The IFF Spring School in Jülich

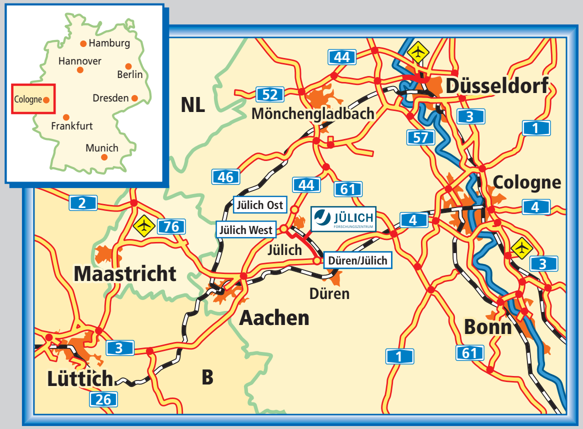
The annual IFF Spring Schools were first brought into being in 1970 by the “Institut für Festkörperforschung” (IFF) founded in 1969. Since then, they have made it possible for students and young scientists to gain a two-week insight into a current topic related to condensed matter physics. As a result of a restructuring process within Forschungszentrum Jülich in 2011, four new institutes emerged, namely the Peter Grünberg Institute (PGI), the Jülich Centre for Neutron Science (JCNS), the Institute of Complex Systems (ICS) and the Institute for Advanced Simulation (IAS). The IFF Spring School is now organized in succession by these four institutes. The 48th Spring School 2017 will be organized by PGI together with the Physics Institute II of the University of Cologne.

The mission of the Peter Grünberg Institute is the discovery and interpretation of new phenomena in condensed matter, the development of new materials and innovation in experimental and theoretical methods. Exploratory research is conducted in electronic systems, quantum phenomena and nanoelectronics with an emphasis on potential long-term applications in information technology and beyond. Considerable resources from PGI are allocated to three major infrastructure facilities that are operated in part in close cooperation with RWTH Aachen University under the umbrella of the Jülich-Aachen Research Alliance (JARA): (i) the Ernst Ruska-Centre (ER-C) for Microscopy and Spectroscopy with Electrons, (ii) the Helmholtz Nanoelectronics Facility (HNF) for the integration of structures, devices and circuits, and (iii) the Synchrotron Radiation Laboratory (J-SRL) coordinating experiments at various synchrotron radiation facilities.

The Peter Grünberg Institute has a long track-record in advancing the field of spintronics, which was recognized through the Nobel Prize awarded to our colleague Peter Grünberg in 2007, after whom the Institute was named. A particular timely example of the role of spins in solids is witnessed in the field of topological matter.

The advancement of experimental condensed matter physics has a long history at the Physics Institute II of the University of Cologne. The seven professors of the institute cover a wide range of experimental techniques, including materials synthesis, transport measurements, scanning tunnelling microscopy, and various types of spectroscopic measurements. This, together with the very collaborative culture of the institute, allows for a comprehensive understanding of interesting materials. Recently, the research efforts of the institute have been largely focused on “quantum materials” to discover and understand novel quantum phenomena stemming from spin-orbit coupling, electron correlations, and topology.

How to find us:



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Registration and further information: www.iff-springschool.de

The lecture programme, travel information, and confirmation of attendance will be sent in due course to all registered participants.

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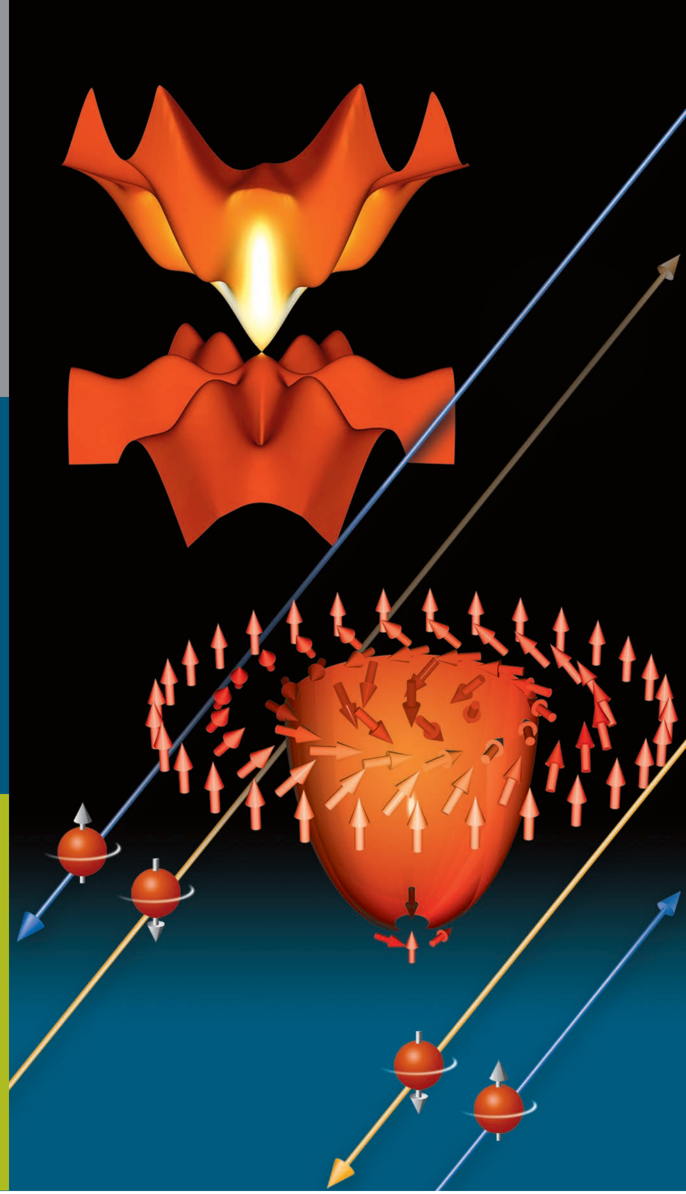

Topological Matter –

Topological Insulators, Skyrmions and Majoranas

48th IFF Spring School 2017
27th March – 7th April 2017
in Jülich, Germany

JÜLICH
FORSCHUNGSZENTRUM

Overview

Topology is the branch of mathematics that deals with properties of spaces that are invariant under smooth deformations. It provides newly appreciated mathematical tools in condensed matter physics that are currently revolutionizing the field of quantum matter and materials. Topology dictates that if two different Hamiltonians can be smoothly deformed into each other they give rise to many common physical properties and states are homotopy invariant. Thus, topological invariance, which is often protected by discrete symmetries, provides some robustness that translates into the quantization of properties; such a robust quantization motivates the search and discovery of new topological matter.

So far, the mainstream of modern topological condensed matter physics relies on two profoundly different scenarios: the emergence of the complex topology either in real space, as manifested e.g. in non-trivial magnetic structures or in momentum space, finding its realization in such materials as topological and Chern insulators. The latter renowned class of solids attracted considerable attention in recent years owing to its fascinating properties of spin-momentum locking, emergence of topologically protected surface/edge states governed by Dirac physics, as well as the quantization of Hall conductance and the discovery of the quantum spin Hall effect. Historically, the discovery of topological insulators gave rise to the discovery of a whole plethora of topologically non-trivial materials such as Weyl semimetals or topological superconductors, relevant in the context of the realization of Majorana fermions and topological quantum computation.

At the same time, the physics of skyrmions with complex magnetic real-space topologies is rapidly moving to the centre of attention in spintronics owing to the bright prospects of skyrmionic materials related to topological protection and robust dynamics. The discovery of skyrmions in various geometries (bulk, thin films, interfaces), the complex interplay of their properties with their topology, the fascinating aspects of their dynamics and transport properties are believed to result in skyrmions and other topological spin structures as basic building blocks for information manipulation and storage.

Overall, the expanding manifold of materials, phenomena and concepts, which are born from the combination of ideas and methods of topological characterization and geometrical analysis with the most advanced developments in modern solid state physics, marks one of the most exciting moments in the history of physics related to a paradigm shift in our understanding of matter.

Program

The IFF Spring School provides a comprehensive introduction to the physics of topological matter. It offers a set of elementary lectures providing a solid foundation of theoretical concepts and phenomenology as well as experimental observations. A spectrum of important experimental and theoretical techniques is introduced that is of practical use in analyzing, characterizing, growing and preparing topological matter in different dimensions. The school provides an overview of current research topics from the discovery of novel topological matter to device concepts and potential applications. This content is distributed over four sections, which are briefly outlined below.

The school comprises around 50 hours of lectures plus discussions and offers the opportunity to visit the participating Institutes in Forschungszentrum Jülich. All lectures will be given in English. Registered participants will receive a book of lecture notes that contains all of the material presented during the school.

Basics: The topology of electronic states and fields in solids will be covered from a model analysis to insights from state-of-the-art first-principles electronic structure methods to include relativistic effects, in combination with lectures on topological classification and geometric phases. On the experimental side, transport phenomena will be discussed with special emphasis on the quantum, anomalous, and spin Hall effects, as well as their quantized counterparts.

Topological Solids: An overview of topological insulators, topological metals, and related materials will be given on the basis of band structure properties, with particular focus on material aspects, dimensionality, and structural engineering. Methods of accessing and modelling transport properties in the context of quantum spin Hall effect or electron interference effects are highlighted.

Skyrmions: The diverse physics of magnetic solitons (dynamics, emergent electrodynamics, and complex phases) and their corresponding observations will be covered, and their prospects for future spintronics applications will be scrutinized. The discussion will be based on three pillars of non-collinear magnetism: the derivation of spin-lattice and microscopic magnetic models, as well as the topological properties of magnetization fields.

Advanced Phenomena include the realization of Majorana bound states in topological superconductors paving the way for topological fault-tolerant quantum computation, as well as the subjects of geometric aspects of pumping in open systems, spin chains and spin ices, Kitaev materials, emergent interfacial topological effects, Floquet topological solids, and beyond.

General Information

Venue
The IFF Spring School will take place in the Auditorium (Building 04.7) of Forschungszentrum Jülich from 27th March – 7th April 2017.

Participation
Participants are expected to have a basic knowledge of condensed matter physics, material science, nanoelectronics.

Registration Deadline
If you wish to attend **without** booking accommodation, the registration fee is 50 Euro. The accommodation fee is 380 Euro (registration fee included – see following section). All participants are asked to register at **www.iff-springschool.de** before 22nd January 2017.

Travel Information
A shuttle service will take participants from the Youth Hostel in Aachen to Forschungszentrum Jülich in the morning and back to their accommodation after the lectures are concluded. The daily transfer is free for all registered participants.

Accommodation, Lunch and Dinner
Low-cost accommodation will be arranged at the A & O Youth Hostel in Aachen. The accommodation fee of 380 Euro includes the registration fee, 12 overnight stays from 26.03. – 07.04.2017 in a four-bed room, breakfast and dinner. Lunch will be provided at Forschungszentrum Jülich from Monday to Friday at your own expense.

Arrival at the hostel: Sunday, 26th March 2017
Start of lectures: Monday, 27th March 2017
Departure: Friday afternoon, 7th April 2017

Students who have not yet finished their Master's degree can apply for financial support from Forschungszentrum Jülich to cover part of the accommodation costs. To qualify for this support, valid proof of student status as well as a letter of reference from your supervisor must be supplied to **springschool@fz-juelich.de** upon registration. Accommodation for participants from nearby universities can only be provided if there are still places available after the registration deadline.

Payment and Cancellation Policy
On completing the registration you will receive an email confirmation. Participants will receive an invoice with all relevant information regarding the transfer of the fee in due course. Cancellations must be received before or on 27th February 2017, otherwise a cancellation fee of 50 Euro is required.

Hotels in Aachen and Jülich
If you would prefer to stay in a hotel in Aachen or Jülich at your own expense, please contact **springschool@fz-juelich.de** for an accommodation list.