Master QTEC | Modules offered by LUH

Name of module	Lecturer	Credits	Name of module (German)	Semester
Elective modules				
Quantum-Structure Devices				
Quantum Sensor Technology	Piet Schmidt, Ernst Maria Rasel	5	Quantensensorik	WS
Nonlinear Optics	Marco Jupè	5	Nichtlineare Optik	SS
Atomic Optics	Christian Ospelkaus, Silke Ospelkaus	5	Atomoptik	SS
Experimental Atomic Physics	Sven Abend	5		WS
[not offered at the moment]	Carsten Klempt	5	Nichtklassische Atomoptik	[not offered at the moment]
Photonics	Boris Chichkov	5	Photonik	WS
Nonclassical Light and Nonclassical Laser Interferometry	Michèle Heurs, Benno Willke	5	Nichtklassisches Licht und Nichtklassische Laserinterferometrie	WS
Optical Experiments and their Control	Michèle Heurs, Benno Willke	5	Optische Experimente und ihre Kontrolle	WS/SS
Quantum Information Processing and Quantum Computing				
Computational Physics	Eric Jeckelmann	6	Computerphysik	SS
Computational Photonics	Ayhan Demircan	6	Computational Photonics	SS
Advanced Computational Physics	Hendrik Weimer	8	Fortgeschrittene Computerphysik	[not offered at the moment]

The above listed modules are also available for QTEC students.
Specific information on each module is available in the following module guide.

Attention:

This English version of the module catalogue MA Quantum Engineering is not legally binding. Only the original German text has some legally binding,which you can find under the following link:

https://www.maphy.uni-hannover.de/de/studium/im-studium/modulkatalog

This version has been automatically translated with DeepL and hasonly been checked superficially for errors, so please note the following limitations:

- technical and legal terms may be incorrect
- the names of modules and courses have been translated

With these limitations, we hope that this version is helpful for you.

Master's programme Quantum Engineering

Module catalogue

(shortened)

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Faculty of Mathematics and Physics
of Leibniz Universität Hannover

in conjunction with
the QUEST Leibniz Research School

in cooperation with
Technische Universität Braunschweig

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Preliminary remark

This document consists of the module catalogue, it presents the modules and their courses.

The module catalogue should also be understood as a supplement to the examination regulations. The current version of the examination regulations can be found at:

https:// www.uni-hannover.de/de/studium/im-studium/pruefungsinfos-fachberatung/studiengang/ordnungen-2

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Please note that the legally binding wording of all examination regulations is exclusively that published in the university's announcements.

Access requirement:

The **Master's degree programmes** are subject to admission restrictions. The exact rules (including exceptions) can be found in the respective admission regulations:

www.uni-hannover.de/bewerbung-und-zulassung/voraussetzungen-zum-studium

The application deadline for admission to a Master's degree programme is 15 July for the winter semester (31 May for non-EU citizens) and 15 January for the summer semester (30 November of the previous year for non-EU citizens).

The study:

The study contents are divided into so-called **modules.** A module is a thematic summary of courses. Therefore, more than one course can belong to a module. In addition to lectures, which are usually accompanied by exercises, laboratories and seminars also contribute to the education. To successfully complete a degree programme, students must complete **coursework** and **examinations in the** individual modules.

As a rule, a minimum number of points from exercises is required for coursework. Assessments of coursework do not count towards the final grade. Course achievements can be repeated as often as desired.

The contents of a module are examined as an examination during the course of study, usually by means of an oral examination or a written examination.

So-called **credit points** are assigned to each module according to the expected workload. After completing the required coursework **and** examinations, students are credited with the credit points assigned to the module.

Credit points according to the *European Credit Transfer and Accumulation System* (ECTS) describe the effort required to acquire the competence imparted by a module. One credit point (LP) corresponds to an estimated workload of 30 hours. Approximately 30 credit points are to be acquired per semester.

At least **120 credit points must be** earned in the **Master**'s degree programmes. The modules extend over one to two semesters. As a rule, they each require a workload of between 150 and 300 hours, corresponding to 5 to 10 credits. The modules of the research phase in the Master's degree programme in particular require a workload that exceeds this standard scope.

The **final grade is** calculated as the weighted average of the examination grades with the credit points of the modules .

You can find out which modules you have to take in your degree programme in the examination regulations for your degree programme.

Registration and conduct of the examinations:

Registration for each examination must be submitted to the Examinations Office within a set registration period. If a student fails an examination, he or she has the option of retaking it twice. Exceptions to this are the Bachelor's and Master's theses. They may be repeated once with a different topic.

The registration and examination dates can be found in your examination regulations.

In the following sections you will find, among other things, concrete **study plans**. Please note that these study plans are only **suggestions for** organising your studies. They are by no means prescribed. However, when planning your personal schedule, please note that some of the basic lectures build on each other and should therefore be listened to in the order given. If you have any questions, the study programme coordination and the subject advisors will be happy to help you.

Quantum sensor technology		Identification number/test code
Master Quantum Engineering		**Module type** Elective
Credit points 5	**Frequency of the offer** WiSe / SoSe	**Language** German / English
Area of competence ---	**Recommended semester** Semester 1 or Semester 2	**Module duration** 1 semester
Student workload Total: 150 h	Of which attendance time: 60 h	Of which self-study: 90 h
Further use of the module		

1	**Qualification goals** Students understand the basic concepts of quantum sensors such as optical clocks and matter wave interferometers, as well as their characterisation. They know advanced experimental methods of the field and can apply them under guidance. They are familiar with applications of optical clocks and matter wave interferometers and can evaluate them independently and competently.
2	**Contents of the module** • Atom-light interaction • Trapped ions, atoms in optical lattices • Components of an optical clock and clock operation • Systematic effects and their suppression; examples of optical clocks • Optical frequency combs and frequency distribution • Statistical uncertainty of clocks • Applications and future developments: Fundamental physics, geodesy, multi-ion clocks, entanglement • Diffraction of atoms and molecules at material lattices and slits • Atom interferometry with laser beam splitters • Path integrals, propagators and phase shift calculation • Acceleration and rotation detection with atomic interferometry • Matter wave diffraction in the different regimes • Interferometry Bose-Einstein condensates • Optical gratings and large pulse transfer • Atomic interferometry with extended time (fountains, microgravity, space missions) • Fundamental tests and detection of gravitational waves with atomic sensors • Atomic interferometry with non-classical states of matter (squeezed sources)
3	**Forms of teaching and courses** Lecture: "Optical Clocks", 2 SWS Lecture: "Matter-Wave Interferometry", 2 SWS
4a	**Participation requirements** ---
4b	**Recommendations** ---
5	**Requirements for the award of credit points**

	Study achievements: -
	Examination achievements: Oral exam 30 min or written exam 90-120 min
6	**Literature**
7	**Further information** ---
8	**Organisational unit** Institute for Quantum Optics (IQO), LUH
9	**Person responsible for the module** Prof. Dr. Piet O. Schmidt, Prof. Dr. Ernst Maria Rasel

Nonlinear optics		**Identification number/test code**
Master Quantum Engineering		**Module type** Elective
Credit points 5	**Frequency of the offer** SoSe	**Language** German / English
Area of competence ---	**Recommended semester** Semester 1 or Semester 2	**Module duration** 1 semester
Student workload Total: 150 h	Of which attendance time: 60 h	Of which self-study: 90 h
Further use of the module		

1	**Qualification goals** The students are able to understand modifications of the optical properties of a material under the influence of light and to modify the optical properties of a material independently. The aim of the module is to investigate frequency-converted processes and to be able to understand their application in science and technology.
2	**Contents of the module** - Nonlinear optical susceptibility - Crystal optics, tensor optics - Wave equation with non-linear source terms - Frequency doubling, sum, difference frequency generation - Optical parametric amplifier, oscillator - Phase matching schemes, quasi-phase matching - Electro-optical effect - Electro-acoustic modulator - Frequency tripling, Kerr effect, self-phase modulation, self-focusing - Raman, Brillouin scattering, four-wave mixing - Nonlinear propagation, solitons
3	**Forms of teaching and courses** Lecture "Nonlinear Optics", 3 SWS Exercise "Nonlinear Optics", 1 SWS
4a	**Participation requirements** ---
4b	**Recommendations** Atomic and molecular physics
5	**Requirements for the award of credit points**
	Study achievements: Exercises

	Examination achievements: Oral exam 30 min or written exam 90-120 min
6	**Literature** - Agrawal, Nonlinear Fiber optics, Academic Press - Boyd, Nonlinear Optics, Academic Press - Shen, Nonlinear Optics, Wiley-Interscience - Dmitriev, Handbook of nonlinear crystals, Springer - Original literature
7	**Further information** ---
8	**Organisational unit** Institute for Quantum Optics (IQO), LUH
9	**Person responsible for the module** Prof. Dr. Uwe Morgner

Photonics

Photonics		**Identification number/test code**
Master Quantum Engineering		**Module type** Elective
Credit points 5	**Frequency of the offer** WiSe	**Language** German / English
Area of competence ---	**Recommended semester** Semester 1 or Semester 2	**Module duration** 1 semester
Student workload Total: 150 h	Of which attendance time: 60 h	Of which self-study: 90 h
Further use of the module		

1	**Qualification goals** After completing the module, students know the essential basics of modern photonics and can apply this knowledge to the assessment, design and simulation of photonic systems.
2	**Contents of the module** - Waves in matter - Dielectric waveguides (planar, glass fibre), integrated waveguides - Photonic crystals - Waveguide - Modes - Nonlinear fibre optics - Fibre optic components (circulators, AWG, fibre Bragg gratings, modulators) - Fibre laser - Laser diodes, photodetectors - Optical communications technology (RZ, NRZ, WDM/TDM) - Networks
3	**Forms of teaching and courses** Lecture "Photonics", 2 SWS Exercise "Photonics", 1 SWS
4a	**Participation requirements** ---
4b	**Recommendations** Coherent optics, non-linear optics
5	**Requirements for the award of credit points**
	Study achievements: Exercises

	Examination achievements: Oral exam 30 min or written exam 90-120 min
6	**Literature** - Reider, Photonics, Springer - Menzel, Photonics, Springer - Agrawal, Nonlinear Fiber optics, Academic Press - Original literature
7	**Further information** ---
8	**Organisational unit** Institute for Quantum Optics (IQO), LUH
9	**Person responsible for the module** Prof. Dr Boris Chichkov

Atom optics		**Identification number/test code**
Master Quantum Engineering		**Module type** Elective
Credit points 5	**Frequency of the offer** SoSe	**Language** German / English
Area of competence ---	**Recommended semester** Semester 1 or Semester 2	**Module duration** 1 semester
Student workload Total: 150 h	Of which attendance time: 60 h	Of which self-study: 90 h
Further use of the module		

1	**Qualification goals** The lecture gives an insight into modern experimental physics with cold atomic gases. This field has become one of the most active areas of atomic and molecular physics in recent years. The aim is for students to master the methods of laser cooling and the storage of atoms in traps, which enable spectroscopic precision measurements and, in particular, the development of very accurate atomic clocks.
2	**Contents of the module** - Atom-light interaction - radiation pressure forces - Atomic and ion traps - Cooling through evaporation - Bose-Einstein condensation - Ultracold Fermi gases - Experiments with ultracold and degenerate quantum gases - Atoms in optical periodic lattices - Atomic interferometry and frequency standards
3	**Forms of teaching and courses** Lecture "Atom Optics", 2 SWS Exercise "Atom Optics", 1 SWS
4a	**Participation requirements** ---
4b	**Recommendations** Atomic and molecular physics, quantum optics
5	**Requirements for the award of credit points**
	Study achievements: Exercises
	Examination achievements: Oral exam 30 min or written exam 90-120 min
6	**Literature** . B. Bransden, C. Joachain, Physics of Atoms and Molecules, Longman 1983 . R. Loudon, The Quantum Theory of Light, OUP, 1973 . Current publications
7	**Further information** ---
8	**Organisational unit** Institute for Quantum Optics (IQO), LUH
9	**Person responsible for the module** Prof. Dr Silke Ospelkaus-Schwarzer

Non-classical atom optics		Identification number/test code
Master Quantum Engineering		**Module type** Elective
Credit points 5	**Frequency of the offer** SoSe	**Language** German / English
Area of competence ---	**Recommended semester** Semester 1 or Semester 2	**Module duration** 1 semester
Student workload Total: 150 h	Of which attendance time: 60 h	Of which self-study: 90 h
Further use of the module		

1	**Qualification goals** The students acquire knowledge about the generation of a Bose-Einstein condensate. You can use your knowledge in the development of high-precision sensors, but also to investigate fundamental physical effects.
2	**Contents of the module** - Generation of ultracold atoms - Many-particle quantum systems - Description and visualisation of atomic many-body states - Entanglement - Interferometry and fundamental limits - Overview of current experimental realisations - Central research results of recent years
3	**Forms of teaching and courses** Lecture "Non-Classical Atomic Optics", 2 SWS Exercise "Non-Classical Atomic Optics", 1 SWS
4a	**Participation requirements** ---
4b	**Recommendations** Atomic and molecular physics, quantum optics
5	**Requirements for the award of credit points**
	Study achievements: Exercises
	Examination achievements: Oral exam 30 min or written exam 90-120 min
6	**Literature** . C. C. Gerry and P.L. Knight, Introductory Quantum Optics, University Press, Cambridge (2005). . Pezzè et al, Quantum metrology with nonclassical states of atomic ensembles, Rev. Mod. Phys. 90, 035005 (2018). . Current publications
7	**Further information** ---
8	**Organisational unit** Institute for Quantum Optics (IQO), LUH
9	**Person responsible for the module** Prof. Dr. Carsten Klempt

Experimental Atomic Physics		**Identification number/test code**
Master Quantum Engineering		**Module type** Elective
Credit points 5	**Frequency of the offer** WiSe	**Language** German / English
Area of competence ---	**Recommended semester** Semester 1 or Semester 2	**Module duration** 1 semester
Student workload Total: 150 h	Of which attendance time: 60 h	Of which self-study: 90 h
Further use of the module		

1	**Qualification goals** After successful completion of the module, students are able to apply experimental methods of atomic physics and quantum sensing to 1. in original literature 2. describe them on a theoretical basis 3. and their practical implementation in current experiments or plan them themselves.
2	**Contents of the module** The aim of the lecture is to gain an overview of the variety of experimental methods in modern atomic physics. The required theoretical basics are introduced in the lecture. In the exercise groups, the topics covered are deepened on the basis of historical and current publications, with a special focus on the understanding of experimental techniques. Topics covered include fundamentals of atom-light interaction, laser cooling methods and techniques for the production of Bose-Einstein condensates. The lecture then covers methods for implementing quantum sensors, particularly with regard to noise and systematic effects. Through affiliated laboratory tours at the Institute of Quantum Optics, the students get a direct insight into typical experimental setups. The lecture thus also serves as content preparation for a subsequent Master's thesis in the field of experimental atomic physics.
3	**Forms of teaching and courses** Lecture "Experimental Methods in Atomic Physics", 2 SWS Exercise "Experimental Methods in Atomic Physics", 1 SWS
4a	**Participation requirements** ---
4b	**Recommendations** Atomic and molecular physics, coherent optics
5	**Requirements for the award of credit points**
	Study achievements: Participation in exercise/presentation/solution of exercise sheets
	Examination achievements: Oral exam 30 min or written exam
6	**Literature** . T. Mayer-Kuckuck, Atomic Physics, Teubner, 1994 . B. Bransden, C. Joachain, Physics of Atoms and Molecules, Longman 1983 . H. Haken, H. Wolf, Atomic and Quantum Physics as well as Molecular Physics and Quantum Chemistry, Springer . H. Metcalf, P. van der Straaten, Laser Cooling and Trapping, Springer 1999 . F. Riehle, Frequency Standards, Wiley 2004

7	**Further information** ---
8	**Organisational unit** Institute for Quantum Optics (IQO), LUH
9	**Person responsible for the module** Prof. Dr Ernst Maria Rasel

Computational Photonics		**Identification number/test code**
Master Quantum Engineering		**Module type** Elective
Credit points 6	**Frequency of the offer** SoSe	**Language** English
Area of competence ---	**Recommended semester** Semester 1 or Semester 2	**Module duration** 1 semester
Student workload Total: 150h	Of which attendance time: 56 h	Thereof self-study: 94 h
Further use of the module		

1	**Qualification goals** The module teaches basic skills of software development for problems of computer-oriented physics and deepens specific techniques for the numerical solution of problems in optics. In addition, it serves as an overview of general aspects of modern optics. After successful completion of the module, students are able to • understand problems in modern and non-linear optics • apply principles of numerical modelling and implementation • Implement software development methods • solve problems in computer-oriented photonics independently
2	**Contents of the module** The lecture is divided into two parallel tracks: Fundamentals of Photonics and Numerical Methods. The course includes a practical exercise that gives students basic experience with computer simulations. Subject content: • Interaction z between light and matter (chromatic and geometric dispersion, second and third order susceptibility, Raman scattering, supercontinuum generation, multiphoton and tunnel ionisation, low order harmonic radiation). • Light transport in turbid media • Photoacoustics • Matrix optics • Pulse propagation equations • Atoms in strong optical fields (Schrödinger equation for atoms, higher-harmonic generation, Brunel/THz radiation, attosecond optics). • Computer modelling methods in electromagnetics (time domain solvers, frequency domain methods, finite element methods). • Monte Carlo method • Spectral and pseudo-spectral methods • Runge-Kutta and operator splitting methods • Parallel Computing (openMP, openMPI)
3	**Forms of teaching and courses** Lecture "Computational Photonics", 2 SWS Exercise "Computational Photonics", 1 SWS
4a	**Participation requirements** ---
4b	**Recommendations** Experience with the computer and basics of programming.

5	**Requirements for the award of credit points**
	Study achievements: Participation in the lecture and in the practical exercises
	Examination achievements: The grade results from 40% of the assessment of the performance in the computer exercises and 60% of the exam grade.
6	**Literature** . S. Obayya, Computational Photonics, John Wiley & Sons, 2011 . oachain, Kylstra, Potvliege: Atoms in Intense Laser fields . Lux/Koblinger: Monte Carlo Particle Transport Methods: Neutron and Photon Calculations
7	**Further information** ---
8	**Organisational unit** Institute for Quantum Optics (IQO), LUH
9	**Person responsible for the module** Prof. Dr Ayhan Demircan

Non-classical light and non-classical laser interferometry		Identification number/test code
Master Quantum Engineering		**Module type** Elective
Credit points 5	**Frequency of the offer** WiSe/SoSe	**Language** German / English
Area of competence ---	**Recommended semester** Semester 1 and Semester 2	**Module duration** 2 semesters
Student workload Total: 150 h	Of which attendance time: 60 h	Of which self-study: 90 h
Further use of the module		

1	**Qualification goals** The students acquire competences beyond Quantum Optics I on the topic of non-classical light, in particular squeezed states, and non-classical laser interferometry, which include measurements with accuracies below the quantum limit of interferometry, among others in interferometric gravitational wave detection.
2	**Contents of the module** - Classical and non-classical states of light - Criteria for "non-classicality - Detection and generation of jib states - Detection and generation of squeezed light - Quantum state tomography - EPR-entangled (two-mode squeezed) light - Optical test of non-locality - Shot noise and radiation pressure noise in the interferometer - Square operators and "input-output" relations of interferometers - The standard quantum limit of position measurement - "Quantum nondemolition" techniques - Interferometer with squeezed light and other non-classical states of light - Opto-mechanical coupling and optical springs - Quantum states of mechanical oscillators - Cooling mechanical oscillators to their quantum mechanical ground state - Interlacing mirrors and light
3	**Forms of teaching and courses** Lecture: "Non-Classical Light", 2 SWS Lecture: "Non-Classical Laser Interferometry", 2 SWS
4a	**Participation requirements** ---
4b	**Recommendations** Coherent Optics, Nonlinear Optics, Nonclassical Light, Quantum Optics
5	**Requirements for the award of credit points**
	Study achievements: none
	Examination achievements: Oral examination or written exam
6	**Literature** . C.C. Gerry and P.L. Knight, Introductory Quantum Optics, University Press, Cambridge (2005). . H.-A. Bachor and T.C. Ralph, A guide to experiments in quantum optics,

	Wiley, 2nd edition (2003). . P. Saulson, Fundamentals of Interferometric GW detectors, World Scientific Pub Co Inc. . Original literature (scientific publications, primary literature)
7	**Further information** ---
8	**Organisational unit** Institute for Gravitational Physics (IGP), LUH
9	**Person responsible for the module** Prof. Dr Michèle Heurs

Optical experiments and their control		**Identification number/test code**
Master Quantum Engineering		**Module type** Elective
Credit points 5	**Frequency of the offer** WiSe/SoSe	**Language** German / English
Area of competence ---	**Recommended semester** Semester 1 and Semester 2	**Module duration** 2 semesters
Student workload Total: 150 h	Of which attendance time: 60 h	Of which self-study: 90 h
Further use of the module		

1	**Qualification goals** Students acquire competences necessary for working in a (quantum) optical laboratory. The competences are extended by corresponding theoretical basics and experimental knowledge and also cover useful technical content.
2	**Contents of the module** - Lasers and the cause of power, frequency and beam position fluctuations - Fundamentals of control engineering - Length control of interferometers and optical resonators - Detection of frequency fluctuations and their suppression - Detection of power fluctuations and their suppression - Beam position control - Electronics basics: Kirchhoff rules, impedance, phasor diagrams - Operational amplifiers: Functionality and basic circuits - Oscillating circuits and filters (active / passive) - Spectrum Analyser and Network Analyser - Measurement and interpretation of transfer functions - Fundamentals of control engineering - Photodetection - Sensors and actuators in optical experiments - Noise measurements
3	**Forms of teaching and courses** Lecture: "Laser stabilisation and control of optical experiments", 2 SWS Lecture: "Electronic metrology in the optics laboratory", 2 SWS
4a	**Participation requirements** ---
4b	**Recommendations** Coherent optics
5	**Requirements for the award of credit points**
	Study achievements: Participation in the lecture; homework assignments
	Examination achievements: Oral examination or written exam
6	**Literature** . Horowitz & Hill, The Art of Electronics, Cambridge University Press . Abramovici & Chapsky, Feedback Control Systems, Kluwer Academic Publishers . Yariv, Quantum Electronics, Wiley . Siegman, Lasers, University Science Books . Original literature (scientific publications, primary literature)

7	**Further information** ---
8	**Organisational unit** Institute for Gravitational Physics (IGP), LUH
9	**Person responsible for the module** Prof. Dr Michèle Heurs, apl. Prof. Dr Benno Willke

Computational Physics		**Identification number/test code**
Master Quantum Engineering		**Module type** Elective
Credit points 6	**Frequency of the offer** SoSe	**Language** German / English
Area of competence ---	**Recommended semester** Semester 1 or Semester 2	**Module duration** 1 semester
Student workload Total:180 h	Of which attendance time: 60 h	Of which self-study: 120 h
Further use of the module		

1	**Qualification goals** Students are able to program basic simulations of physical systems, visualisation of data and statistical data analysis.
2	**Contents of the module** - Basic numerical methods (differentiation, integration, interpolation, solution of a non-linear equation, systems of linear algebraic equations, Monte Carlo methods) - Numerical solution of common problems in physics (differential equations, eigenvalue problems, optimisation, integration and sums of many variables) - Applications from mechanics, electrodynamics, thermodynamics and quantum mechanics - Data analysis (statistical analysis, equalisation, extrapolation, spectral analysis) - Visualisation (graphical representation of data) - Introduction to the simulation of physical systems (dynamic systems, simple molecular dynamics) - Computer algebra
3	**Forms of teaching and courses** Lecture "Computational Physics", 2 SWS Exercise "Computational Physics", 2 SWS
4a	**Participation requirements** ---
4b	**Recommendations** Experience with the computer and basics of programming, Analysis I+II, Theoretical Electrodynamics, Analytical Mechanics, Special Theory of Relativity, Introduction to Quantum Theory.
5	**Requirements for the award of credit points**
	Study achievements: Practical exercises
	Examination achievements: Oral exam 30 min and written exam 90-120 min
6	**Literature** . Wolfgang Kinzel and Georg Reents, "Physik per Computer", Spektrum Akademischer Verlag . S.E. Koonin and D.C. Meredith, "Computational Physics", Addison-Wesley . W.H. Press, S.A. Teukolsky, W.T. Vetterling, B.P. Flannery, "Numerical Recipes in C++", Cambridge University Press . J.M. Thijssen, "Computational Physics", Cambridge University Press . Tao Pang, "An Introduction to Computational Physics", Cambridge University

	Press . S. Brandt, "Data Analysis", Spektrum Akademischer Verlag . V. Blobel and E. Lohrmann, "Statistical and Numerical Methods of Data Analysis", Teubner Verlag . R.H. Landau, M.J. Paez, and C.C. Bordeianu, Computational Physics, Wiley-VCH, 2007
7	**Further information** ---
8	**Organisational unit** Institute for Theoretical Physics (ITP), LUH
9	**Person responsible for the module** Prof. Dr Eric Jeckelmann

Advanced Computational Physics		Identification number/test code
Master Quantum Engineering		**Module type** Elective
Credit points 8	**Frequency of the offer** WiSe/SoSe	**Language** German / English
Area of competence ---	**Recommended semester** Semester 1 or Semester 2	**Module duration** 1 semester
Student workload Total: 240 h	Of which attendance time: 90 h	Of which self-study: 150 h
Further use of the module		

1	**Qualification goals** Students are able to program complex simulations of physical systems, visualisation of data and statistical data analysis - among other things with the help of machine learning.
2	**Contents of the module** - Exact diagonalisation - Monte Carlo simulations - Numerical renormalisation group - density functional theory - Molecular dynamics - Quantum dynamics - Artificial intelligence and machine learning - Quantum computer
3	**Forms of teaching and courses** Lecture "Advanced Computational Physics", 4 SWS Exercise "Advanced Computational Physics", 2 SWS
4a	**Participation requirements** ---
4b	**Recommendations** Introduction to Quantum Theory, Statistical Physics, Computational Physics".
5	**Requirements for the award of credit points**
	Study achievements: Practical exercises
	Examination achievements: Oral exam 45 min and written exam 90-120 min
6	**Literature** . J.M. Thijssen, Computational Physics (Cambridge University Press, 2007) . S.E. Koonin and D.C Meredith, Computational Physics, Addison-Wesley, 1990. . T. Pang, Computational Physics, Cambridge University Press, 2006 . H. Gould, J. Tobochnik, and W. Christian, Computer Simulation Methods, Pearson Education, 2007
7	**Further information** ---
8	**Organisational unit** Institute for Theoretical Physics (ITP), LUH
9	**Person responsible for the module** PD Dr Hendrik Weimer