



# Subdivided Module Catalogue for the Subject

Keine PO-STG-Zuordnung vorhanden  
Responsible: JMU Würzburg

## Learning Outcomes

German contents and learning outcome available but not translated yet.

### **Wissenschaftliche Befähigung**

- Die Absolventinnen und Absolventen verfügen über vertiefte Kenntnisse der physikalischen und technischen Grundlagen der Quantentechnologie.
- Die Absolventinnen und Absolventen können ein fundiertes Wissen über die theoretischen und experimentellen Methoden zur Erlangung neuer Erkenntnisse abrufen.
- Die Absolventinnen und Absolventen können auf einen breiten Überblick über das Gesamtgebiet der Quantentechnologie zurückgreifen.
- Die Absolventinnen und Absolventen verfügen über einen Überblick über angrenzende Gebiete und interdisziplinäre Zusammenhänge.
- Die Absolventinnen und Absolventen besitzen Abstraktionsvermögen, analytisches Denken, hohe Problemlösungskompetenz und die Fähigkeit, komplexe Zusammenhänge zu strukturieren.
- Die Absolventinnen und Absolventen wenden ihre Fähigkeiten und Kenntnisse in eigenen Projekten an und verfügen über Kenntnisse des aktuellen Forschungsstandes in mindestens einem Spezialgebiet der Quantentechnologie.
- Die Absolventinnen und Absolventen sind in der Lage, mit Fachvertretern auf dem aktuellen Stand der Forschung physikalische Fragestellungen zu diskutieren.
- Die Absolventinnen und Absolventen können, physikalische und mathematische Methoden selbstständig auf konkrete experimentelle oder theoretische physikalische Aufgabenstellungen anzuwenden, Lösungswege zu entwickeln und die Ergebnisse zu interpretieren und zu bewerten.
- Die Absolventinnen und Absolventen sind in der Lage, sich anhand von Primärliteratur, insbesondere in englischer Sprache, in den aktuellen Forschungsstand eines Spezialgebiets der Quantentechnologie einzuarbeiten.

### **Befähigung zur Aufnahme einer Erwerbstätigkeit**

- Die Absolventinnen und Absolventen sind in der Lage, auch bei unvollständigen Informationen physikalische und technische Probleme wissenschaftlich und unter Beachtung der Regeln guter wissenschaftlicher Praxis selbstständig zu bearbeiten und die Ergebnisse und Folgen ihrer Arbeit darzustellen, zu bewerten und zu vertreten.
- Die Absolventinnen und Absolventen besitzen die Fähigkeit, als verantwortlicher Wissenschaftler bzw. verantwortliche Wissenschaftlerin in interdisziplinär und international zusammengesetzten Teams aus (Natur-)Wissenschaftlern bzw. (Natur-)Wissenschaftlerinnen und/oder Ingenieuren bzw. Ingenieurinnen in Forschung, Industrie und Wirtschaft mitzuwirken.
- Die Absolventinnen und Absolventen sind in der Lage, physikalische und technische Methoden selbstständig auf konkrete Aufgabenstellungen anzuwenden, Lösungswege zu entwickeln und die Ergebnisse zu interpretieren und zu bewerten.
- Die Absolventinnen und Absolventen sind in der Lage, ihre Fähigkeiten und Kenntnisse in eigenen Projekten umzusetzen und verfügen über Kenntnisse des aktuellen Forschungsstandes in mindestens einem Spezialgebiet der Quantentechnologie.

### **Persönlichkeitsentwicklung**

- Die Absolventinnen und Absolventen sind in der Lage, auch bei unvollständigen Informationen Probleme der Quantentechnologie wissenschaftlich selbstständig zu bearbeiten und die Ergebnisse und Folgen ihrer Arbeit darzustellen, zu bewerten und zu vertreten.
- Die Absolventinnen und Absolventen kennen die Regeln guter wissenschaftlicher Praxis und beachten sie.
- Befähigung zum gesellschaftlichen Engagement

- Die Absolventinnen und Absolventen können naturwissenschaftliche und technische Entwicklungen kritisch reflektieren und deren Auswirkungen auf die Wirtschaft, Gesellschaft und die Umwelt erfassen. (Technikfolgenabschätzung)
- Die Absolventinnen und Absolventen haben ihr Wissen bezüglich wirtschaftlicher, gesellschaftlicher, naturwissenschaftlicher, kultureller etc. Fragestellungen erweitert und können begründet Position beziehen.
- Die Absolventinnen und Absolventen sind in der Lage auf dem aktuellen Stand der Forschung physikalische und technische Fragestellungen zu diskutieren und Nichtwissenschaftlern physikalische Fragen zu erläutern.
- Die Absolventinnen und Absolventen haben die Bereitschaft und Fähigkeit entwickelt, ihre Kompetenzen in partizipative Prozesse einzubringen und aktiv an Entscheidungen mitzuwirken.

## Abbreviations used

Course types: **E** = field trip, **K** = colloquium, **O** = conversatorium, **P** = placement/lab course, **R** = project, **S** = seminar, **T** = tutorial, **Ü** = exercise, **V** = lecture

Term: **SS** = summer semester, **WS** = winter semester

Methods of grading: **NUM** = numerical grade, **B/NB** = (not) successfully completed

Regulations: **(L)ASPO** = general academic and examination regulations (for teaching-degree programmes), **FSB** = subject-specific provisions, **SFB** = list of modules

Other: **A** = thesis, **LV** = course(s), **PL** = assessment(s), **TN** = participants, **VL** = prerequisite(s)

## Conventions

Unless otherwise stated, courses and assessments will be held in German, assessments will be offered every semester and modules are not creditable for bonus.

## Notes

Should there be the option to choose between several methods of assessment, the lecturer will agree with the module coordinator on the method of assessment to be used in the current semester by two weeks after the start of the course at the latest and will communicate this in the customary manner.

Should the module comprise more than one graded assessment, all assessments will be equally weighted, unless otherwise stated below.

Should the assessment comprise several individual assessments, successful completion of the module will require successful completion of all individual assessments.

## In accordance with

the general regulations governing the degree subject described in this module catalogue:

**ASPO2015**

associated official publications (FSB (subject-specific provisions)/SFB (list of modules)):

**??-??-2026 (2026-??)**

This module handbook seeks to render, as accurately as possible, the data that is of statutory relevance according to the examination regulations of the degree subject. However, only the FSB (subject-specific provisions) and SFB (list of modules) in their officially published versions shall be legally binding. In the case of doubt, the provisions on, in particular, module assessments specified in the FSB/SFB shall prevail.

## The subject is divided into

Abbreviation	Module title	ECTS credits	Method of grading	page
<b>Compulsory Electives (60 ECTS credits)</b>				
<b>Subfield Quantum Technology (min. 55 ECTS credits)</b>				
<b>Advanced Laboratory Courses (min. 9 ECTS credits)</b>				
11-P-FM1-161-m01	Advanced Laboratory Course Master Part 1	3	B/NB	61
11-P-FM2-161-m01	Advanced Laboratory Course Master Part 2	3	B/NB	62
11-P-FM3-161-m01	Advanced Laboratory Course Master Part 3	3	B/NB	63
11-P-FM4-161-m01	Advanced Laboratory Course Master Part 4	3	B/NB	64
<b>Advanced Seminar (min. 5 ECTS credits)</b>				
11-OSN-A-212-m01	Advanced Seminar Quantum Technology A	5	NUM	59
11-OSN-B-212-m01	Advanced Seminar Quantum Technology B	5	NUM	60
<b>Focus Nanostructure Technology</b>				
11-HNS-161-m01	Optical Properties of Semiconductor Nanostructures	6	NUM	51
11-HPH-201-m01	Semiconductor Physics	6	NUM	52
11-QTR-201-m01	Quantum Transport	6	NUM	71
11-SPI-161-m01	Spintronics	6	NUM	72
11-BSV-161-m01	Image and Signal Processing in Physics	6	NUM	25
11-PMM-161-m01	Physics of Advanced Materials	6	NUM	65
11-OHL-161-m01	Organic Semiconductors	6	NUM	58
o8-FU-SAM-161-m01	Sensor and Actor Materials - Functional Ceramics and Magnetic Particles	5	NUM	13
o8-PCM4-242-m01	Ultrafast spectroscopy and quantum-control	5	NUM	14
o8-FU-EEW-222-m01	Electrochemical Energy Storage and Conversion	5	NUM	11
o8-FU-MW-222-m01	Structure-Properties Correlations of Light Materials - Experiments and Numerical Simulations	5	NUM	12
11-EXN5-212-m01	Current Topics in Quantum Technology	5	NUM	30
11-EXN6-212-m01	Current Topics in Quantum Technology	6	NUM	31
11-EXN7-212-m01	Current Topics in Quantum Technology	7	NUM	33
11-EXN8-212-m01	Current Topics in Quantum Technology	8	NUM	34
11-EXN6A-212-m01	Current Topics in Quantum Technology	6	NUM	32
11-CSFM-161-m01	Advanced Topics in Solid State Physics	6	NUM	26
11-CSNM-212-m01	Advanced Topics in Quantum Technology	6	NUM	27
11-FK2-201-m01	Solid State Physics 2	8	NUM	45
11-CSPM-161-m01	Advanced Topics in Physics	6	NUM	28
11-FKS-161-m01	Solid State Spectroscopy	6	NUM	47
11-TEFK-201-m01	Topological Effects in Solid State Physics	8	NUM	75
11-FFK-201-m01	Field Theory in Solid State Physics	8	NUM	43
11-NLS-252-m01	Nano-Optics and Hybrid Light-Matter Systems	8	NUM	57
11-AKTF-201-m01	Selected Topics of Theoretical Solid State Physics	6	NUM	21
11-MAG-161-m01	Magnetism	6	NUM	53
11-QM2-161-m01	Quantum Mechanics II	8	NUM	69
11-TQO-221-m01	Theoretical Quantum Optics	8	NUM	78
11-TFK-161-m01	Theoretical Solid State Physics	8	NUM	76

11-PTS-201-m01	Phenomenology and Theory of Superconductivity	6	NUM	66
11-QIC-201-m01	Advanced Theory of Quantum Computing and Quantum Information	6	NUM	68
11-FLV-262-m01	Advanced Lithography Techniques	6	NUM	48
11-MRI-171-m01	Advanced Magnetic Resonance Imaging	6	NUM	56
11-SSC-172-m01	Surface Science	6	NUM	74
11-SPT-211-m01	Scanning Probe Technologies	6	NUM	73
11-EIM-211-m01	Electron and Ion Microscopy	6	NUM	29
11-FPA-161-m01	Visiting Research	10	NUM	49
11-EXP5-161-m01	Current Topics in Physics	5	NUM	36
11-EXP6-161-m01	Current Topics in Physics	6	NUM	37
11-EXP7-161-m01	Current Topics in Physics	7	NUM	39
11-EXP8-161-m01	Current Topics in Physics	8	NUM	40
11-EXP6A-161-m01	Current Topics in Physics	6	NUM	38
<b>Subfield Non-technical Minor</b>				
10-M-VAN-222-m01	Advanced Analysis	10	NUM	20
10-M=VDIM-161-m01	Discrete Mathematics	5	NUM	19
10-I=PA-161-m01	Analysis and Design of Programs	5	NUM	16
10-I=APR-172-m01	Advanced Programming	5	NUM	17
10-I=BS-242-m01	Operating Systems	5	NUM	18
10-I=KI1-212-m01	Artificial Intelligence 1	5	NUM	15
02-EReWi-G-212-m01	Civil Law for Economics and Management	5	NUM	7
02-N-P-Wo6-242-m01	Trade Mark Law	3	NUM	9
02-N-P-Wo7-242-m01	Copyright Law	2	NUM	10
02-G&Hre-G-212-m01	Commercial and Business Law for Economics and Management	5	NUM	8
11-AP-152-m01	Astrophysics	6	NUM	22
11-ASM-161-m01	Methods of Observational Astronomy	6	NUM	23
11-ASP-161-m01	Introduction to Space Physics	6	NUM	24
11-EXZ5-161-m01	Nontechnical Special Topics	5	NUM	41
11-EXZ6-161-m01	Nontechnical Special Topics	6	NUM	42
11-EXNT6-161-m01	Nontechnical Minor Subject	6	NUM	35
<b>Thesis (60 ECTS credits)</b>				
11-FS-N-212-m01	Professional Specialization Quantum Technology	15	B/NB	50
11-MP-N-212-m01	Scientific Methods and Project Management Quantum Technology	15	B/NB	55
11-MA-N-212-m01	Master Thesis Quantum Technology	30	NUM	54

<b>Module title</b>		<b>Abbreviation</b>
Civil Law for Economics and Management		o2-EReWi-G-212-mo1
<b>Module coordinator</b>		<b>Module offered by</b>
Dean of the Faculty of Law		Faculty of Law
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
5	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	undergraduate	--
<b>Contents</b>		
German contents available but not translated yet.		
Dieses Modul bietet eine Einführung in die Rechtswissenschaft. Behandelt wird das Zustandekommen von Gesetzen, Arten von Gesetzen, Organisation des Gerichtswesens, Rechtsquellenkunde, Internationales Recht (Europa, UNO), die deutsche Rechtsordnung (Privatrecht, Öffentliches Recht, Strafrecht).		
<b>Intended learning outcomes</b>		
German intended learning outcomes available but not translated yet.		
Der/Die Studierende verfügt über Kenntnisse der nationalen und internationalen Rechtsordnung, des Zustandekommens und Inhalts sowie der Auflösung und Folgen von Verträgen, des Zustandekommens von Gesetzen, der Struktur der Rechtsordnungen.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + Ü (2)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
written examination (approx. 120 minutes)		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
150 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Commercial and Business Law for Economics and Management		o2-G&Hre-G-212-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Dean of the Faculty of Law		Faculty of Law
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
5	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	undergraduate	--
<b>Contents</b>		
German contents available but not translated yet.		
Dieses Modul bietet eine Einführung in das deutsche und europäische Gesellschafts- und Handelsrecht.		
<b>Intended learning outcomes</b>		
German intended learning outcomes available but not translated yet.		
Der/Die Studierende verfügt über Kenntnisse des Gesellschafts- und Handelsrechts, insbesondere über Gesellschaftsformen, Vertretungsmacht, Haftung, Gründung und Auflösungen von Gesellschaften sowie über Grundlagen des Rechts der Handelsgeschäfte und der Handelsgesellschaften.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + Ü (2)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
written examination (approx. 120 minutes) Assessment offered: Usually once a year, summer semester		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
150 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Trade Mark Law		02-N-P-W06-242-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Dean of Studies Faculty of Law		Faculty of Law
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
3	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	undergraduate	--
<b>Contents</b>		
German contents available but not translated yet.		
Die Vorlesung vermittelt einen Überblick über das Deutsche und Europäische Markenrecht. Neben den Grundlagen des Markenbegriffs und -schutzes nach dem deutschen Markengesetz werden u.a. die Voraussetzungen und Wirkungen der Europäischen Gemeinschaftsmarke nach der Gemeinschaftsmarkenverordnung behandelt. Ferner werden Spezialregelungen des deutschen Markenrechts wie z.B. zu geschäftlichen Bezeichnungen, geographischen Herkunftsangaben sowie zum kennzeichenrechtlichen Schutz von Internet Domains besprochen.		
<b>Intended learning outcomes</b>		
German intended learning outcomes available but not translated yet.		
Die Studierenden können markenrechtliche Fragestellungen unter Gesichtspunkten des deutschen und europäischen Rechts analysieren.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (2)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
a) written examination (approx. 120 minutes) or b) oral examination (approx. 15 minutes)		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
90 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Copyright Law		02-N-P-W07-242-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Dean of Studies Faculty of Law		Faculty of Law
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
2	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	undergraduate	--
<b>Contents</b>		
<p>German contents available but not translated yet.</p> <p>Die Veranstaltung behandelt neben den allgemeinen Grundlagen des Gewerblichen Rechtsschutzes den Schutz von Werken nach dem deutschen Urhebergesetz. In einem weiteren Veranstaltungsteil werden das Geschmacksmusterrecht sowie das Patent- und Gebrauchsmusterrecht beleuchtet.</p>		
<b>Intended learning outcomes</b>		
<p>German intended learning outcomes available but not translated yet.</p> <p>Die Studierenden haben grundlegende Kenntnisse des Gewerblichen Rechtsschutzes und des Urheberrechts erworben. Sie können Problematiken aus diesen Bereichen in den Kontext der deutschen und europäischen Regelungen einordnen.</p>		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (1)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 120 minutes) or b) oral examination (approx. 15 minutes)</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
60 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Electrochemical Energy Storage and Conversion		o8-FU-EEW-222-m01
<b>Module coordinator</b>		<b>Module offered by</b>
holder of the Chair of Chemical Technology of Material Synthesis		Chair of Chemical Technology of Material Synthesis
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
5	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	undergraduate	--
<b>Contents</b>		
Chemistry and application of battery systems (aqueous and non-aqueous systems like lead, nickel cadmium and nickel metal hydride, sodium sulfur, sodium nickel chloride, lithium ion accumulators), electrochemical double layer capacitors, redox-flow battery, fuel cell systems (AFC, PEMFC, DMFC, PAFC, SOFC), Solar cells (Si, CIS, CIGS, GaAs, organic and dye solar cell), thermoelectric devices.		
<b>Intended learning outcomes</b>		
The students gain comprehensive knowledge in the field of electrochemical energy storage and transformation and are able to apply this to scientific problems.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (2) + S (2) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
a) written examination (approx. 90 minutes) or oral examination of one candidate each (approx. 30 minutes) and b) talk (approx. 30 minutes); (weighted 65:35) Language of assessment: German and/or English Assessment offered: Once a year, summer semester		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
150 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
<b>Structure-Properties Correlations of Light Materials - Experiments and Numerical Simulations</b>		08-FU-MW-222-m01
<b>Module coordinator</b>		<b>Module offered by</b>
degree programme coordinator Funktionswerkstoffe (Functional Materials)		Chair of Chemical Technology of Material Synthesis
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
5	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
Material properties of metals and ceramics: Struktur-property relationships through experiments and simulation.		
<b>Intended learning outcomes</b>		
The students gain fundamental knowledge about the properties of modern materials: aviation aluminum alloys and high performance ceramics. Analytical methods and predictions through numerical simulations will be presented. The relationship of mikro- and nanoscopic structure of materials and the resulting properties are emphasized.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (2) + S (2) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
a) written examination (approx. 90 minutes) or oral examination of one candidate each (approx. 30 minutes) and b) talk (approx. 30 minutes); (weighted 60:40) Language of assessment: German and/or English Assessment offered: Once a year, winter semester		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
150 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Sensor and Actor Materials - Functional Ceramics and Magnetic Particles		o8-FU-SAM-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
degree programme coordinator Funktionswerkstoffe (Functional Materials)		Chair of Chemical Technology of Material Synthesis
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
5	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
Fabrication, effects and applications of sensory and actuator materials such as piezoelectrics, shape memory materials and magnetostrictive materials. Electrorheological and magnetorheological fluids, magnetofluids.		
<b>Intended learning outcomes</b>		
Students have developed fundamental knowledge in the area of sensory and actuator materials.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (2) + P (2)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
a) written examination (approx. 90 minutes) or b) oral examination of one candidate each (approx. 20 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) Language of assessment: German and/or English Assessment offered: Once a year, summer semester P: creditable for bonus		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
150 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Ultrafast spectroscopy and quantum-control		o8-PCM4-242-m01
<b>Module coordinator</b>		<b>Module offered by</b>
lecturer of the seminar "Nanoskalige Materialien"		Institute of Physical and Theoretical Chemistry
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
5	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	Prior completion of modules o8-PCM1a and o8-PCM1b recommended.
<b>Contents</b>		
This module discusses advanced topics in ultrafast spectroscopy and quantum control. It focuses on ultrashort laser pulses, time-resolved laser spectroscopy and coherent control.		
<b>Intended learning outcomes</b>		
Students are able to describe the generation of ultrashort laser pulses and to characterise them. They can explain the theory of time-resolved laser spectroscopy and name experimental methods. They can describe the principles and applications of quantum control.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
S (2) + Ü (1) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
a) oral examination of one candidate each (approx. 20 minutes) or b) talk (approx. 30 minutes) or c) portfolio (approx. 50 hours total) Language of assessment: German and/or English		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
150 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Artificial Intelligence 1		10-I=KI1-212-m01
<b>Module coordinator</b>		<b>Module offered by</b>
holder of the Chair of Computer Science VI		Institute of Computer Science
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
5	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
Intelligent agents, uninformed and heuristic search, constraint problem solving, search with partial information, propositional and predicate logic and inference, knowledge representation.		
<b>Intended learning outcomes</b>		
The students possess theoretical and practical knowledge about artificial intelligence in the area of agents, search and logic and are able to assess possible applications.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (2) + Ü (2)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
written examination (approx. 60 to 120 minutes) If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate). Language of assessment: German and/or English creditable for bonus		
<b>Allocation of places</b>		
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<b>Additional information</b>		
Focuses available for students of the Master's programme Informatik (Computer Science, 120 ECTS credits): AT,SE,KI,HCI		
<b>Workload</b>		
150 h		
<b>Teaching cycle</b>		
Teaching cycle: every year, winter semester		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Analysis and Design of Programs		10-I=PA-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
holder of the Chair of Computer Science II		Institute of Computer Science
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
5	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
Program analysis, model creation in software engineering, program quality, test of programs, process models.		
<b>Intended learning outcomes</b>		
The students are able to analyse programs, to use testing frameworks and metrics as well as to judge program quality.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (2) + Ü (2)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
written examination (approx. 60 to 120 minutes). If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate). Language of assessment: German and/or English creditable for bonus		
<b>Allocation of places</b>		
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<b>Additional information</b>		
Focuses available for students of the Master's programme Informatik (Computer Science, 120 ECTS credits): SE,IS,ES,GE		
<b>Workload</b>		
150 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Advanced Programming		10-I-APR-172-m01
<b>Module coordinator</b>		<b>Module offered by</b>
holder of the Chair of Computer Science II		Institute of Computer Science
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
5	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	undergraduate	--
<b>Contents</b>		
<p>With the knowledge of basic programming, taught in introductory lectures, it is possible to realize simpler programs. If more complex problems are to be tackled, suboptimal results like long, incomprehensible functions and code duplicates occur. In this lecture, further knowledge is to be conveyed on how to give programs and code a sensible structure. Also, further topics in the areas of software security and parallel programming are discussed.</p>		
<b>Intended learning outcomes</b>		
<p>Students learn advanced programming paradigms especially suited for space applications. Different patterns are then implemented in multiple languages and their efficiency measured using standard metrics. In addition, parallel processing concepts are introduced culminating in the use of GPU architectures for extremely quick processing.</p>		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (2) + Ü (2)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>written examination (approx. 60 to 120 minutes). If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate). Language of assessment: German and/or English creditable for bonus</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
150 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
§ 22 II Nr. 3 b)		

<b>Module title</b>		<b>Abbreviation</b>
Operating Systems		10-I-BS-242-m01
<b>Module coordinator</b>		<b>Module offered by</b>
holder of the Chair of Computer Science XVII		Institute of Computer Science
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
5	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	undergraduate	--
<b>Contents</b>		
Introduction to computer systems, development of operating systems, architecture principles, interrupt processing in operating systems, processes and threads, CPU scheduling, synchronisation and communication, memory management, device and file management, operating system virtualisation.		
<b>Intended learning outcomes</b>		
The students possess knowledge and practical skills in building and using essential parts of operating systems.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (2) + Ü (2)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
written examination (approx. 60 to 120 minutes). If announced by the lecturer at the beginning of the course, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 15 minutes per candidate). Language of assessment: German and/or English creditable for bonus		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
150 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
§ 22 II Nr. 3 b), § 69 I Nr. 1 c)		

<b>Module title</b>		<b>Abbreviation</b>
Discrete Mathematics		10-M=VDIM-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Dean of Studies Mathematik (Mathematics)		Institute of Mathematics
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
5	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
Advanced methods and results in a selected field of discrete mathematics (e. g. coding theory, cryptography, graph theory or combinatorics)		
Recommended previous knowledge: Basic knowledge of the contents of the module "Introduction to Discrete Mathematics" is required.		
<b>Intended learning outcomes</b>		
The student is acquainted with advanced results in a selected topic in discrete mathematics.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + Ü (1) Module taught in: German and/or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
a) written examination (approx. 60 to 90 minutes, usually chosen) or b) oral examination of one candidate each (approx. 15 minutes) or c) oral examination in groups (groups of 2, approx. 10 minutes per candidate) Language of assessment: German or English Assessment offered: In the semester in which the course is offered and in the subsequent semester creditable for bonus		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
150 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Advanced Analysis		10-M-VAN-222-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Dean of Studies Mathematik (Mathematics)		Institute of Mathematics
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
10	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	undergraduate	--
<b>Contents</b>		
Continuation of analysis in several variables; Lebesgue measure and Lebesgue integral in $\mathbb{R}^n$ , integral theorems.		
<b>Intended learning outcomes</b>		
The student is acquainted with advanced topics in analysis. Taking the example of the Lebesgue integral, he or she is able to understand the construction of a complex mathematical concept.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (4) + Ü (2)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
a) written examination (approx. 90 to 180 minutes, usually chosen) or b) oral examination of one candidate each (15 to 30 minutes) or c) oral examination in groups (groups of 2, 10 to 15 minutes per candidate) Language of assessment: German and/or English creditable for bonus		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
300 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Selected Topics of Theoretical Solid State Physics		11-AKTF-201-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
In this lecture, selected topics of condensed matter theory are addressed. We intend to present new developments to bring the students in touch with actual research topics. Possible subjects are many-body localization and dynamic quantum matter.		
<b>Intended learning outcomes</b>		
The students learn how to describe condensed matter systems in presence of disorder and interactions from a theoretical point of view. This happens on the basis of analytical and numerical methods. Therefore, we envisage a smooth crossover of these students to the next step of becoming a researcher.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Language of assessment: German and/or English Assessment offered: In the semester in which the course is offered and in the subsequent semester		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Astrophysics		11-AP-152-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	undergraduate	--
<b>Contents</b>		
History of astronomy, coordinates and time measurement, the Solar System, exoplanets, astronomical scales, telescopes and detectors, stellar structure and atmospheres, stellar evolution and end stages, interstellar medium, molecular clouds, structure of the milky way, the local universe, the expanding universe, galaxies, active galactic nuclei, large-scale structures, cosmology.		
<b>Intended learning outcomes</b>		
The students are familiar with the modern world view of Astrophysics. They know methods and tools for astrophysical observations and evaluations. They are able to use these methods to plan and analyse own observations. They are familiar with the physics and development of the main astrophysical objects such as stars and galaxies.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (2) + R (2) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes) If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Language of assessment: German and/or English		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
§ 22 II Nr. 1 h) § 22 II Nr. 2 f) § 22 II Nr. 3 f)		

<b>Module title</b>		<b>Abbreviation</b>
<b>Methods of Observational Astronomy</b>		11-ASM-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
Methods of observational astronomy across the electromagnetic spectrum. Evaluation of observational data from radio, optical, X-ray and gamma-ray telescopes.		
<b>Intended learning outcomes</b>		
Overview of the methods used in observational astronomy in various parts of the electromagnetic spectrum (radio, optical, X-ray and gamma-ray energies). Knowledge of principles and applications of these methods and ability to conduct astronomical observations.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes).</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English  Assessment offered: In the semester in which the course is offered and in the subsequent semester</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Introduction to Space Physics		11-ASP-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
<ol style="list-style-type: none"> <li>1. Overview</li> <li>2. Dynamics of charged particles in magnetic and electric fields</li> <li>3. Elements of space physics</li> <li>4. The sun and heliosphere</li> <li>5. Acceleration and transport of energetic particles in the heliosphere</li> <li>6. Instruments to measure energetic particles in extraterrestrial space</li> </ol>		
<b>Intended learning outcomes</b>		
The students acquire basic knowledge of Space Physics, in particular regarding the characterisation of the dynamics of charged particles in space and the heliosphere. They know relevant parameters and theoretical concepts and corresponding measuring methods.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<ol style="list-style-type: none"> <li>a) written examination (approx. 90 to 120 minutes) or</li> <li>b) oral examination of one candidate each (approx. 30 minutes) or</li> <li>c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or</li> <li>d) project report (approx. 8 to 10 pages) or</li> <li>e) presentation/talk (approx. 30 minutes).</li> </ol> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English Assessment offered: In the semester in which the course is offered and in the subsequent semester</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Image and Signal Processing in Physics		11-BSV-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
<p>Periodic and aperiodic signals; principles of discrete and exact Fourier transformation; principles of digital signal and image processing; discretisation of signals/sampling theorem (Shannon); homogeneous and linear filters, convolution product; tapering functions and interpolation of images; the Parseval theorem, correlation and energetic observation; statistical signals, image noise, moments, stationary signals; tomography: Hankel and Radon transformation.</p>		
<b>Intended learning outcomes</b>		
<p>The students have advanced knowledge of digital image and signal processing. They know the physical principles of image processing and are familiar with different methods of signal processing. They are able to explain different methods and to implement them, especially in the field of tomography.</p>		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
<p>V (2) + Ü (2) Module taught in: German or English</p>		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English Assessment offered: In the semester in which the course is offered and in the subsequent semester</p>		
<b>Allocation of places</b>		
--		
<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Advanced Topics in Solid State Physics		11-CSFM-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	Approval from examination committee required.
<b>Contents</b>		
This module will enable the lecturers of Condensed Matter Physics to teach advanced courses on topics not covered in any of the other modules. These topics may relate either to recent research developments or to subjects not included in the regular curriculum.		
<b>Intended learning outcomes</b>		
The students advance their knowledge and understanding of an advanced topic of Condensed Matter Physics and acquire insights into the connections between research and teaching.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes)</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
--		
<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Advanced Topics in Quantum Technology		11-CSNM-212-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	Approval from examination committee required.
<b>Contents</b>		
This module allows lecturers of the quantum technology study programme to give lectures on advanced topics that can not be covered by any other module. These lectures may either reflect new developments in research or deal with topics that are not included in the regular teaching cycle.		
<b>Intended learning outcomes</b>		
The students deepen their knowledge and understanding of an advanced topic in quantum technology, thereby gaining insights into the interface between research and teaching.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes)</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
--		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Advanced Topics in Physics		11-CSPM-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
chairperson of examination committee		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	Approval from examination committee required.
<b>Contents</b>		
This module will enable lecturers of Physics to teach advanced courses on topics not covered in any of the other modules. These topics may relate either to recent research developments or to subjects not included in the regular curriculum.		
<b>Intended learning outcomes</b>		
The students advance their knowledge and understanding of an advanced topic of nanostructure technology and acquire insights into the connections between research and teaching.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes)</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Electron and Ion Microscopy		11-EIM-211-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
Theoretical Foundations. Electron and ion sources, optics of charged particles, interaction of matter with electrons and charged particles, detectors, measurement principles: SEM, STEM, TEM, sample preparation, advanced contrast mechanisms: EBSD, EELS, EDS, cathodoluminescence.		
<b>Intended learning outcomes</b>		
The student has specific and immersed knowledge in electron and ion microscopy. He/she knows the theoretical and instrumental basics and principles of detectors and contrast mechanisms. He/she knows different modi of electron microscopy and their applications. He/she knows ongoing developments in this field.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Language of assessment: German and/or English Assessment offered: In the semester in which the course is offered and in the subsequent semester		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
Teaching cycle: annually, after announcement		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Current Topics in Quantum Technology		11-EXN5-212-m01
<b>Module coordinator</b>		<b>Module offered by</b>
chairperson of examination committee		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
5	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	Approval from examination committee required.
<b>Contents</b>		
Current topics in experimental or theoretical physics. Credited academic achievements, e.g. in case of change of university or study abroad.		
<b>Intended learning outcomes</b>		
The student possesses advanced knowledge meeting the requirements of a module in theoretical or experimental physics on Master's level in the study programme Quantum Technology. He/She commands knowledge in a current field in physics and insight into the measuring and calculating methods which are necessary to acquire this knowledge. He/She is able to classify and to link the learnt. He/She knows about fields of application.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (2) + R (2)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes)</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
150 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Current Topics in Quantum Technology		11-EXN6-212-m01
<b>Module coordinator</b>		<b>Module offered by</b>
chairperson of examination committee		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	Approval from examination committee required.
<b>Contents</b>		
Current topics in experimental or theoretical physics. Credited academic achievements, e.g. in case of change of university or study abroad.		
<b>Intended learning outcomes</b>		
The student possesses advanced knowledge meeting the requirements of a module in theoretical or experimental physics on Master's level in the study programme Quantum Technology. He/She commands knowledge in a current field in physics and insight into the measuring and calculating methods which are necessary to acquire this knowledge. He/She is able to classify and to link the learnt. He/She knows about fields of application.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes)</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Current Topics in Quantum Technology		11-EXN6A-212-m01
<b>Module coordinator</b>		<b>Module offered by</b>
chairperson of examination committee		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	Approval from examination committee required.
<b>Contents</b>		
Current topics in experimental or theoretical physics. Credited academic achievements, e.g. in case of change of university or study abroad.		
<b>Intended learning outcomes</b>		
The student possesses advanced knowledge meeting the requirements of a module in theoretical or experimental physics on Master's level in the study programme Quantum Technology. He/She commands knowledge in a current field in physics and insight into the measuring and calculating methods which are necessary to acquire this knowledge. He/She is able to classify and to link the learnt. He/She knows about fields of application.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes)</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Current Topics in Quantum Technology		11-EXN7-212-m01
<b>Module coordinator</b>		<b>Module offered by</b>
chairperson of examination committee		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
7	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	Approval from examination committee required.
<b>Contents</b>		
Current topics in experimental or theoretical physics. Credited academic achievements, e.g. in case of change of university or study abroad.		
<b>Intended learning outcomes</b>		
The student possesses advanced knowledge meeting the requirements of a module in theoretical or experimental physics on Master's level in the study programme Quantum Technology. He/She commands knowledge in a current field in physics and insight into the measuring and calculating methods which are necessary to acquire this knowledge. He/She is able to classify and to link the learnt. He/She knows about fields of application.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes)</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
210 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Current Topics in Quantum Technology		11-EXN8-212-m01
<b>Module coordinator</b>		<b>Module offered by</b>
chairperson of examination committee		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
8	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	Approval from examination committee required.
<b>Contents</b>		
Current topics in experimental or theoretical physics. Credited academic achievements, e.g. in case of change of university or study abroad.		
<b>Intended learning outcomes</b>		
The student possesses advanced knowledge meeting the requirements of a module in theoretical or experimental physics on Master's level in the study programme Quantum Technology. He/She commands knowledge in a current field in physics and insight into the measuring and calculating methods which are necessary to acquire this knowledge. He/She is able to classify and to link the learnt. He/She knows about fields of application.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (4) + R (2)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes)</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
240 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Nontechnical Minor Subject		11-EXNT6-161-mo1
<b>Module coordinator</b>		<b>Module offered by</b>
chairperson of examination committee		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	Approval from examination committee required.
<b>Contents</b>		
Non-technical minor. Crediting for academic achievements, e.g. from university change or study abroad		
<b>Intended learning outcomes</b>		
The students have advanced competencies on the Master's level which correspond to the requirements of a module in the field of a non-technical minor (mathematics, chemistry, informatics, law, business sciences...).		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes).</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Current Topics in Physics		11-EXP5-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
chairperson of examination committee		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
5	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	Approval from examination committee required.
<b>Contents</b>		
Current topics in Experimental or Theoretical Physics. Credited academic achievements, e.g. in case of change of university or study abroad.		
<b>Intended learning outcomes</b>		
The students have advanced competencies corresponding to the requirements of a module of Experimental or Theoretical Physics of the Master's programme of Nanostructure Technology. They have knowledge of a current subdiscipline of Physics and understand the measuring and/or calculation methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (2) + R (2)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes).</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
150 h		
<b>Teaching cycle</b>		
--		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Current Topics in Physics		11-EXP6-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
chairperson of examination committee		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	Approval from examination committee required.
<b>Contents</b>		
Current topics in experimental or theoretical physics. Credited academic achievements, e.g. in case of change of university or study abroad.		
<b>Intended learning outcomes</b>		
The students have advanced competencies corresponding to the requirements of a module of Experimental or Theoretical Physics of the Master's programme of Nanostructure Technology. They have knowledge of a current subdiscipline of Physics and understand the measuring and/or calculation methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes)</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
--		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Current Topics in Physics		11-EXP6A-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
chairperson of examination committee		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	Approval from examination committee required.
<b>Contents</b>		
Current topics in Experimental or Theoretical Physics. Credited academic achievements, e.g. in case of change of university or study abroad.		
<b>Intended learning outcomes</b>		
The students have advanced competencies corresponding to the requirements of a module of Experimental or Theoretical Physics of the Master's programme of Nanostructure Technology. They have knowledge of a current subdiscipline of Physics and understand the measuring and/or calculation methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes)</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English</p>		
<b>Allocation of places</b>		
--		
<b>Additional information</b>		
--		
<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
--		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Current Topics in Physics		11-EXP7-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
chairperson of examination committee		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
7	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	Approval from examination committee required.
<b>Contents</b>		
Current topics of Experimental and Theoretical Physics. Accredited academic achievements, e.g. in case of change of university or study abroad.		
<b>Intended learning outcomes</b>		
The students have advanced competencies corresponding to the requirements of a module of Experimental or Theoretical Physics of the Master's programme of Nanostructure Technology. They have knowledge of a current subdiscipline of Physics and understand the measuring and/or calculation methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes).</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
--		
<b>Workload</b>		
210 h		
<b>Teaching cycle</b>		
--		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Current Topics in Physics		11-EXP8-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
chairperson of examination committee		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
8	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	Approval from examination committee required.
<b>Contents</b>		
Current topics of Experimental and Theoretical Physics. Accredited academic achievements, e.g. in case of change of university or study abroad.		
<b>Intended learning outcomes</b>		
The students have advanced competencies corresponding to the requirements of a module of Experimental or Theoretical Physics of the Master's programme of Nanostructure Technology. They have knowledge of a current subdiscipline of Physics and understand the measuring and/or calculation methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (4) + R (2)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes).</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
240 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Nontechnical Special Topics		11-EXZ5-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
chairperson of examination committee		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
5	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	Approval from examination committee required.
<b>Contents</b>		
Additional skills for engineers. Accredited academic achievements, e.g. in case of change of university or study abroad.		
<b>Intended learning outcomes</b>		
The students have advanced competencies corresponding to the requirements of a module of the Master's degree programme of Nanostructure Technology. They have qualifying knowledge for an occupation in the industry or industrial research.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (2) + R (2)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes)</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
150 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Nontechnical Special Topics		11-EXZ6-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
chairperson of examination committee		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	Approval from examination committee required.
<b>Contents</b>		
Additional skills for engineers. Accredited academic achievements, e.g. in case of change of university or study abroad		
<b>Intended learning outcomes</b>		
The students have advanced competencies corresponding to the requirements of a module of the Master's degree programme of Nanostructure Technology. They have qualifying knowledge for an occupation in the industry or industrial research.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes)</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Field Theory in Solid State Physics		11-FFK-201-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
8	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
<p>This will usually be a course on quantum many particle physics approached by the perturbative methods using Green's functions An outline could be:</p> <ol style="list-style-type: none"> <li>1. Single-particle Green's function</li> <li>2. Review of second quantization</li> <li>3. Diagrammatic method using many particle Green's functions at temperature <math>T=0</math></li> <li>4. Diagrammatic method for finite T</li> <li>5. Landau theory of Fermi liquids</li> <li>6. Superconductivity</li> <li>7. One-dimensional systems and bosonization</li> </ol>		
<b>Intended learning outcomes</b>		
Working knowledge of the methods of quantum field theory in a non-relativistic context. Ability to study properties of Fermi liquids (and bosonic systems) beyond the one-particle picture. Acquisition of methods which are essential for the understanding the effects of interactions, including superconductivity and the Kondo effect.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (4) + R (2) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English Assessment offered: In the semester in which the course is offered and in the subsequent semester</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
240 h		
<b>Teaching cycle</b>		
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<b>Module title</b>		<b>Abbreviation</b>
Solid State Physics 2		11-FK2-201-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
8	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	Approval from examination committee required.
<b>Contents</b>		
<p>1. Electrons in a periodic potential - the band structure</p> <p>a. Electrical and thermal transport</p> <p>b. Bloch theorem</p> <p>c. Electrons</p> <p>2. Semi-classical models of dynamic processes</p> <p>a. Electrical transport in partially and completely filled bands</p> <p>b. Fermi surfaces; measurement techniques</p> <p>c. Electrical transport in external magnetic fields</p> <p>d. Boltzmann-equations of transport</p> <p>3. The dielectric function and ferroelectrics</p> <p>a. Macroscopic electrodynamics and microscopic theory</p> <p>b. Polarizability of solids, of lattices, of valence electrons and quasi-free electrons; optical phonons, polaritons, plasmons, inter-band transitions, Wannier-Mott excitons</p> <p>c. Ferromagnetism</p> <p>4. Semiconductors</p> <p>a. Characteristics</p> <p>b. Intrinsic semiconductors</p> <p>c. Doped semiconductors</p> <p>d. Physics and applications of p-n junctions</p> <p>e. Heterostructures</p> <p>5. Magnetism</p> <p>a. Atomic dia- and paramagnetism</p> <p>b. Dia- and paramagnetism in metals</p> <p>c. Ferromagnetism</p> <p>6. Superconductivity</p> <p>a. Phenomena</p> <p>b. Models of superconductivity</p> <p>c. Tunnel experiments und applications</p>		
<b>Intended learning outcomes</b>		
Knowledge of effects, concepts and models in advanced solid state physics. Familiarity with the theoretical principles and with applications of experimental methods.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (4) + R (2) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or</p> <p>b) oral examination of one candidate each (approx. 30 minutes) or</p> <p>c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or</p> <p>d) project report (approx. 8 to 10 pages) or</p> <p>e) presentation/talk (approx. 30 minutes).</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method</p>		
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of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.

Language of assessment: German and/or English

Assessment offered: In the semester in which the course is offered and in the subsequent semester

**Allocation of places**

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**Additional information**

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**Workload**

240 h

**Teaching cycle**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<b>Module title</b>		<b>Abbreviation</b>
Solid State Spectroscopy		11-FKS-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
Single- and many-particle pictures of electrons in solids, light-matter interaction, optical spectroscopy, electron microscopy, X-ray spectroscopy.		
<b>Intended learning outcomes</b>		
The students have specific and advanced knowledge in the field of solid-state spectroscopy. They know different types of spectroscopy and their fields of application. They understand the theoretical principles and the current developments in research.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes)</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English  Assessment offered: In the semester in which the course is offered and in the subsequent semester</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Advanced Lithography Techniques		11-FLV-262-m01
<b>Module coordinator</b>		<b>Module offered by</b>
--		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	--	--
<b>Contents</b>		
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<b>Intended learning outcomes</b>		
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<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes).</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English  Assessment offered: In the semester in which the course is offered and in the subsequent semester</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Visiting Research		11-FPA-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
chairperson of examination committee		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
10	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
	graduate	Approval from examination committee required.
<b>Contents</b>		
Independent work on a current research topic of Experimental and Theoretical Physics. Implementation of scientific experiments including analysis and documentation of the results, especially in the context of research visits to other universities or research institutes.		
<b>Intended learning outcomes</b>		
The students are able to independently work on a current research area of Experimental or Theoretical Physics, to conduct and analyse scientific experiments and to document the results.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
R (0)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
project report (10 to 20 pages) Language of assessment: German and/or English		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
300 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Professional Specialization Quantum Technology		11-FS-N-212-m01
<b>Module coordinator</b>		<b>Module offered by</b>
chairperson of examination committee		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
15	(not) successfully completed	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
Introduction to current experimental, theoretical or engineering research topics within quantum technology research that are of particular relevance for the envisaged topic of the master thesis. A seminar talk summarizing the required underlying fundamental topics.		
<b>Intended learning outcomes</b>		
Thorough understanding of a current experimental, theoretical or engineering research topic in the field of quantum technology research chosen for the master thesis. In-depth knowledge of the current state of research and ability to present and convey this knowledge in a seminar talk.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
S (4) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
talk with discussion (30 to 45 minutes) Language of assessment: German and/or English		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
450 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Optical Properties of Semiconductor Nanostructures		11-HNS-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
<p>Semiconductor nanostructures are frequently referred to as "artificial materials". In contrast to atoms, molecules or macroscopic crystals, their electronic, optical and magnetic properties can be systematically tailored by changing their size. The lecture addresses technological challenges in the preparation of semiconductor nanostructures of varying dimensions (2D, 1D, 0D). It provides the basic theoretical concepts to describe their properties, with a focus on optical properties and light-matter coupling. Moreover, it discusses the challenges and concepts of novel optoelectronic and quantum photonic devices based on such nanostructures, including building blocks for quantum communication and quantum computing architectures.</p>		
<b>Intended learning outcomes</b>		
<p>The students know the theoretical principles and characteristics of semiconductor nanostructures. They have knowledge of the technological methods to fabricate such structures, and of their applications to novel photonic devices. They are able to apply their knowledge to problems in this field of research.</p>		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
<p>V (3) + R (1) Module taught in: German or English</p>		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Language of assessment: German and/or English Assessment offered: In the semester in which the course is offered and in the subsequent semester</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Semiconductor Physics		11-HPH-201-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
<p>The lecture deals with the fundamental properties of semiconductors. It begins with an analysis of the crystal structure, leading to methods for describing band structures. These form a basis for discussing optical and electronic properties of monolithic semiconductors. It then turns to examining semiconductor heterostructures, and studies how these can be used to modify and design optical and electrical properties, especially in the case of lowered dimensionality systems. Examples are selected from current research activities.</p>		
<b>Intended learning outcomes</b>		
<p>To provide the student with a working knowledge semiconductors pertaining to crystal structure, symmetries, and band structures, as well as electrical and optical properties. This establishes a solid basis preparing him for the more targeted specially lectures in the program.</p>		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
<p>V (3) + R (1) Module taught in: German or English</p>		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English Assessment offered: In the semester in which the course is offered and in the subsequent semester</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Magnetism		11-MAG-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
Dia- and paramagnetism, exchange interaction, ferromagnetism, antiferromagnetism, anisotropy, domain structure, nanomagnetism, superparamagnetism, experimental methods to measure magnetic properties, Kondo effect.		
<b>Intended learning outcomes</b>		
The students know basic terms, concepts and phenomena of magnetism and measuring methods for magnetic experiments; they are skilled in simple model building and in the formulation of mathematical-physical approaches and are able to apply them to tasks in the stated areas; they have competencies in independently working on problems of these areas; they are able to evaluate the accuracy of observations and analyses.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes). If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest. Language of assessment: German and/or English Assessment offered: In the semester in which the course is offered and in the subsequent semester		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Master Thesis Quantum Technology		11-MA-N-212-m01
<b>Module coordinator</b>		<b>Module offered by</b>
chairperson of examination committee		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
30	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
Independent work on an experimental, theoretical or engineering research task within nanotechnology research, in particular using state-of-the-art methods and according to scientific aspects. Writing of the master thesis.		
<b>Intended learning outcomes</b>		
Ability to independently work on an experimental, theoretical or engineering task in quantum technology research, in particular according to state-of-the-art methods and scientific aspects, and to discuss and present it in a written final thesis.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
No courses assigned to module		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
Master's thesis (750 to 900 hours total) Language of assessment: German and/or English		
<b>Allocation of places</b>		
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<b>Additional information</b>		
Time to complete: 6 months.		
<b>Workload</b>		
900 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Scientific Methods and Project Management Quantum Technology		11-MP-N-212-m01
<b>Module coordinator</b>		<b>Module offered by</b>
chairperson of examination committee		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
15	(not) successfully completed	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
Introduction to the scientific approach and practice, including project planning within a current experimental, engineering or theoretical research topic in the field of quantum technology research chosen for the master thesis. Establishment of a scientific project plan for the planned master thesis.		
<b>Intended learning outcomes</b>		
Knowledge of the scientific approach and practice, including project planning in a current experimental, engineering or theoretical research topic in the field of quantum technology research chosen for the master thesis. Ability to establish a research plan for the master thesis, and to plan the required experimental or theoretical work. Ability to present the project in a seminar talk.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
R (4) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
talk with discussion (30 to 45 minutes) Language of assessment: German and/or English		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
450 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Advanced Magnetic Resonance Imaging		11-MRI-171-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
<p>Nuclear magnetic resonance (NMR) is a quantum mechanical phenomenon that, through magnetic resonance imaging (MRI), has played a major role in the revolution of medical imaging over the last 30 years. Based on the fundamental principles of nuclear magnetic resonance (resonance principle, relaxation times, chemical shift) this course covers:</p> <ol style="list-style-type: none"> <li>1) the NMR signal theory and signal evolution (Bloch equations),</li> <li>2) the principles of spatial encoding, magnetic resonance imaging (MRI) and corresponding imaging sequences and measurement parameters,</li> <li>3) the concept of k-space and Fourier imaging, and</li> <li>4) the physical, methodological and technical possibilities and limits of MRI. As a last point, exemplary applications in fields of MRI of biomedical research, clinical imaging and non-destructive testing are introduced.</li> </ol>		
<b>Intended learning outcomes</b>		
The students have advanced knowledge of the mathematical-theoretical and physical principles of modern imaging magnetic resonance, image generation and processing. They gain a broad overview of the field of modern MRI and its interdisciplinary contexts and applications.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes)</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English  Assessment offered: In the semester in which the course is offered and in the subsequent semester</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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Master's with 1 major Quantum Technology (2026)	JMU Würzburg • generated 24-Mär-2026 • exam. reg. data record Master (120 ECTS) Quantentechnologie - 2026	page 56 / 79

<b>Module title</b>		<b>Abbreviation</b>
Nano-Optics and Hybrid Light-Matter Systems		11-NLS-252-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
8	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
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<b>Intended learning outcomes</b>		
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<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (4) + R (2) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes)</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English  Assessment offered: In the semester in which the course is offered and in the subsequent semester</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
240 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Organic Semiconductors		11-OHL-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
Fundamentals of organic semiconductors, molecular and polymer electronics and sensor technology, applications.		
<b>Intended learning outcomes</b>		
The students have advanced knowledge of organic semiconductors.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes)</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English  Assessment offered: In the semester in which the course is offered and in the subsequent semester</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Advanced Seminar Quantum Technology A		11-OSN-A-212-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
5	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
Seminar on current issues in theoretical or experimental physics.		
<b>Intended learning outcomes</b>		
In-depth knowledge about a current topic in experimental or theoretical physics. Ability to read scientific publications, summarizing them and presenting them to a peer audience.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
S (2) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
talk with discussion (30 to 45 minutes) Language of assessment: German and/or English		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
150 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Advanced Seminar Quantum Technology B		11-OSN-B-212-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
5	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
Seminar on current issues in theoretical or experimental physics.		
<b>Intended learning outcomes</b>		
In-depth knowledge about a current topic in experimental or theoretical physics. Ability to read scientific publications, summarizing them and presenting them to a peer audience.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
S (2) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
talk with discussion (30 to 45 minutes) Language of assessment: German and/or English		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
150 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Advanced Laboratory Course Master Part 1		11-P-FM1-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
3	(not) successfully completed	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	Preparation and safety briefing.
<b>Contents</b>		
Principles of Nuclear, Atomic and Molecular Physics, experiments on cryogenic temperatures and correlated systems, properties of solids, surfaces and interfaces. Experiments on the following topics: X-rays - nuclear magnetic resonance (NMR) - quantum Hall effect - optical pumping and spectroscopy in the field of optics - Hall effect - superconductivity - laser - solid-state optics		
<b>Intended learning outcomes</b>		
Knowledge of conducting experiments, analysing and documenting experimental results, basic knowledge of issuing scientific publications, application of modern evaluation systems. The students are familiar with modern experimental methods. They are able to work on a task on the basis of publications, to conduct and evaluate an experiment and to present and discuss their results in a scientific publication.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
P (3)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
practical examination Students must successfully prepare, perform, document (lab notebook) and evaluate (in the form of a scientific publication) an experiment to be considered to have successfully completed this experiment. Students must successfully complete two experiments to be considered to have successfully completed this module. Detailed regulations are laid down in the respective module description. Language of assessment: German and/or English		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
90 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Advanced Laboratory Course Master Part 2		11-P-FM2-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
3	(not) successfully completed	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	Preparation and safety briefing.
<b>Contents</b>		
Principles of Nuclear, Atomic and Molecular Physics, experiments on cryogenic temperatures and correlated systems, properties of solids, surfaces and interfaces. Experiments on the following topics: X-rays - nuclear magnetic resonance (NMR) - quantum Hall effect - optical pumping and spectroscopy in the field of optics - Hall effect - superconductivity - laser - solid-state optics		
<b>Intended learning outcomes</b>		
Knowledge of conducting experiments, analysing and documenting experimental results, basic knowledge of issuing scientific publications, application of modern evaluation systems. The students are familiar with modern experimental methods. They are able to work on a task on the basis of publications, to conduct and evaluate an experiment and to present and discuss their results in a scientific publication.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
P (3)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
practical examination Students must successfully prepare, perform, document (lab notebook) and evaluate (in the form of a scientific publication) an experiment to be considered to have successfully completed this experiment. Students must successfully complete two experiments to be considered to have successfully completed this module. Detailed regulations are laid down in the respective module description. Language of assessment: German and/or English		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
90 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Advanced Laboratory Course Master Part 3		11-P-FM3-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
3	(not) successfully completed	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	Preparation and safety briefing.
<b>Contents</b>		
Principles of Nuclear, Atomic and Molecular Physics, experiments on cryogenic temperatures and correlated systems, properties of solids, surfaces and interfaces. Experiments on the following topics: X-rays - nuclear magnetic resonance (NMR) - quantum Hall effect - optical pumping and spectroscopy in the field of optics - Hall effect - superconductivity - laser - solid-state optics		
<b>Intended learning outcomes</b>		
Knowledge of conducting experiments, analysing and documenting experimental results, basic knowledge of issuing scientific publications, application of modern evaluation systems. The students are familiar with modern experimental methods. They are able to work on a task on the basis of publications, to conduct and evaluate an experiment and to present and discuss their results in a scientific publication.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
P (3)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
practical examination Students must successfully prepare, perform, document (lab notebook) and evaluate (in the form of a scientific publication) an experiment to be considered to have successfully completed this experiment. Students must successfully complete two experiments to be considered to have successfully completed this module. Detailed regulations are laid down in the respective module description. Language of assessment: German and/or English		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
90 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Advanced Laboratory Course Master Part 4		11-P-FM4-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
3	(not) successfully completed	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	Preparation and safety briefing.
<b>Contents</b>		
Principles of Nuclear, Atomic and Molecular Physics, experiments on cryogenic temperatures and correlated systems, properties of solids, surfaces and interfaces. Experiments on the following topics: X-rays - nuclear magnetic resonance (NMR) - quantum Hall effect - optical pumping and spectroscopy in the field of optics - Hall effect - superconductivity - laser - solid-state optics		
<b>Intended learning outcomes</b>		
Knowledge of conducting experiments, analysing and documenting experimental results, basic knowledge of issuing scientific publications, application of modern evaluation systems. The students are familiar with modern experimental methods. They are able to work on a task on the basis of publications, to conduct and evaluate an experiment and to present and discuss their results in a scientific publication.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
P (3)		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
practical examination Students must successfully prepare, perform, document (lab notebook) and evaluate (in the form of a scientific publication) an experiment to be considered to have successfully completed this experiment. Students must successfully complete two experiments to be considered to have successfully completed this module. Detailed regulations are laid down in the respective module description. Language of assessment: German and/or English		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
90 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Physics of Advanced Materials		11-PMM-161-mo1
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
General properties of various material groups such as liquids, liquid crystals and polymers; magnetic materials and superconductors; thin films, heterostructures and superlattices. Methods of characterising these material groups; two-dimensional layer materials.		
<b>Intended learning outcomes</b>		
The students know the properties and characterization methods of some modern materials.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes).</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English  Assessment offered: In the semester in which the course is offered and in the subsequent semester</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Phenomenology and Theory of Superconductivity		11-PTS-201-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Applied Physics and Managing Director of the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
<p>Basic Properties of Superconductors and their Applications, Development of technological platforms, Methods of material science for calculating temperature profiles in superconductors. Overview of the phenomenology of conventional and unconventional superconductivity. Review of BCS theory and its applicability for different types of superconductors. Extension of Ginzburg-Landau theory to a quantum field theory formalism using Feynman diagrams and functional integrals. Theoretical formalism of Ward identities and response functions. Goldstone modes, phase fluctuations, and coupling to the electromagnetic field. Interpretation of the Meissner effect in terms of the Higgs mechanism. Interplay of magnetism and conventional/unconventional superconductivity. Discussion of current research topics and perspective on room-temperature superconductivity.</p>		
<b>Intended learning outcomes</b>		
<p>Acquisition of basic knowledge about superconductivity as a macroscopic quantum phenomenon. Profound understanding of unconventional superconductivity and its interplay with magnetism in the context of current research. Knowledge of BCS mean-field theory, the quantum-field theory methods necessary to extend BCS theory, as well as the Meissner effect and the Higgs mechanism. Basic understanding of unconventional superconductors and their fascinating connection with competing magnetic phases.</p>		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes).</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English  Assessment offered: In the semester in which the course is offered and in the subsequent semester</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<b>Module title</b>		<b>Abbreviation</b>
Advanced Theory of Quantum Computing and Quantum Information		11-QIC-201-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
<ol style="list-style-type: none"> <li>1. Brief summary of classical information theory</li> <li>2. Quantum theory seen from the perspective of information theory</li> <li>3. Composite systems and the Schmidt decomposition</li> <li>4. Entanglement measures</li> <li>5. Quantum operations, POVMs, and the theorems of Kraus and Stinespring</li> <li>6. Quantum gates and quantum computers</li> <li>7. Elements of the theory of decoherence</li> </ol>		
<b>Intended learning outcomes</b>		
Comprehensive understanding of quantum states and identity matrix beyond the usual textbook interpretation. Knowledge of handling tensor products and dealing with quantum effects in multipartite quantum systems. In-depth understanding of the phenomenon of entanglement. Knowledge of the fundamental mathematical concepts of quantum information theory. Ability to assess the limitations of quantum computing arising from decoherence.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<ol style="list-style-type: none"> <li>a) written examination (approx. 90 to 120 minutes) or</li> <li>b) oral examination of one candidate each (approx. 30 minutes) or</li> <li>c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or</li> <li>d) project report (approx. 8 to 10 pages) or</li> <li>e) presentation/talk (approx. 30 minutes).</li> </ol> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English Assessment offered: In the semester in which the course is offered and in the subsequent semester</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Quantum Mechanics II		11-QM2-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
8	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	undergraduate	--
<b>Contents</b>		
<p>The contents of this lecture build upon and will be chosen in accordance with the topics of the Bachelor's degree course "Quantum Mechanics I". Topics might include: for QM:</p> <ol style="list-style-type: none"> <li>1. Historical introduction</li> <li>2. Single-particle states in a central potential</li> <li>3. Principles of quantum mechanics</li> <li>4. Spin and angular momentum</li> <li>5. Approximations of energy eigenvalues</li> <li>6. Approximations for time-dependent problems</li> <li>7. Second quantisation</li> <li>8. Potential scattering</li> <li>9. General scattering theory</li> <li>10. Canonical formalism</li> <li>11. Charged particles in electromagnetic fields</li> <li>12. Quantum theory of radiation</li> <li>13. Quantum entanglement</li> </ol>		
<b>Intended learning outcomes</b>		
<p>The students acquire in-depth knowledge of advanced quantum mechanics. This knowledge is highly relevant to most of the theoretical Master's degree courses in Astrophysics, Particle Physics and Condensed Matter Physics. The completion of this master is highly recommended.</p>		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
<p>V (4) + R (2) Module taught in: German or English</p>		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English Assessment offered: In the semester in which the course is offered and in the subsequent semester</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>
240 h
<b>Teaching cycle</b>
--
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)
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<b>Module title</b>		<b>Abbreviation</b>
Quantum Transport		11-QTR-201-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
<p>The lecture addresses the fundamental transport phenomena of electrons in solids where Electron-electron interaction and the wave nature are the determining factors. This includes the diffusive and ballistic transport regime as well as the Coulomb blockade. Observations of electron interference effects, conductance quantization and the quantum Hall effect will be discussed. Thermoelectric properties of electronic system and the phenomenon of superconductivity will be examined as well. Low dimensional electron systems and its quantum mechanical description are the basis of this lecture. Relevant material systems are semiconductor heterostructures as well as topological insulators, topological semimetals, and topological superconductors. The content will be guided by actual research results.</p>		
<b>Intended learning outcomes</b>		
Working knowledge of basic transport experiments, its analysis and its interpretation which enables the student to discuss results critical.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (3) + R (1) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes).</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English  Assessment offered: In the semester in which the course is offered and in the subsequent semester</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Spintronics		11-SPI-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
<p>This lecture covers the basic principles of spin transport, with a particular emphasis on the phenomena of giant magnetoresistance and tunnel magnetoresistance. As a last point, we discuss new phenomena from the field of spin dynamics and current-induced spin phenomena.</p>		
<b>Intended learning outcomes</b>		
<p>The students know the basic principles of spin transport models and the applications of spin transport in information technology. They have gained an overview of current findings in this field (giant magnetoresistance, tunnel magnetoresistance).</p>		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
<p>V (3) + R (1) Module taught in: German or English</p>		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or  b) oral examination of one candidate each (approx. 30 minutes) or  c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or  d) project report (approx. 8 to 10 pages) or  e) presentation/talk (approx. 30 minutes).</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English  Assessment offered: In the semester in which the course is offered and in the subsequent semester</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Scanning Probe Technologies		11-SPT-211-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
<p>Basic theoretical principles of scanning force, tunneling, and near-field optical microscopy; basic principles of surface science; tip-sample interactions; design principles and material considerations; fundamentals of control engineering; measurement modes, e.g., contact and non-contact, Kelvin probe, friction force microscopy, etc; basic principles of processing and presenting microscopy data; measurement techniques and their application: lock-in, phase-lock loop, etc.</p>		
<b>Intended learning outcomes</b>		
<p>Student acquires specific knowledge in scanning probe microscopy. He/she knows the basic theoretical principles, is aware of basic design principles, knows pros and cons of various materials, and is familiar of measurement modes, contrast mechanisms, and their application. He/she is aware of recent development in the field.</p>		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
<p>V (3) + R (1) Module taught in: German or English</p>		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English Assessment offered: In the semester in which the course is offered and in the subsequent semester</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
Teaching cycle: annually, after announcement		
<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Surface Science		11-SSC-172-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Applied Physics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
6	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
<p>Relevance of surfaces and interfaces, distinction between bulk phases, classical description, continuum models. Atomic structure: Reconstructions and adsorbates, surface orientation and symmetries. Microscopic processes involving surfaces. Thermodynamics of surfaces, adsorption and desorption, equilibria, thermodynamic phases, experimental characterisation. Electronic structure of surfaces, chemical bonding, surface conditions, spin-orbit coupling: Rashba effect and topological insulators. Magnetism on surfaces.</p>		
<b>Intended learning outcomes</b>		
<p>The students have gained an overview of the diverse aspects of surface physics and especially know the causes and contexts of physical peculiarities of surfaces and interfaces. Additionally, they know the most important experimental techniques and their specific application possibilities in the context of surface physics.</p>		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
<p>V (3) + R (1) Module taught in: English</p>		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes)</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English Assessment offered: In the semester in which the course is offered and in the subsequent semester</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
180 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Topological Effects in Solid State Physics		11-TEFK-201-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
8	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
<ol style="list-style-type: none"> <li>1. Geometric phase in quantum systems</li> <li>2. Mathematical basics of topology</li> <li>3. Time-reversal symmetry</li> <li>4. Hall conductance and Chern numbers</li> <li>5. Bulk-boundary correspondence</li> <li>6. Graphene (as a topological insulator)</li> <li>7. Quantum Spin Hall insulators</li> <li>8. <math>Z_2</math> invariants</li> <li>9. Topological superconductors</li> </ol>		
<b>Intended learning outcomes</b>		
In-depth theoretical understanding of the topological concepts in quantum physics related to solid state systems. Ability to connect their knowledge with different research activities at the Department of Physics and Astronomy at Würzburg University.		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (4) + R (2) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<ol style="list-style-type: none"> <li>a) written examination (approx. 90 to 120 minutes) or</li> <li>b) oral examination of one candidate each (approx. 30 minutes) or</li> <li>c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or</li> <li>d) project report (approx. 8 to 10 pages) or</li> <li>e) presentation/talk (approx. 30 minutes).</li> </ol> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English Assessment offered: In the semester in which the course is offered and in the subsequent semester</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
240 h		
<b>Teaching cycle</b>		
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<b>Referred to in LPO I</b> (examination regulations for teaching-degree programmes)		
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<b>Module title</b>		<b>Abbreviation</b>
Theoretical Solid State Physics		11-TFK-161-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
8	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
<p>The contents of this two-term course will depend on the choice of the lecturer, and may include parts of the syllabus which could alternatively be offered as "Quantum Many Body Physics" (11-QVTP). A possible syllabus may be:</p> <ol style="list-style-type: none"> <li>1 Band structure (Sommerfeld theory of metals, Bloch theorem, k.p approach and effective Hamiltonians for topological insulators (TIs), bulk-surface correspondence, general properties of TIs)</li> <li>2 Electron-electron interactions in solids (path integral method for weakly interacting fermions, mean field theory, random phase approximation (RPA), density functional theory)</li> <li>3 Application of mean field theory and the RPA to magnetism</li> <li>4 BCS theory of superconductivity</li> </ol>		
<b>Intended learning outcomes</b>		
<p>During the two-semester lecture, the students acquire a basic understanding of many topics of Solid-State Physics, which are addressed in classical textbooks, and thereby advance their knowledge of the underlying concepts and the methods of description. The course builds upon the courses "Experimental Condensed Matter Physics" and "Quantum Mechanics".</p>		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (4) + R (2) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<p>a) written examination (approx. 90 to 120 minutes) or b) oral examination of one candidate each (approx. 30 minutes) or c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or d) project report (approx. 8 to 10 pages) or e) presentation/talk (approx. 30 minutes).</p> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English Assessment offered: In the semester in which the course is offered and in the subsequent semester</p>		
<b>Allocation of places</b>		
--		
<b>Additional information</b>		
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<b>Workload</b>		
240 h		
<b>Teaching cycle</b>		
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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<b>Module title</b>		<b>Abbreviation</b>
Theoretical Quantum Optics		11-TQO-221-m01
<b>Module coordinator</b>		<b>Module offered by</b>
Managing Director of the Institute of Theoretical Physics and Astrophysics		Faculty of Physics and Astronomy
<b>ECTS</b>	<b>Method of grading</b>	<b>Only after succ. compl. of module(s)</b>
8	numerical grade	--
<b>Duration</b>	<b>Module level</b>	<b>Other prerequisites</b>
1 semester	graduate	--
<b>Contents</b>		
<ol style="list-style-type: none"> <li>1. Semi-classical atom-field interactions</li> <li>2. Interaction of atoms with quantized light fields and dressed-atom model</li> <li>3. Master equation and open systems</li> <li>4. Coherence and interference effects</li> <li>5. Coherent light propagation in resonant media</li> <li>6. Photon statistics and correlations</li> <li>7. Quantum optics of many-body systems</li> </ol>		
<b>Intended learning outcomes</b>		
<p>Comprehensive understanding of phenomena involving light and its interaction with atoms at the microscopical level. Knowledge of density matrix formalism for quantum systems and the related mathematical concepts. In-depth understanding of quantum properties of light and their experimental signatures, including photon statistics and correlations. Knowledge of the theory of open systems and master equation description involving Lindblad superoperators. Understanding and modeling the role of coherence and interference in light propagation effects in resonant atomic media. Knowledge of cooperative effects in many-body systems: super- and subradiance, collective light shifts and their applications.</p>		
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)		
V (4) + R (2) Module taught in: German or English		
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module can be chosen to earn a bonus)		
<ol style="list-style-type: none"> <li>a) written examination (approx. 90 to 120 minutes) or</li> <li>b) oral examination of one candidate each (approx. 30 minutes) or</li> <li>c) oral examination in groups (groups of 2, approx. 30 minutes per candidate) or</li> <li>d) project report (approx. 8 to 10 pages) or</li> <li>e) presentation/talk (approx. 30 minutes).</li> </ol> <p>If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.</p> <p>Language of assessment: German and/or English Assessment offered: In the semester in which the course is offered and in the subsequent semester</p>		
<b>Allocation of places</b>		
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<b>Additional information</b>		
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<b>Workload</b>		
240 h		
<b>Teaching cycle</b>		
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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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