During the Tutorial Session on Neutron Scattering

News and Events 2005

Photo: Peter Witt

Dr. Ulrich Breuer becomes administrative director of the Hahn-Meitner-Institut

On July 1st 2005, Dr. Ulrich Breuer joined the Hahn-Meitner-Institut as the Institute's new administrative director.

A physicist by education, Ulrich Breuer began his transition from science into science administration whilst still working on his Ph.D. thesis at the Research Centre Jülich: He accepted the offer to become the assistant of the Chairman of the Board of Directors of the research Centre Joachim Treusch and started to work in this position in January 1991 – four months before his thesis defence. Although it was scientific work he was to administer in his new job and this way he remained true to science, Breuer remembers that he had to learn everything concerning the organizational and formal aspects of a scientific institute from scratch.

After four years in this position, Breuer changed his field of activity and replaced the retired head of the Public Relations department of the Research Centre devoting himself fulltime to presenting the science done at Jülich to a large public – an activity he had been working with even in his former position editing brochures and guiding groups of VIP visitors. In preparation for his new job, Breuer did an internship in the science department of the German quality daily *Frankfurter Allgemeine Zeitung* where he had the opportunity to learn the craft of science journalism by researching and writing several articles for the paper's science pages. Among the highlights of his time in the PR department were the celebrations of the 40 year anniversary of the Research Centre with an event that drew more than 40,000 visitors to the centre.

Although Breuer enjoyed working in PR, he felt that his mission was shaping things rather than only describing the work of others. And he got his chance to influence developments when he became head of the Department *Scientific and Technical Planning* of the Research Centre Jülich in 2000.In this position, he was responsible for the overall long-term research and development planning at the research centre and held responsibilities for various international programmes. When the Helmholtz Association started the process towards developing the structure of the programme oriented funding, Breuer was on the main working groups and thus contributed to many aspects of the new Helmholtz structure.

Having spent 18 years at the Research Centre Jülich, Ulrich Breuer felt it was time for a change and a new challenge and so applied for the position at the Hahn-Meitner-Institut. He admits that being 44 years old he considered this to be the last opportunity for moving to a new place and starting anew – a big decision when taking into account that it would not only involve himself but also his wife and his three children.

What makes the new position at the Hahn-Meitner-Institut so attractive for him is the fact that – together with the scientific director – he is actually responsible for running the every day business of the institute and in this way can have a strong impact on the developments of the institute even beyond the administrative realm. Breuer sees that his main task is making sure that the Hahn-Meitner-Institut is well-positioned in the world-wide landscape of science. Part of this is developing a programme for the future development of the institute for the next 15–20 years and making the success of the institute visible in the scientific community, the public and among politicians. In his plans, Breuer puts a particular emphasis on activities connected to applications and names the founding of the company Sulfurcell as a particularly successful example.

But Breuer does not only feel responsible for the institute's development. Although he thinks that the organization of the institute is very good as nobody would let a badly organized institution run a reactor – he sees room for improvement in the administrative procedures, internal communication and some other fields. He wants to make sure that the administrative departments see themselves as service providers for the scientists and in the long run sees more financial independence for the two scientific divisions as an important goal.

However, it is not only the professional challenge, Breuer emphasizes, that makes moving to Berlin so attractive, it is also the chance to live in a city with a unique vibrant cultural life and he hopes to be able to benefit from it as much as possible. Having found a house for himself and his family on the outskirts of the town, he will be able to enjoy the city life and the surrounding landscape of Brandenburg where he plans to train for his next (short) triathlon.

Bella Lake becomes head of young investigators group at the Hahn-Meitner-Institut

The English physicist Bella Lake has become head of the first young investigators group at the Hahn-Meitner-Institut and junior professor at the Technische Universität Berlin. Here, she is going to continue her successful work on investigating superconductivity and quantum magnetism by means of neutron scattering. In her new position, she can run her own research group and employ a PhD-student and a post-doc. The institution of young investigators groups has been introduced by the Helmholtz-Association as a way of enabling young researchers to work independently at an early stage in their career.


Photo: Bernhard Schurian

Bella Lake has been a frequent guest to the Hahn-Meitner-Institut in the past years, and she has performed numerous neutron scattering experiments using the institute's unique sample environment equipment. These experiments resulted in many remarkable results, some of them published in the journals *Nature* or *Nature Materials*. In the present issue of the *Hahn-Meitner-Institut Annual Report*, Bella Lake discusses the most recent results of her research on the role antiferromagnetism plays in making high temperature superconductivity stable against external magnetic fields (page 42).

Bella Lake was born and brought up in England. She studied physics at the University of Oxford and did her PhD there with a thesis on *Neutron scattering studies of alternating chain antiferromagnets*. After that, she worked at the University of Toronto (Canada), Risø National Laboratory (Roskilde, Denmark), Oak Ridge National Laboratory (Tennessee, U.S.A) and again at Oxford. During her time at Oxford, she held the prestigious Advanced Research Fellowship of the Engineering and Physical Sciences Research Council. Before coming to HMI she was assistant professor at Iowa State University in the USA.

Since September 22, 2005 Bella Lake has been working at the Hahn-Meitner-Institut, and she is not only happy about the excellent technical equipment but also praises the working conditions in general. "One has better opportunities to try out completely new experiments than at the larger neutron sources. Often, one does not have enough time there to make a novel set-up run. In that sense, one can do better science here." she says.

News from the Instrumentation Project in Neutron Guide Hall II

By the end of 2004, important milestones for the integration of the new second neutron guide hall (NGH II) into the Berlin Neutron Scattering Center (BENSC) were reached: The building structure was completed as an extension to Neutron Guide Hall I, where experiments have been performed since 1992. Particular challenges related to this project were the deep foundation in the neighborhood of existing buildings, the unusual condition to use only hardly magnetizable reinforcement steel for this type of constructions in an area of approximately 750 m^2 which is meant for heavy loads. Another problem was the connecting opening to NGH I, where valuable instrumentation sensitive to dust is installed in a radiation protection area. The replacement of the old neutron guide elements by a conceptionally new extraction guide at a tight schedule of approximately 6 weeks was a logistical challenge, in particular because manifold technical and radiological safety requirements had to be fulfilled. The new innovative extraction guides were implemented at a neutron source for the first time ever. The exchange of the neutron guide was the general prerequisite to resume the highly demanded user operation at all instruments except for the three that were located on the old NL4 guide. Hence, the thermal beam ports and the experiments using cold neutrons on the remaining guides NL1–3 were operational again by January 2005.

In 2005, the construction and delivery of the components of the complex neutron guide system at continued operation of the neutron source made good progress. The most prominent achievement in the guide section was the completion of the common initial section which than splits into three individual guides. The necessary biological shielding, which has the function to guarantee for safe top quality working conditions, was installed subsequently. This set the stage for successful tests and a swift resumption of the user operation of the upgraded (increased flux) neutron reflectometer at the beginning of 2006.

1 Photo: Bernhard Schurian

By the end of 2005, the infrastructure components were completed to a large extent. The guest groups will cooperate with their local contacts in spacious cabins that host control units and computer equipment for the experiments. Neutron choppers which will be implemented into the neutron guides will define the velocity of the neutrons before they hit the sample under investigation. Infrastructure systems required to accommodate the three big instruments in NGH II, i.e. a Very Small Neutron Scattering Instrument (VSANS) for soft matter investigations, e.g. biosytems, polymers, etc., a Large Angle Spin Echo Spectrometer (SPAN), for the investigation of slow dynamics in matter, and a versatile Extreme Environment Diffractometer (EXED) have been prepared and the instruments have partially been installed. It is planned to combine the EXED instrument with a 25–35 Tesla magnet, which will provide the highest magnetic field world wide available in neutron scattering techniques, strengthen the leading role of HMI in this area of research and provide exciting new information on magnetic structures.

1 The stained glass window of the Neutron Guide Hall II reflected in the metal platform. The sample position and the detectors for EXED will be located on this platform.
2 The neutron guides leading from the reactor to the instruments in Neutron Guide Hall II are being installed
3 General view of the Neutron Guide Hall II in early 2006. The Spin Echo Spectrometer SPAN is already in its new position. In the foreground: components to be used for building up the new instruments.
4 January 2005: New Year reception in the Neutron Guide Hall II
5 Open double disc chopper. The neutrons will be able to pass through the slits in the white rings.
6 The disc choppers will select the neutrons for the instrument EXED. Not yet in their final position.


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Photo: Bernhard Schurian 3


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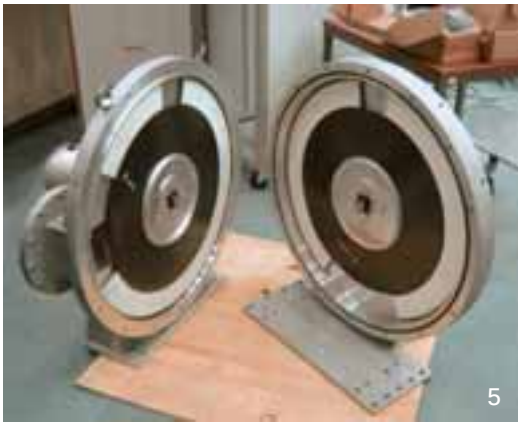
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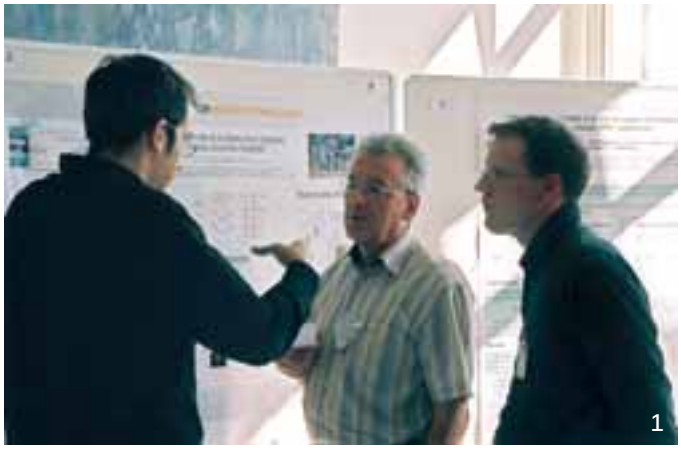
6 Photo: Bernhard Schurian

Meetings and Conferences

Several meetings, schools and conferences have been organised at or by the Hahn-Meitner-Institut in 2005. A table presents an overview; some events are described in more detail.

Event	organized together with	Location	Dates
26th Tutorial Session on Neutron Scattering	–	Hahn-Meitner-Institut	February 21–25
RADAM 05 – Conference on Radiation Damage in Biomolecular Systems	Organized within the COST P9 Action	Potsdam	March 17–20
FVS-Workshop TCO III Transparent Conducting Oxides for Thin Film Solar Cells and other Applications	Solar Energy Research Association (FVS – Forschungsverbund Sonnenenergie)	Freyburg/Unstrut	April 10–12
Summer Student Programme	–	Hahn-Meitner-Institut	August/September
1st International Summer Academy on Photovoltaics	Research Centre Jülich	Berlin	August 24–September 4
PIANO Summer School on Physics with Ions – from Analysis to Nanotechnology	GANIL (Caen, France)	Blainville-sur-Mer, France	September 19–26
BENSC Users' Meeting	–	Hahn-Meitner-Institut	September 22–23
4th Workshop on Orbital Physics and Novel Phenomena in Transition Metal Oxides	University of Hamburg	Hamburg	October 5–6
PNAM Autumn School about Application of Neutrons and Synchrotron Radiation in Engineering Materials Science	GKSS, DESY, Technical Universities of Berlin, Claustahl, Dresden and Vienna	Hamburg	October 10–14
4th Workshop on Metallo- and Metalloid Proteins (Herbsttagung)	GSF – National Research Center for Environment and Health	Hahn-Meitner-Institut	November 24–25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1–3 At the 2005 BENSC Users' Meeting
4–6 At the 4th Workshop on Metallo- and Metalloid Proteins (Herbsttagung)

First International Summer Academy on Photovoltaics

In summer 2005, the First International Summer Academy on Photovoltaics took place in Berlin. In the time from the 28th of August until the 4th of September, a scientific overview of the field as well as expert knowledge ranging from the fundamentals to the forefront of current research was provided. More than 60 PhD students and young scientists from 14 countries followed the invitation of the Hahn-Meitner-Institut (HMI) and the Research Centre Jülich (FZJ). The participants, selected from a large number of applicants, were predominantly PhD students working in the fields of physics, chemistry and material science. In addition to these participants from academic institutions, scientists from the photovoltaic industry attended the Academy as well.

The participants were first presented with an overview of Fundamentals of Semiconductors. This was followed by the topics Solar Energy Conversion and Characterisation of Materials and Solar Cells. In the presentations in the topic Preparation of Materials for Solar Cells, not only these physical fundamentals were covered, but also practical questions such as the upscaling of cells from laboratory-size to industrial-size production were discussed. In Computer Modelling and Simulation, the participants could experience the complexity of a solar cell, for even in a simple model more than 100 materials parameters are necessary to define the electrical behaviour of a cell. Additionally, aspects of wider interest like System Analysis, Scenarios, Sustainability and Technology for Solar Cells and Modules were covered. One day of the academy was used to visit the laboratories of the HMI, providing first-hand insights into modern research technology.

The response from the participants exceeded all expectations. Especially the multitude of overview presentations was highly welcomed, for they offered a compact and specific introduction to the relevant subject. A comparable event in this field – so the unanimous opinion – had not been offered before.

The booming market in photovoltaics creates an increasing demand for qualified specialists in this field. In the Helmholtz Association, the HMI and the FZJ are researching the physical and technological aspects of photovoltaics. In both institutes together, more than 200 scientist work on this key technology. By organising the summer academy, the institutes reacted to an increasing demand for further education on photovoltaics.

Discussing novel instrumentation

The 91st meeting of the *Studiengruppe für Elektronische Instrumentierung* (SEI) (Study group on electronic instrumentation) was held at the Hahn-Meitner-Institut in the time September 26–28, 2005. For 44 years, the focus of these meetings has been the exchange of experience in building large scientific measuring instrumentsbetween scientists and engineers from various institutes (e.g. Helmholtz Centres, the Federal Institute for Materials Research and Testing BAM, Germany's national metrology institute PTB and many others), Universities and electronic companies.

The main topics of this meeting were data-acquisition systems for neutron detectors using time stamp data with 100 ns resolution, front-end electronic for large position sensitive detectors, new concepts for stepping motor controller and high resolution frequency measurements which are necessary to standardize voltage measurements. One presentation showed an on-line measurement system at the Lehrter Hauptbahnhof – Berlin's new central railway station to monitor with high accuracy the different motions of this large building. An in-situ beam loss monitor system in combination with a total ionization dose measurement system for electron accelerator (e.g. TTF 2 at DESY) was presented.

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PIANO 05: French-German Summer School on Physics with Ions

Following the first German-French summer school TRACKS 03 in Mühlhausen, Thüringen, in 2003, the second French-German summer school *PIANO 05 Physics with Ions – from Analysis to Nanotechnology* was held September 19–26, 2005 in the holiday resort Blainville-sur-Mer in Normandy. Like already two years earlier, the school was organized jointly by scientists from ISL at the Hahn-Meitner-Institut and the centre for interdisciplinary research CIRIL at the accelerator centre GANIL (Caen, France) additionally sponsored by the Université-Franco-Allemande UFA – Deutsch-Französische Hochschule DFH in Saarbrücken and several French institutions: the research association CNRS, the technical university ENSICAEN and the Université de Caen.

The school was attended by 71 participants including 24 lecturers, most of them from Germany and France, but other nationalities were also represented. The main goal of the school was, to present the fundamentals of ion-solid interaction and to cover the use of ions in materials analysis as well as problems in the production of micro- and nanostructures with fast heavy ions and their characterization with complementary methods. Among the complementary methods discussed were the small angle scattering techniques with neutrons and synchrotron radiation, x-ray absorption spectroscopy (like EXAFS), and x-ray-diffraction, thus illustrating the power of combining the three "probing radiations" of PNI (photons, neutrons, and ions). It was an important intention of the organizing scientists to bring together young scientists, from the graduate student to the university teacher or researcher at national laboratories.

Additional tutorials on computer simulations – most likely a novelty for such a school – were also part of the programme. In these tutorials, the participants had the chance to explore modern characterization techniques by using analytical programs and to benefit from explanations and guidance by the experts. In the discussion at the end of the school, these tutorials received high marks as a very good means for presenting the subjects and were highly recommended for future schools and workshops.

Besides the scientific programme, the participants had enough time to familiarise themselves with some special features of the area such as the culturing of oysters in extended off-shore fields being intermittently visible or covered by water because of the large difference in tides along the coast of Normandy and Brittany. The participants also took a short trip to Mt. Saint Michel and to St. Malo in Brittany.

In summarizing the summer school PIANO 05, one can quote a commentary of one of the participants, Mme. Sophie Jequier, University of Bordeaux:
As a lecturing researcher in physics at the University of Bordeaux, I appreciated the efforts and achievements in presenting the different aspects of the field. I particularly want to emphasize how well the workshops on numerical simulations, that constitute a new approach necessary these days, were received.
At the end of this report one can only repeat the wish expressed by many of the participants to try to organize a German-French school under a well defined subject in two years again.

1–3 Summer Academy on Photovoltaics
4 PIANO 05 – Summer School on Physics with Ions


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Insights for the public: The Hahn-Meitner-Institut participated in the annual *Lange Nacht der Wissenschaften*

It has become a good tradition in Berlin that every year about one hundred research institutes invite people to the *Lange Nacht der Wissenschaften* – the largest and most important event for the general public interested in science in Berlin. The Hahn-Meitner-Institut also used this opportunity to give insights into its research activities and to rouse people's interest in physics.

In connection with the *Einstein Year 2005*, the Hahn-Meitner-Institut presented its solar energy research and introduced some aspects of Einstein's popular papers about the properties of light that formed today's basic principles of photovoltaics. About 3.000 people came to the locations in Wannsee and Adlershof and visited laboratories, talks and experiments.

In Wannsee, for example, visitors could observe how many steps are needed to fabricate solar cells with thin films of the semiconductor CIS at laboratory scale. Scientists informed also about the quality control and diagnosis of solar cells. They invited people into their laboratories and explained different procedures, for example scanning electron microscopy, infrared thermography and photoluminescence.

Many guests were attracted by a zeppelin model powered by ultra-thin, flexible solar cells which scientists from the Hahn-Meitner-Institut are developing for – amongst others – space-use. People interested in solar modules for their house roofs acquired information about materials and efficiencies of different types of solar modules offered by certain manufacturers.

The institute's scientists working at BESSY explained to visitors how they use synchrotron radiation to gain insights into the three-dimensional structures of technical components.

The *Lange Nacht der Wissenschaften 2005* was very successful – in Berlin and at the Hahn-Meitner-Institut. According to a questionnaire in Wannsee, 90 percent of the guests really enjoyed visiting the institute, felt well informed and were satisfied. The next *Lange Nacht der Wissenschaften* will take place on May 13, 2006. On this occasion, the Hahn-Meitner-Institut will present its structural research.

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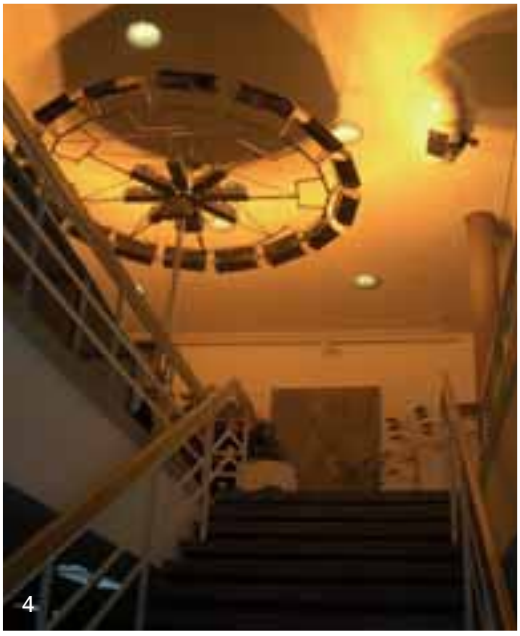
1 The building of the Department of Silicon Photovoltaics in Berlin-Adlershof illuminated for the *Lange Nacht der Wissenschaften*
2 Visitors to the Department of Silicon Photovoltaics making their own solar cells
3 An infrared camera showing the different temperatures in the head
4 The solar zeppelin – powered by a ring of strong lamps
5 The energy bike – measuring the power humans can produce
6 A PhD student happy to present her work on fuel cells



The school lab is in town

Educating future scientists and creating interest in natural sciences in the general public are some of the main tasks of a large scientific institution like the Hahn-Meitner-Institut. An important part of this effort is the institute's school lab *Blick in die Materie* (Looking into Matter) – a place where pupils from primary and secondary school have the chance to experience the atmosphere of a scientific institute, to perform physics experiments on their own and to feel the thrill of real science. In the two years of its activity, the school lab attracted more than 50 school classes comprising more than 700 pupils from all over Germany. In addition to that, the school lab offers education programmes for teachers, and particularly interested pupils get the opportunity to work in the school lab for a longer period of time. Being located on the institute's premises, the school lab in its every day work contributes to the institute's visibility almost only among the visitors themselves, their friends and families.

In order to present their work to a broader public, the school labs of nine institutes within the Helmholtz-Association joined forces and opened for one week in June a science village right in the city centre of Berlin at the magnificent boulevard of *Unter den Linden*, between the main building of the Humboldt University and the Opera House. The school labs attracted more than 12,000 people from a large crowd of passers-by enjoying a walk in the wonderful sunny weather. The school lab of the Hahn-Meitner-Institut – present in the science village for three days – gave them the opportunity to do various simple but revealing experiments about magnetism – one of the foci of its activities.

Following the route from playing via experiments to understanding, the visitors of the Hahn-Meitner-Institut school lab learned how to build an electric motor from a screw, a wire and a small magnet or how to produce electricity using magnetic induction. A more sophisticated experiment showed the reorientation of magnetic domains in a magnetic material. However, the most impressive exhibit did not fit into the pavilion and had to be placed outside: a simple magnetic accelerator speeding up steel balls to a surprisingly high velocity.

The reactions of the younger visitors showed how much they were impressed by the fact that science can be taught via hands-on experiments instead of standard school lessons. "I liked it because it wasn't boring at all. Kids don't like boring stuff." was the comment a thirteen year old girl wrote in the guest book.

1 The magnetic accelerator presented by the school lab of the Hahn-Meitner-Institut
2 Exploring eddy currents at the school lab presentation in central Berlin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PhD students meet at the Hahn-Meitner-Institut

In September 2005 a joint PhD students day was organised by the Hahn-Meitner-Institut and the Helmholtz Juniors – the Helmholtz Association's newly founded organisation for PhD students. Students from all Helmholtz research centres in Berlin and Brandenburg were invited to learn about possible career opportunities after the completion of their theses and to discuss their plans and ideas for the future. In addition, the initiative Helmholtz Juniors itself was presented.

Approximately 70 PhD students from the seven research centres located in the region attended the event. As an introduction, Professor Gereon Fink from the Research Centre Jülich (FZJ) gave a scientific talk about the functional anatomy of the human brain. Afterwards, the PhD students could learn about national and European funding opportunities as well as about the application procedures for projects supported by the German Federal Ministry of Education and Research (BMBF). An alternative option to a scientific career was presented by the directors of the two start-up companies Sulfurcell and sglux. Dr. Nikolaus Meyer (Sulfurcell) and Dr. Tilman Weiss (sglux) discussed with the PhD students about their own experience and important points to consider when starting a business. In the following poster session, the PhD students presented their own scientific results to their colleagues stimulating an intensive interdisciplinary exchange. During a barbecue evening the PhD students had further opportunity to initiate and develop new contacts in a relaxed atmosphere.

The event was a great success and this format might, in the future, serve as a model for meetings at other Helmholtz research centres.

PhD students from different Helmholtz centres arriving to the meeting of the Helmholtz-Juniors

New partner for neutron autoradiography

For more than 20 years, the Hahn-Meitner-Institut has been using neutron autoradiography for the investigation of old masters' paintings. With this method, layers of paint and pencil drawings hidden behind the surface become visible. The results of these investigations allow art historians to get access to important information about the techniques used by the painter – his typical hand –, changes made during the creation and sometimes even help decide whether a painting is an original or a forgery.

Jean-Baptiste Pater's painting *The Fair at Bezons* (owned by the Prussian Palaces and Gardens Foundation Berlin-Brandenburg) on its way into the irradiation box at the HMI

In an autoradiography experiment, the painting is irradiated with neutrons. Some atoms in the image absorb one of the incoming neutrons and thus become radioactive. When the paining is then put on an X-ray film or on imaging plates, the radiation emitted creates an image showing all the layers in the painting. Due to the different half lives of the different nuclei, one can even distinguish particular pigments in the hidden layers by comparing autoradiographs taken at different times.

Until now, almost all the paintings investigated at the Hahn-Meitner-Institut were owned by the *Gemäldegalerie Berlin* and were mostly works of Italian and Flemish painters of the 16th and 17th centuries. In late 2005, the Hahn-Meitner-Institut started a new cooperation with the Prussian Palaces and Gardens Foundation Berlin-Brandenburg administering the former Prussian royal residences in and around Berlin including hundreds of paintings purchased by the Prussian kings. As there is no doubt as to the painter in these cases, it is more the study of the painter's style and the chronology of his works that drives the interest in the investigations. As works of French painters of the 18th century make up an important part of the collections of the Palaces and Gardens Foundation, the scientists at the Hahn-Meitner-Institut now have the opportunity to extend their expertise to a new class of paintings. The first painting investigated in the framework of the cooperation was Jean-Baptiste Pater's *The Fair at Bezons* (approx. 1733) from the Sans Souci Palace in Potsdam. This painting is a smaller version of Pater's masterpiece now owned by the Metropolitan Museum of Art in New York.

Theory and experiment – a really interdisciplinary ccoperation within the Helmholtz Association

Usually, a theoretical physicist is not the kind of person one meets in a biological laboratory doing experiments with cell cultures. But in the case of a current project initiated by Martin Falcke within the department Theoretical Physics (SF5) of the Hahn-Meitner-Institut, it actually became necessary for Alexander Skupin, a new PhD student expected to work on theoretical studies of the Calcium dynamics in living cells, to perform the necessary experiments himself.

The goal of the project is to create and test a mathematical model describing the dynamics of Calcium ions in living cells. Calcium ions act as second messengers in the cells by forwarding information arriving from outside within the cell. Among the typical features of calcium dynamics are oscillations of the calcium concentration in the cell. And it is the detailed behaviour of these oscillations (Do the times between subsequent concentration maxima vary and if so how do they vary?) that carries the information necessary to decide whether the mathematical model suggested by the theoretical physicists correctly describes the processes going on inside the cell. But, as it turned out, the oscillations had never before been investigated in the detail necessary to test these theoretical predictions and this is why Skupin had to become an experimentalist for a few months.

That Skupin managed to collect the necessary data is thanks to the hospitality of two biology labs that opened their doors to the theorist – both of them located at other Helmholtz research centres: H. Kettenmann's laboratory at the Max-Delbrück-Centrum in Berlin-Buch and M. Wartenberg's laboratory at the GKSS outstation in Teltow outside Berlin. In addition to that, results achieved by other researchers at C. Taylor's laboratory at the University of Cambridge and M. Bootman's laboratory at the Babraham Institute in Cambridge were used.

Now, Skupin is back at his desk and his computer and working on his theories. The first results of this project can be found on p. 62 of this report.

In the biology lab at the Max-Delbrück-Centrum: the lab's boss Prof. H. Kettenmann (left) and Alexander Skupin, the theoretical physicist doing biology experiments there

Virtual institute to solve real problems

Non-destructive techniques employing neutrons and synchrotron radiation are becoming more and more important in the development of novel engineering materials. But do the materials scientists always know how to use the full potential of these techniques? And do the scientists running the experiments always know which are the most pressing questions the materials scientists need answers to and do they develop their equipment according to these needs?

In order to bring together expertise from both fields and to develop the techniques in joint projects, the three Helmholtz research centres: Hahn-Meitner-Institut, GKSS, and DESY as well as the Technical Universities of Berlin, Dresden, Clausthal and Vienna have founded the virtual institute *Photon and Neutron Research on Advanced Engineering Materials (PNAM)*. On January 1st, 2006, the Max-Planck Institut für Eisenforschung in Düsseldorf replaced the Technical University of Vienna as partner of the virtual institute.

The participants of the PNAM Autumn school on Applications of Neutrons and Synchrotron Radiation in Engineering Materials Science

A project run by the Hahn-Meitner-Institut and the Technical University of Dresden may serve an example for the approach of the virtual institute. Scientists at the Chair for Powder Metallurgy, Sintered Materials and Composites at the Technical University of Dresden investigate the processes going on in a metal powder during sintering, and they would like to be able to observe the sintering process in real time. The department *Materials* (SF3) of the Hahn-Meitner-Institut operates a facility for synchrotron tomography – a method providing three dimensional images of the interior of different objects with a resolution of down to a few micrometers. In a joint project, a sintering furnace will be installed on the tomography facility, and it will thus become possible to take tomography images during the running sintering process.

In addition to the scientific work, an important goal of the virtual institute is educating young scientists beginning to work in the fields of non-destructive testing and materials science: The cooperation partners have hired several PhD students to work on projects within the institute and in 2005, PNAM organised an autumn school on Applications of Neutrons and Synchrotron Radiation in Engineering Materials Science. The autumn school took place in a small conference centre right outside Hamburg. In five days, it provided a theoretical and practical introduction into the fields covered by the institute: three days of lectures were followed by two days at the GKSS research centre and at Hasylab – DESY's synchrotron radiation facility. Inspired by the success of the 2005 autumn school, the partners of the virtual institute PNAM plan to organise the next autumn school in Berlin in 2007.

The virtual institute is part of the Helmholtz Association's initiative to strengthen the cooperation between universities and Helmholtz-centres and is funded by the Association via the President's Initiative and Networking Fund.

From laboratory to production – research meets market

The company Sulfurcell

The technology company Sulfurcell intends to offer modules for the photovoltaic generation of energy at attractive prices and to help solar technology to become more economic. Being the first company world wide using Copper-Indium-Sulphide (CIS) as absorber material, Sulfurcell has begun setting up production for solar modules. The technology used for the industrial production at Sulfurcell was developed at the Hahn-Meitner-Institut (HMI) in Berlin. The innovative use of sulphur is characteristic of the technology and also influences the company name.

In 1991, HMI scientist Roland Scheer produced the first CIS solar cell with 10 % efficiency. Following further promising results, in 1998 the European research project Sulfurcell was initiated, leading to the creation of the company Sulfurcell in 2001. The Senate of Berlin honoured these efforts by granting 7m Euro for research and development activities in 2003. At the end of that year, pilot production commenced. In 2005, production was finally launched. In 2006, Sulfurcell started a cooperation with the photovoltaics company IBC Solar to promote and distribute the modules. Located in the middle of Berlin's modern Science and Technology Park Berlin-Adlershof, Sulfurcell and its more than 20 employees are planning to distribute the first modules in the 2nd quarter of 2006.

The production hall of Sulfurcell

Photo: Sulfurcell

The Technology

Sulfurcell is processing ordinary window glass and transforms the glass into solar modules generating electric energy. At the heart of the solar module is the thin CIS-layer, which absorbs as much sunlight as Silicon wafers of conventional solar modules being a hundred times thicker. The use of sulphur reduces the number of processing steps by one third and the amount of energy needed for manufacturing by two thirds compared to a conventional solar module. Apart from the p-type absorber CIS – this is where the absorbed light is transformed into electric current – a module consists of a second, n-type semiconductor layer, a metallic back contact and a transparent, conducting front contact. Within a module, a number of solar cells are series-interconnected.

The most common solar PV modules are based on crystalline silicon as absorbing material. CIS, the material Sulfurcell uses as absorber, has significantly better absorption properties. Therefore, the thickness of a CIS solar cell can be reduced to about 1 % of the thickness of a common solar cell based on crystalline silicon.

The various layers a solar module consists of are deposited one after another on a glass substrate. The glass substrate serves two purposes: as support for the very thin solar cells and as part of the later encapsulation. For the deposition of the various layers of a CIS based solar PV module, techniques such as sputtering are used which have been applied successfully for a long time in the area of large scale glass pane deposition for architectural applications. By using sputtering, one can deposit large areas at low energy consumption.

On the molybdenum back contact precursors consisting of copper and indium are deposited. In the presence of elemental sulphur vapour at a temperature of about 500° C the precursor reacts within a short time to form the absorber material CIS. The device is completed by the deposition of a front contact, and after the contacting, it is encapsulated to secure it from climatic influences. The resulting modules produce 45 to 55 Watt, depending on the model, and impress by their elegant design.

SULFURCELL

Information day for the industry

Many of the methods used for investigating matter at the large scale facilities of the Hahn-Meitner-Institut provide unique opportunities for solving technological problems in materials science and engineering. The institute should be thus considered an obvious cooperation partner for innovative industrial companies. However, a large scientific facility focusing on fundamental science is not the first place where a development engineer would look for solutions to his problems.

Thus, it is an important task for the institute to approach relevant companies, to inform them about the research opportunities offered and to emphasize that they when cooperating with the Hahn-Meitner-Institut they will find a reliable partner offering convenient conditions adjusted to each particular case. Due to extensive networking, some methods – in particular the investigation of residual stresses by means of neutron scattering – struggle with a high demand from various companies. Others are still virtually unknown among prospective industrial users. This is especially the case for methods that might be applied in many different fields of industry. In 2004, the Hahn-Meitner-Institut has founded the application centre NIXE (Neutrons, Ions and X-Rays for Engineering).

At the centre of 2005's marketing activities at the Hahn-Meitner-Institut was the *Industrietag* on June 1st – an information day for the industry – offering engineers and researchers an opportunity to visit the institute, get an overview of the of the offer and to discuss possible modes of cooperation with the scientists.

More than 60 representatives of companies and institutions supporting the transfer of knowledge accepted the invitation and spent an interesting day at the Hahn-Meitner-Institut. A large number of participants were mainly interested in the applications of the institute's imaging methods – in particular for the investigation of processes in fuel cells. Neutron tomography and radiography are the only methods that can show the flow of water in a running fuel cell.

In his opening address, Berlin's Permanent Secretary for Economics Volkmar Strauch, welcomed the participants and thanked the institute for its initiative to draw the attention of the German industrial community to Berlin's activities in the field of applied science.

As usual, the impact of the event went beyond the immediate circle of participants. Many recipients of the promotional material sent out to inform about the event got in touch with the Hahn-Meitner-Institut without being able to come as did the readers of a news-paper article announcing the event. Thus, the *Industrietag* turned out to be an efficient method of promoting the applications of materials research at the large scale facilities to the prospective user from the industry.

1 Poster session during the *Industrietag*. Discussing the use of neutron tomography for investigations on fuel cells
2 Berlin's Permanent Secretary for Economics Volkmar Strauch welcomes the participants of the *Industrietag*


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The new neutron tomography instrument

Using neutron tomography, one can investigate the macroscopic inner structure of large objects (with sizes of up to several hundreds of cubic centimeters) with a spatial resolution of down to 100 micrometers. The method provides three-dimensional images of the material distribution inside the object. It is particularly well suited for showing the distribution of light elements in or behind metals because the neutron beam can easily pass through several centimeters of metal, but it is strongly attenuated by small amounts of hydrogen, boron or lithium. This makes neutron tomography a unique tool for non-destructive testing with applications in industry, materials science and various other fields.

In a tomography experiment, one takes several hundred two-dimensional radiography images – similar to medical x-rays – from different directions. Using sophisticated reconstruction software, one can create a data set containing the complete information about the three-dimensional material distribution in the sample. Based on this data set, one can produce various images of the sample's inner structures. In the case of fast processes, it is often impossible to take many pictures of the object in exactly the same state and therefore only two-dimensional radiography images are achievable. It is, however, possible to take the radiography images with very short time intervals between them and thus to follow the developments in the investigated object in real time.

The main application tasks for neutron radiography and tomography are investigations connected with in-situ visualization of water management in fuel cells and quality tests of Diesel particulate filters, adhesive joints and lubricate films. Interesting applications in archeology and medicine were reported recently.

1 Image of a small combustion engine taken at the new neutron tomography facility of the Hahn-Meitner-Institut. Inner components of the engine – usually hidden behind the aluminium casing – are clearly visible.
2 The new neutron tomography facility CONRAD of the Hahn-Meitner-Institut
3 Neutron radiography images showing the water uptake in a tomato seedling. From some point in time, the plant was watered with heavy water that is clearly visible in black in the image.

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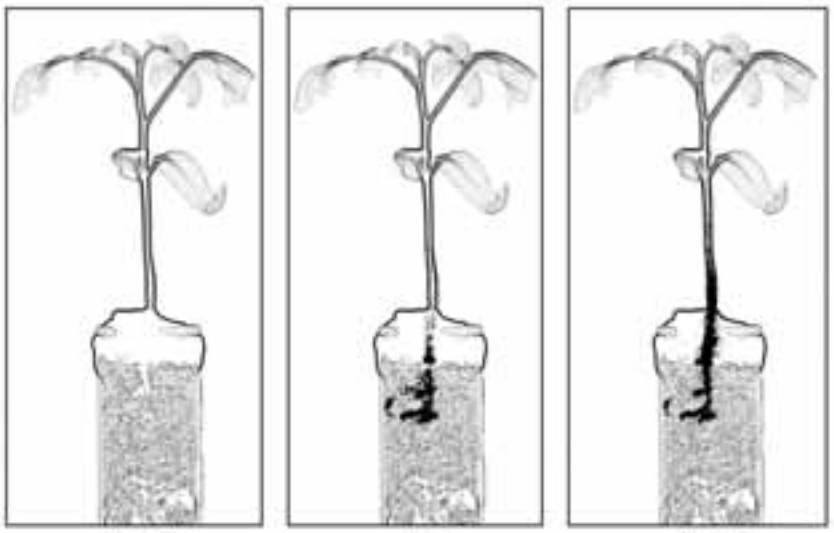
The high potential of neutron tomography was the motivation for setting up a new neutron tomography facility at the Hahn-Meitner-Institut. The facility has been designed to meet the needs of high flux applications such as real time imaging and high-speed tomography as well as high-resolution applications and phase-contrast tomography and to provide high flexibility for different kinds of radiographic and tomographic measurements.

The new tomography instrument CONRAD is a multifunctional facility for radiography and tomography with cold neutrons. It is located at the end of a curved neutron guide facing the cold neutron source of the research reactor BER II. The geometry provides a cold neutron beam with wavelengths between 2 Å and 12 Å.

Two measuring positions are available for radiography and tomography investigations. The first one is placed at the end of the guide. It is optimized for in-situ experiments, in which a high neutron flux is required. The available flux at this position is approx. $10^9\,cm^{-2}s^{-1}$. The second measuring position uses a pin-hole geometry, which allows better beam collimation (L/D up to 1000) and higher image resolution in the range of 100 µm in the CCD based detector system ($10\times10\,cm^2$). The use of cold neutrons for radiography purposes increases the image contrast and improves the sensitivity for example in detecting small amounts of materials containing water and hydrogen in metal matrices. In addition to that, the cold neutron beam can easily be modified by diffraction and neutron optical techniques. This enables one to perform radiography and tomography experiments with more sophisticated measuring techniques such as phase-contrast imaging, imaging with polarized neutrons, energy-selective radiography and microtomography.

Photo: Bernhard Schurian 2



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First experiments using the new Small Angle X-ray Scattering Instrument at BESSY

A new instrument for Small Angle X-ray Scattering (SAXS) developed, constructed and assembled by the Hahn-Meitner-Institut has been taken into operation by HMI at the synchrotron source BESSY. This instrument is designed for the non-destructive characterization of structures in the nanometre range. In addition to normal SAXS, the instrument will be used for Anomalous and Grazing Incidence SAXS (ASAXS and GISAXS).

ASAXS allows the user to identify the elemental composition of the nanosized structures investigated. The method is based on the element dependent variation of the scattering amplitude near the X-ray absorption edges. GISAXS yields structural information on lateral and vertical nanostructures close to the surface using incidence angles close to total reflection ($<1°$).

The detector of the instrument is mounted at the end of an evacuated tube with a diameter $285\,\mathrm{mm}$. This tube is built as an edge welded bellow system that allows for continuous variable sample-detector distances between $750\,\mathrm{mm}$ and $3750\,\mathrm{mm}$. The edge welded bellow system consists of two parts: The longer one runs on support tracks and can be removed. The whole system is mounted on an optical bench that can be tilted up to $3°$ for GISAXS experiments.

The samples for the experiments will be mounted on the Huber diffractometer used by the instrument for magnetic scattering MAGS. Several different sample environments – not connected to the bellow system – will be available for the experiments. Currently, an in air sample changer and a high temperature furnace are available.

In the course of the year 2005, the SAXS instrument was installed at the monochromatic beam of the 7T Wiggler operated by the Hahn-Meitner-Institut at the synchrotron source BESSY. The commissioning measurements for the SAXS instrument were done in 2005. A first successful ASAXS test experiment was performed on gold nanoclusters in an oxide glass showed that it is possible to extract the weak anomalous scattering effect.

The SAXS beamline is run in time sharing with MAGS. It has been available for user service since March 2006.

1 The SAXS instrument in its measuring position at a beamline operated by the Hahn-Meitner-Institut at BESSY. Left hand side: detector chamber, right hand side: diffractometer used together with the instrument for magnetic scattering MAGS.
2 The detector chamber of the new Small Angle X-ray Scattering instrument in the HMI workshop before being brought to BESSY


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2 Photo: Bernhard Schurian

The new 7T high field end station – a unique instrument for magnetic studies of ultrathin films and nanostructures

Experimental studies of magnetic properties of ultrathin films and nanostructures are demanding concerning photon source and sample environment because these systems consist of small quantities of material. In order to get a measurement signal of sufficient intensity they have to be excited with extraordinarily high photon flux. Measurements with elemental resolution and strong magnetic effects are possible with radiation sources which are monochromatic, tunable in energy and polarized. In the soft x-ray range these demands as to the photon source are fulfilled by state-of-the-art beamlines like our UE46-PGM at the electron storage ring BESSY.

In addition, ultrathin films and nanostructures are reduced in dimension which leads to great demands on the sample environment, namely external magnetic field and temperature under ultra high vacuum conditions. In order to also fulfil these criteria we have constructed our new high-field end station which combines magnetic fields up to $7\,\mathrm{T}$ with sample temperatures down to $2.6\,\mathrm{K}$. It has been designed for the two methods X-Ray Magnetic Circular Dichroism (XMCD) using the total electron yield to monitor the absorption and X-Ray Resonant Magnetic Reflectometry (XRMR). The absorption option has been tested and successfully applied during a beamtime immediately after the installation of the high-field end station in the experimental hall of BESSY. Measurements at a sample temperature of $3.4\,\mathrm{K}$ and a magnetic field of $6.5\,\mathrm{T}$ were routinely performed. The reflectometry option is going to be tested and used during beamtimes in the second semester of 2006.

The new ultra high vacuum high magnetic field reflectometer at the UE46-PGM beamline operated by the Hahn-Meitner-Institut at BESSY