AG Reader

Faculty of Physics

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edition notice

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Experimental Physics

Biophysics - Drescher

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Research topics

- Which processes are important during the formation of bacterial communities?
- Physical properties of bacterial communities
- Mechanics in the development of bacterial communities
- Collective behavior and self-organization of bacteria in communities
- Swarm formation and transport processes in bacterial communities
- Evolution of social behavior in bacterial communities

Description of the research group

Our research focuses on discovering which physical and biological processes are important during the formation of bacterial communities. Many bacterial species colonize surfaces and form dense three-dimensional structures, known as biofilms, which are resistant to antibiotics and constitute one of the major forms of bacterial biomass on Earth. As a consequence, biofilms are important in medicine and have an impact on all life on our planet. The developmental processes that give rise to biofilms are largely unknown. We use high-throughput fluorescence microscopy methods (confocal and light-sheet) and computer based image processing to learn more about the processes involved in biofilm formation. Pathogenic bacteria (Vibrio cholerae, Salmonella Typhimurium) are used as model organisms. Experience in theory and/or experimental physics are welcome.

Theses

Which theses can be written in the research group?
☑ Bachelor thesis (B) ☑Master thesis (M) ☐ Staatsexamensarbeit (S)

Example topics	B	M	S
Investigating the interaction dynamics of horizontal gene transfer and collective motion of bacteria	x	x	
Measuring the adhesion force of Vibrio cholerae cells to abiotic surfaces and to biofilms	x	x	
Investigating the response of biofilms to antibiotics	x	x	
Investigating the transcriptional (RNA) response of bacteria to general stress conditions	x	x	

Experimental Semiconductor Physics - Heimbrodt

Research group leader: Prof. Dr. Wolfram Heimbrodt

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Research topics

- semiconductor nanostructures
- magnetic semiconductors
- energy transfer in quantum dot systems
- type-II excitons
- organic-anorganic hybrids
- new laser structures

Description of the research group

We investigate novel semiconductor structures with many different optical spectroscopy methods. In collaboration with theory we get a deeper and more detailed insight into the complexity of the investigated nano structures. We use manyfold spectroscopical methods like time-resolved photoluminescence spectroscopy in the time range from nanoseconds to milliseconds. Other methods used in this group are excitation spectroscopy, modulation spectroscopy, and raman spectroscopy to name but a few. All investigations are done in the temperature range from room temperature down to 1.7 Kelvin which is achieved by liquid-helium cooled cryostates. Furthermore we have the opportunity to study magneto-optical properties with a superconducting magnet with fields up to 7 Tesla.

Theses

Which theses can be written in the research group?
☑ Bachelor thesis (B) ☑Master thesis (M) ☑ Staatsexamensarbeit (S)

Example topics	B	M	S
energy transfer in quantum dot systems	x	x	x
modulation spectroscopy on laser structures	x	x	x
spectroscopy on organic molecules	x	x	x
optical spectroscopy on semiconductor structures	x	x	x
raman spectroscopy	x	x	x
exciton spectroscopy on unordered semicond. heterostructures	x	x	x
exciton spectroscopy on internal interfaces	x	x	x

Surface Science - Höfer

Research group leader: Prof. Dr. U. Höfer

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Research topics

- Charge transfer across buried interfaces of solids
- Electronic structure of interfaces
- Interfaces of novel 2D materials (graphene / TMDC)
- Reaction of organic molecules on silicon surfaces
- Charge transfer dynamics in topological insulators
- Development of time-resolved interface-specific optical methods

Description of the research group

Our group investigates the dynamics of fundamental processes at surfaces and interfaces of solids.

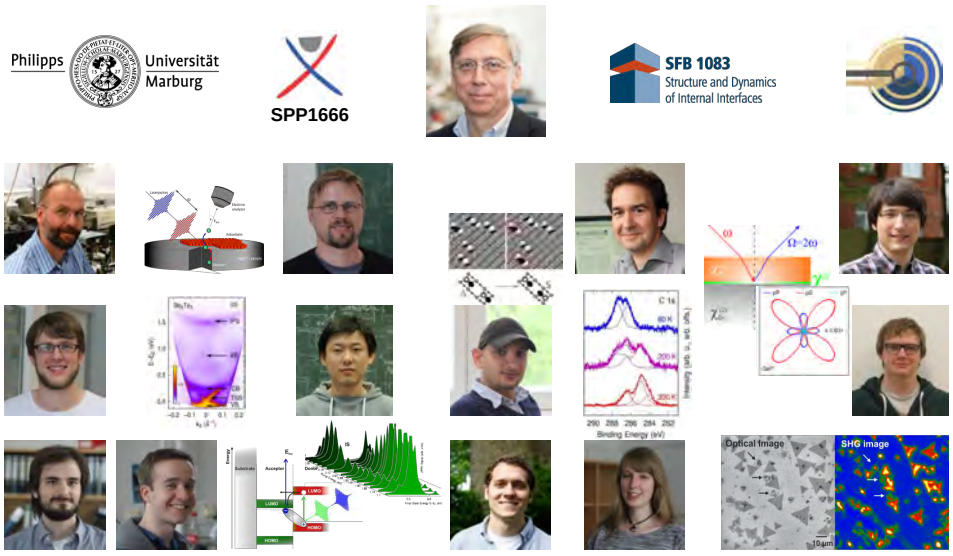
Our laboratories provide several state-of-the-art experiments for surface science and ultrafast laser-spectroscopy: Time-resolved photoelectron spectroscopy, scanning tunneling microscopy, laser pump-probe experiments and molecular-beam-techniques. The combination of ultrahigh-vacuum technology and laser-spectroscopy allows us to study well-defined surfaces and interfaces on a femtosecond timescale.

The group takes part in the Collaborative Research Centre 1083 and the Research Training Group 1782. Thereby and through the DFG Priority Program "topological insulators" und a "materials-world network", we maintain various national und international cooperations, e.g. universities and research facilities in San Sebastián, Lund, New York, Pittsburgh, Tokio und Osaka.

Theses

Which theses can be written in the research group?
☑ Bachelor thesis (B) ☑Master thesis (M) ☐ Staatsexamensarbeit (S)

Example topics	B	M	S
Scanning tunneling spectroscopy of org. molecules on silicon	x		
Setup of SHG microscopy with cryostat	x		
Non-linear optical spectroscopy on semicond. interfaces	x	x	
Two-photon-photoemission at interfaces / 2D materials		x	
Laser-induced reactions of org.molecules on Si by means of STM		x	
Adsorption of org. molecules on Si by molecular beam technique		x	
Optical generation of spinpolarized currents in topol. insulators		x	



Oberflächenphysik - Jacob

Research group leader: Prof. Dr. Peter Jakob

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Research topics

- Structural and vibrational properties of molecular layers on metal surfaces
- Growth of molecular thin films
- Adsorption on graphene/metal surfaces
- Characterization and functionalization of hetero-organic interfaces
- Dynamics of vibrational excitations
- Kinetics of surface processes

Description of the research group

The main topic of our research concerns the growth of molecular thin films under UHV conditions and their characterization in terms of structural and vibrational properties (SPA-LEED, FTIR-Spectroscopy). Various aspects related to the morphology, molecular orientation and thermal stability of the layered compounds will be explored. Particular attention is devoted to the formation of new chemical bonds at interfaces of organic compounds. One of the goals is to develop recipes to produce well defined organic heterolayer systems with destined properties. Special attention is devoted to the optimization of the quality of thus prepared layers by means of our highly specific and sensitive spectroscopic techniques. The projects in our group are associated with the Collaborative Research Centre SFB 1083 "Structure and Dynamics of Internal Interfaces" (funded by the DFG) which investigates solid/solid interfaces of a variety of organic and inorganic materials.

Theses

Which theses can be written in the research group?
☑ Bachelor thesis (B) ☑Master thesis (M) ☐ Staatsexamensarbeit (S)

Example topics	B	M	S
Growth of nanoribbons on Gold surfaces		x	
Structure of molecular thin films on metal surfaces	x	x	
Growth of organic hetero-layer systems		x	
Thermal stability of organic-organic interfaces		x	
Structural phase transitions of molecular thin films	x	x	
Chemical reactions at the molecule-metal interface	x	x	

Experimental Semiconductor Physics - Koch

Research group leader: Prof. Dr. Martin Koch

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Research topics

- Ultrafast Spectroscopy in semiconductor structures
- Semiconductor disc lasers
- Terahertz systems development and application

Description of the research group

The AG Koch represents a broad range of topics and is located at two different places. At the Renthof (Ultrafast Spectroscopy and Semiconductor disc lasers) and at the Lahnbergen (Terahertz systems development and application). Ultrafast Spectroscopy studies light-matter-interaction in semiconductor structures. Pulsed Lasers are used to explore the dynamics of optical and electronic transitions on a timescale from femto- to nanoseconds. Semiconductor disc lasers combine the advantages of semiconductor lasers and solid state or gas lasers by use of an external cavity. They gained huge attention in the field of laser development in recent years. Terahertz-Spectroscopy and the development of terahertz systems is another interesting research field.

Theses

Which theses can be written in the research group?
☑ Bachelor thesis (B) ☑Master thesis (M) ☑ Staatsexamensarbeit (S)

Example topics	B	M	S
Charge Carrier dynamics at buried interfaces in semiconductor heterostructures	x	x	x
Investigation of the hydration shell of proteins by terahertz-spektroscopy	x	x	x
Self-mode-locking of semiconductor disk lasers	x	x	x
Detection of microplastic by means of spectroscopy	x	x	x

History of Astronomy and Observational Astronomy - Schrimpf

Research group leader: Prof. Dr. Andreas Schrimpf

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Research topics

- History of astronomy in Hesse
- Analysis of the astronomical plate archive in Sonneberg
- Machine learning and data mining in astronomical datasets
- Participation in observational campaigns on variable stars

Description of the research group

Our research group combines the historical progress in the discovery of the variable sky (minor solar system bodies and variable stars) with current observations in connection with national and international cooperation.

The worldwide number of astronomical photoplates from the 19th and 20th century covering a time span of more than 100 years is estimated to roughly 7 mio. The plate archive of the Sonneberg Observatory is one of the largest archives and contains about 300.000 plates. Our group is developing a software pipeline for automated brightness determination of stars in these plates. Modern statistical methods of data mining are used to study the time variations, and especially the long-term behavior. In addition we participate in observational campaigns on variable stars, e.g. Novae. The research in history of astronomy is studying the beginning of astronomical research in Hesse on the development of star catalogues, the discovery of asteroids and studies of variable stars.

Theses

Which theses can be written in the research group?
☑ Bachelor thesis (B) ☑Master thesis (M) ☑ Staatsexamensarbeit (S)

Example topics	B	M	S
Observational campains on variable Stars	x	x	x
Detection and orbit determination of asteroids	x	x	x
Spectroscopy on variable stars		x	
Image processing of astronomical photo plates		x	
Classification of light curves from photplates	x	x	
Components of a robotic telescope	x	x	x
Observations of comets and orbit calculation in the 19th century	x		x
Analysis of the star catalogue of Wilhelm IV	x		x
History of scientific instruments of the Phys. Instrum. Collection	x		x

Quantitative Biology - Sourjik

Research group leader: Prof. Dr. Victor Sourjik

Point of contact: Gabriele Malengo
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Research topics

- System level properties of cellular networks
- Bacterial chemotaxis, biofilms and collective swimming
- Synthetic Biology
- Protein diffusion in bacterial cells
- Mathematical modelling of cellular systems
- Modelling fluctuations in sensory protein networks

Description of the research group

We are interested in a broad range of topics in quantitative microbiology, using both bacteria (E. coli, B. subtilis) and yeast (S. cerevisiae) as model systems. Our main focus is on quantitative analysis of the spatial organization and real-time functioning of cellular networks. We use experimental (fluorescence microscopy including FRET and super-resolution, genomics and proteomics) and theoretical approaches (mathematical analysis, modelling, simulations, bioinformatics) to elucidate properties that are common to most networks, such as the capability to function robustly in a noisy environment and to integrate multiple extra- and intracellular cues, and the process of network evolution. We are also interested in how individual proteins behave within the cell and how they self-assemble or self-organise at specific sub-cellular locations. Beyond individual cells, we investigate cellular organization, signal exchange and gene regulation in multicellular microbial communities.

Theses

Which theses can be written in the research group?
☑ Bachelor thesis (B) ☑Master thesis (M) ☐ Staatsexamensarbeit (S)

Example topics	B	M	S
Protein diffusion in bacteria and model systems	x	x	
Collective navigation of confined swimming bacteria	x	x	
Fluorescence lifetime imaging microscopy	x	x	
Modelling protein self-organisation within bacteria	x	x	
Bistability in gene regulatory networks	x	x	
Modelling DNA segregation and partitioning within bacteria	x	x	
Modelling fluctuations for protein networks	x		

Structure and Technology Research Laboratory - Volz & Stolz

Research group leader: Prof. Dr. Kerstin Volz & Prof. Dr. Wolfgang Stolz

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Research topics

- Epitaxial growth of III/V-semiconductors
- Realization and analysis of novel semiconductor devices
- Integration of III/V-semiconductors on silicon
- Quantitative structural analysis of semiconductors
- Quantitative structural analysis of other functional materials
- Metastable material systems, i.e. Ga(NAsBi), (GaIn)(AsBi), etc.

Description of the research group

Our research group (AG) investigates on one side the epitaxial growth (using metal organic vapour phase epitaxy) of novel semiconductor materials and their heterostructures, which can not be found in nature (i.e. also metastable materials) and on the other side the quantitative structural characterization (primarily using transmission electron microscopy) of these own layer structures but also of other function materials of different AGs. The material selection is always motivated by an application in order to realize improved laser, solar cells or transistor structures. In the structural analysis we would like in particular to understand the electron scattering mechanisms quantitatively to gain information on compositions and atomic positions in solids on a real atomic scale. In all of these studies the correlation of the epitaxial growth with the structure and the optoelectronic properties is of key importance to obtain a complete understanding of the respective material system.

Theses

Which theses can be written in the research group?
☑ Bachelor thesis (B) ☑Master thesis (M) ☑ Staatsexamensarbeit (S)

Example topics	B	M	S
Growth of dilute-N III/V-semiconductors on Si-substrate		x	
Spectroscopic analysis of III/V-semiconductor heterostructures	x		
Role of Bi for the growth of quaternary III/V-semiconductors		x	
Analysis of opto-electronic devices	x	x	
Method developments for quantitative structural analysis		x	
Systematic structural analysis of metastable material systems	x	x	
Correlation of the structure of internal interfaces with the growth conditions		x	
Optimization of sample preparation for the structural analysis	x		
Concept/extension/optimization of FP- practical courses etc.			x

Molecular Solids - Witte

Research group leader: Prof. Dr. Gregor Witte

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Research topics

- Preparation and characterization of organic functional layers
- Basic research in organic electronics
- Scanning probe microscopy and x-ray diffraction of organic semiconductors
- Preparation of molecular nanostructures
- Synthesis of biochemical sensors
- Further development of synchrotron based structure characterization

Description of the research group

The manifold properties of conducting and semiconducting organic molecules have already enabled a number of novel technical applications, suc highly efficient displays employed in mobile devices (e.g. AMOLED displays) or organic solar cells. However, the comprehension of numerous fundamental physical processes in such materials and especially multilayered devices is still insufficient. Our research group prepares and analyses suitable model systems of organic semiconductors to bridge this gap and to develop an extensive understanding of these systems . Our focus is investigation of so-called structure-property relationships, that means to investigate in which way the structural quality and the molecular packing motifs influence spectroscopic properties. By combining structure analytical and spectroscopic methods the research routine is determined by variety and immediate experimental feedback.

Theses

Which theses can be written in the research group?
☑ Bachelor thesis (B) ☑Master thesis (M) ☑ Staatsexamensarbeit (S)

Example topics	B	M	S
Preparation and Characterization of Ordered Phthalocyanine Thin Films with Controllable Molecular Orientation		x	
Thermally Induced Structural Changes in Pentacene and Perfluoropentacene Thin Films		x	
Heterogrowth of Crystalline Organic Films: Preparation, Characterization and Interface Properties		x	
Preparation and Characterization of Native Molybdenum Disulphide Cleavage			x
Optical Excitation in Stilbendithiol SAMs	x		

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Theoretical Physics

Disordered many-particle systems - Baranovski

Research group leader: Prof. Dr. Sergei Baranovski

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Research topics

- Charge transport in disordered materials
- Generation und recombination of charge carriers in disordered systems
- Optical properties of disordered semiconductors

Description of the research group

Small and nice team

Theses

Which theses can be written in the research group?
☑ Bachelor thesis (B) ☑Master thesis (M) ☐ Staatsexamensarbeit (S)

Example topics	B	M	S
Theory of charge transport in disordered systems	x	x	
Theory of charge generation in disordered systems	x	x	
Theory of charge recombination in disordered systems	x	x	
Theory of photoluminescence in disordered systems	x	x	

Komplexe Systeme - Eckhardt

Research group leader: Prof. Dr. Bruno Eckhardt

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Research topics

- Turbulence
- Self-Organization and complexity in biological systems
- Dynamics of atoms and molecules at interfaces

Description of the research group

We use methods from nonlinear dynamics and statistical physics, combined with numerical simulations, to study a variety of physical and biological systems. (i) Large scale patterns that are observed in the transition to turbulence are analyzed as coherent structures. (ii) We develop models for the empirically observed but poorly understood "law of the wall". (iii) Many bacteria have flagellae which they use to move in their habitat. Under normal conditions, the flagellae form screws behind the cell, but sometimes they wrap around the cell body, which we model as an elastic instability of the flagellum. (iv) We develop models for the motion of DNA and other molecules that can be imaged with high-resolution microscopy in cells. (v) Molecular dynamics is used to study the motion of atoms and molecules at interfaces, e.g. pentacene at Cu-interfaces.

Theses

Which theses can be written in the research group?
☑ Bachelor thesis (B) ☑Master thesis (M) ☐ Staatsexamensarbeit (S)

The topics are developed out of research activites in the group and adjusted to individual interests. At the core of theses topics are questions that can be addressed with known methods and within the allowed time, but that leaves room for further expansions depending on progress and interest.

Many-particle theory - Gebhard

Research group leader: Prof. Dr. Florian Gebhard

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Research topics

- Magnetism and superconductivity in transition metals and their compunds
- Optical properties of polymers
- Dynamics of interacting many-particle systems

Description of the research group

The many-particle theory group develops analytic methods for man-particle systems and applies them to material-oriented problems. The research focus lies on a suitable treatment of the electron-electron interaction in solids for the description of quantum-mechanical problems beyond perturbation theory. In particular, we investigate, (i), the dynamical properties of correlated quasi one-dimensional materials, e.g., optical excitations in polymers, (ii), quasi-particle band structures of strongly correlated electron systems, e.g., of transition metals and their compounds, and, (iii), the theory of metallic ferromagnetism. As tools we use diagram techniques for weak and strong coupling and the Gutzwiller variational approach

Theses

Which theses can be written in the research group?
☑ Bachelor thesis (B) ☑Master thesis (M) ☑ Staatsexamensarbeit (S)

Example topics	B	M	S
Optical phonons in short molecules	x		x
Gutzwiller approach to the spin susceptibility in Anderson models		x	

Theoretical Semiconductor Physics - Koch

Research group leader: Prof. Dr. Stephan W.Koch

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Research topics

- Theory of ultrashort blue and THz lasers
- THz-Spectroscopy of semiconductors
- Charge and exciton transfer at interfaces
- Quantum design of optoelectronic semiconductor systems
- New two-dimensional materials
- Combination of cluster expansion and density functional theory

Description of the research group

Subject of our work is the theoretical description of the optical and electronical properties of semiconductors. We focus on the development and application of microscopic models for the interaction between material excitations and external fields. Of special importance are material aspects such as the quantization of elementary excitations by reduction of the dimensions.
This requires the theory of quantum particles and optics which can be learned in our group. Developing a theory requires both, mathematical understanding and skill. Since the mathematical evaluation of a theory is often not only possible by pencil and paper, we usually utilize numerical methods. Therefore, we have an excellent computer setup and also access to a high performance cluster.

Theses

Which theses can be written in the research group?
☑ Bachelor thesis (B) ☑Master thesis (M) ☐ Staatsexamensarbeit (S)

Example topics	B	M	S
Semiconductor heterostructure modelling	x		
Influence of pump-laser quantum statistics on quantum-dot lasing		x	
Microscopic simulation of functionalized semiconductors		x	
Graphene, transition metal dichalcogenides (TMDs)		x	
Wide-gap lasers	x	x	
Atomic & semiconductor high-harmonic generation	x	x	
XUV lasers		x	
Charge transfer excitons in semiconductors	x	x	
Merging cluster kinetics and DFT		x	

Complex Systems - Lenz

Research group leader: Prof. Dr. Peter Lenz

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Research topics

- Geometrical aspects of complex systems

Description of the research group

Our research interests range from purely theoretical issues to more phenomenological topics in soft matter and biological physics with the geometrical properties of living systems as the main focus. Associated subjects are morphological transitions, shape fluctuations and instabilities in soft matter systems, the emergence of order in systems far from equilibrium and geometro-mechanical properties of cells. On the more theoretical side we study geometrical formulations for the dynamics of classical and quantum mechanical systems.

Theses

Which theses can be written in the research group?
☑ Bachelor thesis (B) ☑Master thesis (M) ☑ Staatsexamensarbeit (S)

Example topics	B	M	S
Dynamics on hyperbolic surfaces	x	x	
Fields close to geometrical singularities		x	
Classical and quantum mechanical Maupertuis principle	x	x	
Geometry of chromosomes	x	x	x