij

ontvangen heeft voor de onderdelen van het masterexamen voldoen aan de volgende voorwaarde: alle beoordelingen zijn voldoende, dat wil zeggen tenminste 6.0, respectievelijk voldaan, gevolgd of vrijstelling.

9. In bijzondere gevallen kan de examencommissie van het hierboven bepaalde afwijken.

Artikel 5: Judicia

Er worden 4 categoriën onderscheiden:

- Geen judicium: Het gewogen gemiddelde van alle vakken is kleiner dan 7.5
- Bene meritum: Het gewogen gemiddelde van alle vakken ligt tussen 7.5 en 8.0
- Cum Laude: Het gewogen gemiddelde van alle vakken ligt tussen 8.0 en 9.0
- Summa cum laude: Het gewogen gemiddelde van alle vakken is groter dan 9.0

Het gewogen gemiddelde wordt bepaald door de studielast (aantal ec) per vak.

Artikel 6: Cijfers

De cijfers die voor de beoordeling van de tentamens uitsluitend gebruikt mogen worden zijn: 10,0; 9,5; 9,0; 8,5; 8,0; 7,5; 7,0; 6,5; 6,0; 5,0; 4,5; 4,0; 3,5; 3,0; 2,5; 2,0; 1,5; 1,0; voldaan.

Artikel 7: Aanmelding tentamens

1. Deelneming aan een schriftelijk tentamen als bedoeld in artikel 8 lid 1, kan pas plaatsvinden na deugdelijke en tijdige aanmelding bij de facultaire studentenadministratie.
2. Als tijdige aanmelding geldt een opgave tenminste 5 werkdagen voor het tijdstip waarop het desbetreffende tentamen zal worden afgenomen. De examencommissie kan in bijzondere gevallen toestaan dat een latere aanmelding niettemin als tijdig wordt aangemerkt.

Artikel 8: De orde tijdens een tentamen

1. De desbetreffende examinator zorgt dat t.b.v. de schriftelijke examinering, surveillanten worden aangewezen die erop toezien dat het tentamen in goede orde verloopt.
2. De desbetreffende examinator informeert de examinandi bij schriftelijke examinering vooraf over de voorgenomen normering van de tentamenonderdelen.
3. De examinandus is verplicht zich op verzoek van de surveillant te legitimeren.
4. De examinandus is verplicht de aanwijzingen van de examencommissie c.q. de examinator, die voor de aanvang van het tentamen zijn gepubliceerd, alsmede aanwijzingen die tijdens het tentamen en onmiddellijk na afloop daarvan worden gegeven, op te volgen.
5. Volgt de examinandus een of meer aanwijzingen als bedoeld in het vierde lid niet op, dan kan hij door de examencommissie c.q. de examinator worden uitgesloten van de verdere deelname aan het desbetreffende tentamen. De uitsluiting heeft tot gevolg dat geen uitslag wordt vastgesteld van dat tentamen. Voordat de examencommissie c.q. de examinator een besluit tot uitsluiting neemt, stelt zij de examinandus in de gelegenheid te worden gehoord.

Artikel 9: Fraude

1. Er is sprake van fraude wanneer als gevolg van handelen of verzuim van handelen van een examinandus het vormen van een juist oordeel omtrent zijn kennis, inzicht en vaardigheden geheel of gedeeltelijk onmogelijk wordt.
2. In geval van fraude tijdens het afleggen van een tentamen kan de examinator de examinandus uitsluiten van verdere deelname aan het tentamen.
3. De beslissing inzake uitsluiting wordt genomen naar aanleiding van door de examinator of surveillant geconstateerde of vermoede fraude.
4. In spoedeisende gevallen kan de examinator een voorlopige beslissing tot uitsluiting nemen op grond van zijn constatering c.q. vermoeden of, indien van toepassing, een mondeling verslag van de surveillant. Desgevraagd draagt de examinator er zorg voor dat, binnen een redelijke termijn, het verslag van de geconstateerde of vermoede fraude op schrift wordt gesteld en in afschrift aan de examinandus wordt verstrekt.
5. De examinandus kan aan de examencommissie verzoeken de uitsluiting ongedaan te maken.
6. Voordat de examencommissie een beslissing neemt op een verzoek, als bedoeld in het vijfde lid, stelt zij de examinandus en de examinator in de gelegenheid te worden gehoord.
7. Een uitsluiting heeft tot gevolg dat geen uitslag wordt vastgesteld voor het in het tweede lid bedoelde tentamen.

Artikel 10: Dubbele Bachelor Wiskunde en Natuur- & Sterrenkunde

1. Studenten die de dubbele bachelor Wiskunde en Natuur- & Sterrenkunde volgen, hebben een verzwaard studieprogramma in de propedeusefase (75 ec) en de postpropedeusefase (150 ec).
2. In de propedeusefase komen de wiskundevakken Wiskunde en Computers (3 ec) en Euclidische Meetkunde (3) te vervallen als verplichte vakken.
3. In de postpropedeusefase zijn de wiskundevakken Inleiding Statistiek (3 ec), Krommen en Oppervlakken (3 ec) en Inleiding Partiële Differentiaalvergelijkingen (6 ec) verplichte vakken.
4. In de postpropedeusefase
   1. wordt een keuze gemaakt tussen de wiskundevakken Discrete wiskunde 1 (3 ec) en Discrete Wiskunde 2 (3 ec);
   2. wordt het verplichte natuurkundevak Practicum Natuurkunde 2b (6 ec) vervangen door Practicum Natuurkunde 2c (3 ec)
   3. wordt 3 ec keuzeruimte benut voor het ontbrekende wiskundevak Discrete Wiskunde 1 (3 ec) of Discrete Wiskunde 2 (3 ec), dan wel het complemeteren van het natuurkundevak Practicum Natuurkunde 2c tot Practicum Natuurkunde 2b (6 ec in plaats van 3 ec).
5. In de postpropedeusefase komt het wiskundevak Logica 1 (3 ec) te vervallen als verplicht vak.
6. In de postpropedeusefase wordt één Bachelorstage (12 ec) verricht bij een Wiskunde- of Natuurkunde-afdeling naar keuze.
7. Bovenstaande regels (artikel 10.1-10.6) worden getoetst in een gezamenlijke zitting van de examencommissies van de opleidingen Wiskunde en Natuur- en Sterrenkunde.

Artikel 11: Minoren

1. Het samenhangende vakkenpakket omvattende Tensoren & Toepassingen (3 ec),

Inleiding Algemene Relativiteitstheorie (3 ec), Stromingsleer (3 ec), Inleiding Groepentheorie (3 ec), Elektronica (3 ec), 2 verplichte keuzevakken (6 ec; uit Inleiding Biofysica (3 ec), Subatomaire Fysica (3 ec), Atoom- en Molecuulfysica 33 ec) en Vaste Stoffysica (3 ec)) en keuze (9 ec) uit natuur- en sterrenkundevakken of wiskundevakken (zie de desbetreffende studiegidsen) geldt als minor natuurkunde.

2. Het samenhangende vakkenpakket omvattende Planetenstelsels (3 ec), Sterevolutie (3 ec), Radio-Astronomie (3 ec), Sterrenstelsels (3 ec), Stralingsprocessen (3 ec), Asteroseismologie (6 ec), Tensoren & Toepassingen (3 ec), Inleiding Algemene Relativiteitstheorie (3 ec), 1 verplicht keuzevak (3 ec: keuze uit Inleiding Groepentheorie (3 ec), Stromingsleer (3 ec), Nucleosynthese (3 ec)) en de 2 vakken Observational Astronomy (3 ec) en Space Astronomy (3 ec) in plaats van Practicum 2b (6 ec) geldt als minor Sterrenkunde.
3. Het samenhangende vakkenpakket omvattende Getallen (6 ec), Analyse 1 (6 ec), Analyse 2 (6 ec), Symmetrie (6 ec), verplichte keuze (6 ec) uit Inleiding Fouriertheorie (3 ec) en Krommen en Oppervlakken (3 ec) of Inleiding Partiële Differentiaalvergelijkingen (6 ec) is goedgekeurd als minor Wiskunde. Het natuurkundevak Inleiding Groepentheorie komt dan te vervallen als verplicht vak.
4. Het samenhangende vakkenpakket omvattende Voortgezette Kansrekening (3 ec), Inleiding Biofysica (3 ec), Inleiding Magnetische Resonantie (3 ec), Neurofysica (3 ec), MRI of Living Systems (3 ec), Toegepaste Stochastiek (6 ec), Mathematical Biology & Neuroscience (3 ec), Neural Networks and Information Theory (3 ec) en vrije keuze (3ec) is goedgekeurd als minor Neurosciences.
5. Het samenhangende vakkenpakket Celbiochemie (6 ec), Biochemische Processen (3 ec), Celbiologie der Dieren (6 ec), Biochemie & Moleculaire Biologie 2 (6 ec), Toegepaste Bioinformatica (6 ec) en vrije keuze (3 ec) is goedgekeurd als minor Biologie.
6. Het samenhangende vakkenpakket Atoom- en Molecuulbouw (3 ec), Moleculaire Structuur (3 ec), Reacties en Kinestiek (3 ec), Chemische Thermodynamica (3 ec), Synthese Biomoleculen (3 ec), Coördinatie-Chemie (3 ec), Chemische binding (3 ec), Kristalstructuur (3 ec), Microscopische Technieken (3 ec) en Gecondenseerde Materie (3 ec) is goedgekeurd als minor Chemie.

Artikel 12: Wijziging regels en richtlijnen

Geen wijzigingen vinden plaats die van toepassing zijn op het lopende studiejaar, tenzij de belangen van de studenten daardoor redelijkerwijs niet worden geschaad.

Artikel 13: Inwerkingtreding

Deze regels en richtlijnen treden onder voorbehoud in werking op 1 september 2010. De definitieve versie is te raadplegen op het web: http://science.ru.nl/winst

Aldus vastgesteld door de examencommissie voor de opleiding Natuur- en Sterrenkunde.

7 The Administrative Structure

The master programme Physics and Astronomy is one out of eleven master programs of the Faculty of Science. In this chapter an outline is given of the administrative structure of the Faculty.

The Executive Board of the Faculty is formed by the Dean, two Vice-Deans (for research and education) and a Managing Director (HRM, administration and PR). One Student Assessor, who has an advisory vote, completes the board. There is a Joint Faculty Council (FGV) of the Faculty Employees' Council (OC) and the Faculty Students' Council (FSR). The FGV has the right of consent in regard to policy plans, faculty regulations, education and examination regulations, and quality control of education and research.

The Faculty of Science is one out of the nine faculties and together they make up the Radboud University, which is run by the University Board (CVB). The Joint University Council (UGV) of the Employees' Council (OR) and Students' Council (USR) advises the University Board.

7.1 The Educational Institute for Mathematics, Physics and Astronomy (WiNSt)

The Faculty of Science encompasses 6 research institutes and 4 educational institutes. The educational institute for Mathematics, Physics and Astronomy (WiNSt) is one of the educational institutes and it is chaired by a Director of Education. The institute homes the School of Mathematics and the School of Physics and Astronomy. A programme coordinator is responsible for each of the educational programmes. The programme coordinator is supported by authorative committees: an Education Committee, an Examination Committee and a Committee for Study Advice at the end of the first year. The Education Committee advises on matters relating to education, by own initiative or on request. This Committee consists of 8 members: 4 scientific staff and 4 students.

8 Student Facilities

This chapter provides an overview of the facilities accessible to students. Names and addresses can be found in Appendix A. For more information see: http://www.ru.nl/students

Student Advisor

For advice on matters relating to their studies, students can contact the Student Advisor (see Appendix A). The Student Advisor monitors the students' progress. Students whose progress is not quite up to par are invited for an interview. This service is much appreciated, particularly in connection with the 'tempo' or performance-related grant. The Student Advisor assists students to answer questions about the choice of suitable fields of study, internal or external traineeships. If preferable, he may refer them to staff faculty of the institute and advisors at the central university level or beyond. He may also provide information on study skills training and study planning. You can call on him at any time you like. He will either help you immediately or make an appointment.

Student Affairs Office

At the university Student Affairs Office (see Appendix A) you can obtain information on student counsellors, student psychologists and the Study and Career Advice Group. At the desk you can make an appointment with a student counsellor or psychologist, or register for study skills training. Here you can also ask any questions concerning registration, obtain information on the Graduation Fund and Emergency Fund, report study delays due to special circumstances, obtain basic information on student financing, register for examinations through the Examination Office of the Arts Faculties, and obtain various flyers, forms and brochures. The Student Affairs Office also houses the KISS Help Desk.

Infotheque

At the 'infotheque' of the Student Affairs Office you can find all the information and documentation you need on study programmes offered at the Radboud University Nijmegen and other institutions, the labour market, and studying and doing work experience abroad. The infotheque also has excellent computer facilities, which enable you to search for information on the Internet (if necessary, with the help of special search engines).

Student Counselling Service

You can contact the Student Counselling Service (see Appendix A) if you have any study-related or personal questions. The Student Counselling Service also organizes various courses which will help you to develop study and professional skills (e.g. 'Writing Papers' and 'Speaking in Public'). The following professionals and bodies are part of the Student Counselling Service:

- study and careers consultant
- student counsellors
- student psychologists

- skills instructors
- Grievance Person and Undesired Behaviour Complaints Committee
- SLAG: Study and Career Advice Group
- Service Point Labour Market for the Highly Educated.

Central Student Administration

The Central Student Administration (see Appendix A) takes care of the registration of all students at the Radboud University Nijmegen. Its other activities include:

- managing student data
- issuing certificates of registration
- processing applications for tuition fee refunds

Students are registered as soon as the payment of tuition fee has been settled and the registration form has been processed. Registered students receive a student card. Information on study results is provided by the secretariat of the faculty or department responsible for the study programme in question.

KISS (RU Internet Service for Students)

All students at the Radboud University Nijmegen (RU) have access to KISS. KISS enables you to look up the results of the interim examinations you have taken, register for seminars and interim examinations, change your address, send and receive e-mail, create your own Web page and surf the Internet. KISS is also used to send the monthly newsletter to all RU students. This newsletter contains all kinds of news on the Radboud University Nijmegen. At the beginning of the first year, you will receive information on your KISS account and your personal login code. The first time you use KISS, you should convert this code into a personal password. If you cannot remember your password, you can apply for a new password at the Student Affairs Office (for which you need to submit your student card). You can find the KISS program on the Internet via www.ru.nl/kiss/english. If you want to use the university's computer facilities to go on the Internet, you need the Surfkit CD-ROM to install the software for dial-up access to the server. This CD-ROM can be obtained from the Student Affairs Office. If you have any questions about or problems with your KISS account, contact the Student Affairs Office or send an e-mail to: *helpdesk@student.ru.nl.*

Computing

Students may use the computers located in the various computer rooms. Each student has a login code that enables them to gain access to the network, send and receive e-mails and go online.

University Library

The central University Library (UB) is on the Erasmuslaan and is open to everyone. To borrow books from the library you need to show your student card. Most of the book collection is stored in a central repository that is not open to the public. This entails that all the applications for books and journals from the collection need to be made via the Online

Public Catalogue (OPC), with the exception of the collections of reference works in the Catalogue Room and Reading Room, which are directly accessible to the public. The Catalogue Room contains library catalogues, bibliographies, and directories, the Reading Room dictionaries, encyclopaedias, biographical materials, special bibliographies, and catalogues of manuscripts and early printed books.

Faculty Library

The Faculty Library (see Appendix A) is also accessible to students. Here you can consult and borrow books and journals, and study in peace.

Syllabus Office (Dictaten Centrale)

Syllabuses can be bought at the Syllabus Office (see Appendix A). Chapter 4 mentions the subjects for which you need to purchase syllabuses. The costs of books and syllabuses will not amount to more than a few hundred Euro's per semester.

Faculty Student Administration

To register for examinations and examination subjects and obtain information on student registration, contact the Student Administration of the Science Faculties (see Appendix A).

General Notice Board

The general notice board for students of Physics and Astronomy is located near the Physics Lab on the first floor, wing 8, in the Huygens building. On this board, you can find the latest information on lectures, interim examinations, etc.

Possibilities of appeal

With regard to examination-related matters, students can appeal to the Examination Appeals Board of the Radboud University Nijmegen. In addition to the Examination Appeals Board, there is a Higher Education Appeals Tribunal in The Hague. For procedures see: http://www.ru.nl/students

Functionally disabled, chronically ill and dyslexic students

Functional disabilities and chronic diseases are disorders of a permanent nature that tend to slow down the progress of the students suffering from them. These include: visual, auditory and motor dysfunctions, linguistic dysfunctions (dyslexia), speech impediments, reduced endurance, impaired memory and powers of concentration, organic dysfunctions, mental disorders, epilepsy, rheumatism, ME, severe migraine, whiplash injuries and RSI. Education is organized in such a way that functionally disabled students are just as likely to succeed as any other student. For this purpose, they have recourse to all kinds of legal and academic regulations for funding, housing, study materials, education and examination. For these students to make the best possible use of the Radboud University Nijmegen's facilities it is essential that they contact the study advisor and student counsellor at their earliest convenience (e.g. before they begin their studies). This also leaves time to discuss the required facilities and financial consequences. Further information can be found on the website: *www.ru.nl/students*

There is also a 'sounding-board group' for students with a handicap at the Radboud University Nijmegen. This group promotes the interests of handicapped students, and provides information on the existing facilities and policies, and where necessary, tries to improve these in collaboration with the student counsellors. The group consists of students, lecturers, a student counsellor and a policy official. Students and lecturers are requested to report to this group any regulations that are lacking or are not implemented properly (for example, with regard to accessibility of buildings).

Address: Comeniuslaan 4, P.O. Box 9102, 6500 HC Nijmegen, tel. (024) 3512345, e-mail: *balie@dsz.ru.nl*

University chaplaincy

The University Chaplaincy at the Catholic University of Nijmegen extends a warm welcome to all students and staff from abroad. In the Chaplaincy we work from an ecumenical Christian perspective. There are two Catholic pastors and one Protestant. There is a quiet meditation rooom and also a muslim prayer room.

Students and staff from all backgrounds are welcome, whatever your faith or persuasion. We intend to be a place where people share experiences, talk about issues that matter to them, and make friends.

Opening hours: 10 a.m. to 5 p.m. on Monday to Friday, during term time.

Address: Erasmuslaan 9

More information: www.ru.nl/chaplaincy/home/vm/university/

Beta Bedrijven Beurs

Jaarlijks wordt in het Huygensgebouw door een groep studenten een groots opgezette beurs georganiseerd waar meedere bedrijven zich presenteren en hopen op bijna afgestudeerde

9 Student Activities

9.1 Marie Curie

Marie Curie is the Student Association for Physics and Astronomy, meant for all students. Its basic goal is providing these students with the opportunity to get to know each other in an informal way. Here are a few ways (out of many) to achieve this.

- We share a canteen with two other student associations on the Faculty of Science where coffee, tea, candybars and sodas are sold during lunch hours, all at very affordable prices. On top of that it is the perfect place to hang out with your fellow students before, between or after classes, to study with nice music on the background, take a break on one of the many couches or maybe to challenge your companions for a game.
- Besides that, plenty of activities are organised. Sporting competitions (pool, karting), laserquest-matches, movie nights and barbecues are just a couple of examples. There are also loads of get-togethers for students, where one can for example play casino games, compete in interesting quizzes or just have a relaxing drink with other students.
- A great deal of time is spent in organising course-related activities. Several times a year we visit a company which houses physicists (f.e. KVI, NXP and ESA/ESTEC). Also, we organise a symposium in which physics is set in different perspectives once a year.
- Four times a year Marie Curie provides you with the opportunity to order books you need for classes. Prieces lie way below those which are common in bookstores. Serway and Calculus can be bought during the introduction. These books will be delivered to Institute WiNSt.
- Marie Curie has its own magazine too, named Impuls. It updates its readers on everything that is happening in Marie Curie and around our study, but you can also find interviews, interesting stories, views and a lot more.
- Last but definitely not least two study tours are organised every year. It enables 18 of our members to experience culture and physics in great destinations in- and outside Europe. In past years we travelled through Russia, Scandinavia, Canada and India whilst in 2010 we head for the United States. In May there will be a short break.

In case all this information has not convinced you: membership is only 10 euros. Although not obligatory, over 90% of the students in Physics and Astronomy become a member. If you would like more information or want to become a member right away: check our website at www.marie-curie.nl/ or contact us at: bestuur@marie-curie.nl

10 Appendices

In this appendices many practical details are given, important for students as well as staff. The telephone numbers look like (36)54321. That means: calling from inside the university you only need the last 5 figures. Calling from outside the university, but within Nijmegen you need all 7 figures. Calling from elsewhere you also need the area code prefix, 024 within the Netherlands, but 24 outside the Netherlands.

10.1 Appendix A: Important departments and persons

1. Educational Institute for Mathematics, Physics and Astronomy (WiNSt)

Director	Prof. Dr N. de Groot
Educational coordinator (Astro)Physics	Prof. dr W.L. Meerts
Educational coordinator Mathematics:	Prof. dr H.T. Koelink
Coordinator (Astro)Physics:	Dr G.W.M. Swart
Coordinator Mathematics:	Drs I. de Vries
Student-assessor (Astro)Physics:	Tijs Karskens
Student-assessor Mathematics:	Rutger Kuyper
Secretary (Astro)physics:	Ms J.Th.M. Vos - van der
Secretary Mathematics:	Lugt(secrons@science.ru.nl)
	Ms M. van Megen
	(m.vanmegen@science.ru.nl)
	Room: HG 01.831; tel.: 024-(36)52739

The office is open: Monday through Thursday, 08:30 - 16:30 p.m.; Friday, 08:30 - 12:30 p.m.

2. Board of Examination of Physics and Astronomy

President:	Prof. Dr T.H.M. Rasing
Members:	Prof. Dr S.J. de Jong
	Prof. dr R.H.P. Kleiss
	Dr G.W.M. Swart
	Vacancy

3. Education Committee of Physics and Astronomy

President:	Ms Prof. Dr. A. Fasolino
Members:	Dr W. Beenakker
	Dr A. Kimel
	Dr J. Hörandel
	Dr G.W.M. Swart
	V. Gerritsen (student)
	E. van Loon (student)
	P. van Oirschot (student)
	R. Ouwersloot (student)

4. PR committee of WiNSt

President:	Prof. Dr W.J. van der Zande
Members:	Prof. Dr Erik Koelink
	Dr Theo Smits
	Drs Ina de Vries
	Dr Bas Terwijn
	Dr Charles Timmermans
	Drs Lennart van Haaften
	Remco Castelijn (student)
	Mike Hoffmeister (student)
	Gillian Lustermans (student)

5. Student Advisor

Dr G.W.M. Swart (g.swart@science.ru.nl)
Room: HG 01.832; tel. (36)52559

6. Coordinator of Physics and Astronomy

Dr G.W.M. Swart (g.swart@science.ru.nl)
Room: HG01.832; tel. (36)52559

7. Coordinator International Affairs for Physics

Prof. Dr D. Parker (parker@science.ru.nl)
Room: HG 01.718; tel. (36)53423

8. Library of the Faculty of Physics and Astronomy

Heijendaalseweg 135, Huygensgebouw, ground floor, wing 2
Open: Monday through Thursday, 08:30 - 20:00 p.m. *(Except Summer Holidays)* and Friday 08:30 - 17:30 p.m.

Internetadres:www.ru.nl/fnwi/bibliotheek

9. Office of administration and exams for Students FNWI

Room: HG 00.134; tel. (36)53392 of (36)52247
The office is open:

- Monday through Thursday, 13:00 - 16:00 p.m.
- Friday, 09:00 - 12:00 a.m.

10. Lecture notes in stock

Address: Thomas van Aquinostraat 2
Tel: (36) 16250

Open: Monday through Thursday, 09:00 - 16:30 p.m.; Friday 09:00 - 13:00 p.m.
Except periods without education

Address at Internet: www.ru.nl/dictaten

11. Student counsellors' Office

Postaddress: POBox 9102, 6500 HC Nijmegen
Visit address: Comeniuslaan 4

Tel.: (36)12345
Internet address: www.ru.nl/students/facilities/student_counsellors/

Open: Monday through Friday, 10:00 - 17:00 p.m. (Except the first Friday afternoon of every month).

12. University Chaplaincy

Pastores: John Hacking, Theo Koster o.p. and Ms Ds Froukien Smit
Address: Erasmuslaan 9, 6525 GE Nijmegen, tel.: 3619188.
info@studentenkerk.ru.nl.
Internet address: www.ru.nl/studentenkerk

13. Board of the Faculty of Science, Mathematics, and Information Theory

Dean:	Prof. Dr C.C.A.M. Gielen
Vice-dean education:	Prof. Dr J.J. ter Meulen
Vice-dean research:	Prof. Dr Ir. J.C.M. van Hest
Dir. Management:	Dr. A. Geurtsen RC
Student-assessor:	Ms J. Rotink
Secretary:	Drs D.A.L.E. de Vries

14. Board of Marie Curie

Chairman:	Nicole Orval
Vice-chairman:	Edo van Veen
Secretary:	Erik van Loon
Members:	Esther Gellings
	Stan Jacobs
	Gillian Lustermans

15. Board of Faculty Student Councel

Members:	Ole Brauckmann, Scheikunde
	Jesper Dijkstra, Biologie
	Lieneke van den Heuvel, Biologie
	Laurens Lambert, Biologie
	Michiel van Lierop, Informatiekunde

Sander Uijlen, Natuurkunde

Internet address: www.ru.nl/fnwi/fsr

Email: fsr@science.ru.nl

10.2 Appendix B: Dates of Examinations 2010/2011

Masters exams

date of exams	final date of registration	presentation
Sept. 30 - 2010	Sept. 16 - 2010	Dec. 16 - 2010
Oct. 28 - 2010	Oct. 14 - 2010	Dec. 16 - 2010
Nov. 25 - 2010	Nov. 11 - 2010	March 25 - 2011
Dec. 16 - 2010	Dec. 02 - 2010	March 25 - 2011
Jan. 27 - 2011	Jan. 13 - 2011	March 25 - 2011
Febr. 24 - 2011	Feb. 10 - 2011	June 24 - 2011
March 31 - 2011	March 17 - 2011	June 24 - 2011
April 28 - 2011	April 14 - 2011	June 24 - 2011
May 26 - 2011	May 12 - 2011	Oct. 14 - 2011
June 30 - 2011	June 16 - 2011	Oct. 14 - 2011
August 31 - 2011	May 31 - 2011	Oct. 14 - 2011

Please note that the admittance to the exam of August 31, 2011, is subject to a special arrangement. The deadline for application is already scheduled at May 31, 2011, but it is allowed to have a few marks still missing. The last mark has to be filled in at last at August 31, 2011.

For more information look at the notice-board.

10.3 Appendix C: Teaching 2010/2011

1. **Semesters**:
   - 1st half-year: Monday August 30, 2010 through Friday January 28, 2011
   - 2nd half-year: Monday January 31, 2011 through Friday July 15, 2011
2. **Quarters**:
   - 1st quarter: Monday August 30, 2010 through Friday November 05, 2010
   - 2nd quarter: Monday November 08, 2010 through Friday January 28, 2011
   - 3rd quarter: Monday January 31, 2011 through Friday April 15, 2011
   - 4th quarter: Monday April 18, 2011 through Friday July 15, 2011
3. **Vacation periods**:
   - Winter break:
     Monday December 20, 2010 through Friday December 31, 2010

- Spring break: Monday March 07, 2011 trough Friday March 11, 2011
- May break: Monday May 02, 2011 through Friday May 06, 2011
- Summer Holidays: Monday July 18, 2011 through Friday August 26, 2011
- Easter break: Good Friday April 22, 2011 through Monday April 25, 2011
- Ascension day: Thursday June 02, 2011 through Friday June 3, 2011
- Whit Monday: June 13, 2011
- Fall break (eventual): Monday October 18, 2010 trough Friday October 22, 2010

4. **Holidays**:

Index of courses

Advanced Computational Neuroscience....18
Advanced Quantitative Brain Networks....19
Advanced Spectroscopy....21
Advanced Statistical Physics....22
Astroparticle Physics....23
Astrophysics Seminar....25
Beroepsorientatie....26
Beyond the Standard Model....28
Black Holes in Active Galactic Nuclei....29
Brain and Behaviour 2....30
Compact Binaries: Physics and Evolution....32
Computational Neuroscience....34
Computational Physics....36
Condensed Matter Theory....38
Cosmology....39
Data Analysis....41
Electrodynamics 1....43
Electrodynamics 2....44
Electronic Structure of Materials....45
Experimental Techniques....46
Interacademic Course Astrophysics....47
Interaction of Light with Molecules and Materials....48
Introduction to C++....50
Introduction to Computer Graphics....52
Introduction to Neuroimaging techniques....54
Introduction to Partial Differential Equations....56
Introduction to String Theory....58
Lasers and Electro-Optics....59
Lie Algebras....60
Machine Learning....61
Materials Science....63
Mechanical engineering; designing and manufacturing instruments....64
Monte Carlo Techniques....65
Nano Magnetism....67
NIKHEF Topical Lectures....69
Nuclear Physics....70
Numerical Methods....71
Oriëntatiestage E-variant....72
Particle Detection and Acceleration....73
Particle Physics Experiment Analysis....74
Particle Physics Phenomenology....75
Philosophy 2 (for Physicists)....76
Physics of Molecules and Molecular aggregates....78
Professional Preparation....80

Quantitative Brain Networks.....81
Quantum Field Theory.....82
Quantum Transport.....84
Research Labs.....85
Scanning Probe Microscopy.....86
Seminar Stochastics Neuroscience.....88
Solid State Physics.....89
Telescope Observing.....91
The Structure of Spacetime.....93
Theoretical Foundations of Elementary Particle Physics.....92