100 years 2008
swiss physical society

SPG MITTEILUNGEN

COMMUNICATIONS DE LA SSP

NR. 23 April 2008

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The parc of the "Musée d'Histoire des Sciences", where the participants enjoyed an excellent guided tour and an apéro before the traditional conference dinner, offered a nice view on the lake and the Alps.

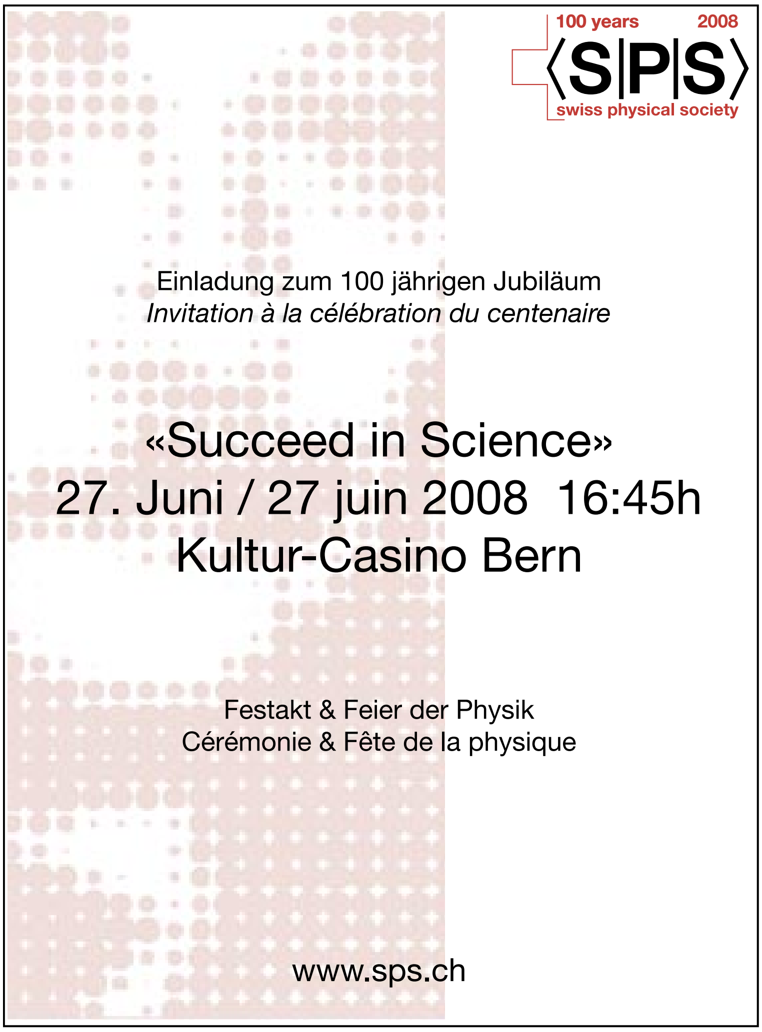
A Centenary of Physics: The SPS celebrates its 100th Birthday

In 2008 the Swiss Physical Society celebrates its centennial. All members of the SPS as well as all friends of physics from pupils to Nobel laureates are invited to the ceremonial act for the 100th Birthday, to be held on Friday, **27 June 2008, 16:45 h** at the **Kultur-Casino in Bern**. In the upcoming days, the invitation below will reach all members by ordinary mail.

We expect approximately 1'000 participants and among them we will welcome several Nobel Laureates in Physics: Heinrich Rohrer (1986), K. Alex Müller (1987), J. Georg Bednorz (1987), Gerardus 't Hooft (1999), Theodor W. Hänsch (2005) and Peter Grünberg (2007). We hope to have about 500 students, showing that physics will be important for another hundred years. The celebration is lead by the TV journalist David Jans who will show how fascinating Physics was in the past and will be in the future. The ceremonial act will consist of a greeting address from the Swiss Federal Council, a panel discussion about the past of our Society and a keynote presentation of Nobel prize laureate Prof. Theodor W. Hänsch about his Visions for Physics. After the ceremonial act the Swiss organizations for the promotion of Science to young people will present their achievements, experiments and demonstrations within a physic fair.

Registration is now open and may be done either online by using our web page: http://www.sps.ch, by email (C.Foeldy@unibas.ch) or by phone (061 267 15 21).

We hope to meet many members and friends of physics in Bern.



The Winners of the SPS Awards 2008

The SPS award committee, presided by Prof. Hans Beck (Uni Neuchâtel), has again worked hard to nominate three winners for this year's SPS awards. The outstanding work of these three young physicists are presented below.

(Laudations written by Hans Beck, abstracts written by the respective authors.)

SPS Award for General Physics, sponsored by ABB

Thorsten Lisker obtained his diploma in physics in 2003 at the University of Erlangen-Nürnberg. The topic of his diploma thesis was already in his preferred field, namely astrophysics. He then realized that the small neighboring country in the south might offer him further interesting insight into the world of stars and galaxies. After one year at ETHZ he went to the University of Basel for his PhD work that he completed a year ago with the highests honors – summa cum laude. His thesis asks a question: "Early-type Dwarf Galaxies in the Virgo Cluster: Nature or Nurture ?"

Galaxy formation and evolution is a central problem of today's astrophysics. Analysing data obtained by an impressive photometric and spectroscopic sky survey project, Thorsten Lisker performed the first systematic classification of the dwarf galaxy population of the Virgo cluster. He identified subpopulations with statistically significant different age, chemical composition, structure and dynamics within the galaxy cluster. He even succeeded – in a highly competitive process – in obtaining observing time for follow-up studies with the Very Large Telescope of the European southern Observatory in Chile. He has already 13 papers in his publication list and his PhD work has significantly advanced the understanding of galaxy evolution.

Dr. Lisker is now back in his home country as a post-doctoral researcher at the "Zentrum für Astronomie" of the University of Heidelberg where he is organizing his research group showing convincing leadership abilities – as we can read in one of the recommendation letters. He has already obtained a prize in 2007: the Camille & Henry Dreyfus Award, given by the University of Basel. So – in case he continues to have a prize every year – the Nobel prize may be his in due time….

Early-type Dwarf Galaxies in the Virgo Cluster: Nature or Nurture ?

The light of galaxy clusters, the largest gravitationally bound structures in the Universe, is dominated by a few dozen very bright and massive galaxies. However, a closer look reveals a huge number of faint and small "dwarf" galaxies, of which more than a thousand reside in the nearby Virgo galaxy cluster, 50 million light years away. Most of them belong to the class of dwarf elliptical galaxies, which appear to be of rather simple and homogeneous structure and consist mostly of old stars. Surprisingly, though, our detailed study [1] of these galaxies with the multicolour imaging data of the Sloan Digital Sky Survey revealed a pronounced complexity with regard to their internal composition, their location in areas of different mass density, and most importantly, their origins.

For many galaxies, a careful image analysis uncovered weak spiral arms and other disk features, with a structure similar to that of giant spiral galaxies and unlike that of faint star-forming galaxies that are commonly discussed as possible progenitors. But there are also other subpopulations of dwarf ellipticals that do not show spiral features, yet still violate the common picture of a spheroidal object located in the galaxy cluster's central region: instead, they exhibit a flat shape, similar to a thick disk, and are preferentially found in the outskirts of the cluster. In some of them, we are even witnessing the very last stages of star formation, in which the final few percent of stellar mass will be created before all gas is consumed.

Only those dwarf ellipticals hosting a compact, bright star cluster in their center follow the classical conception of this galaxy class: they are spheroidal, prefer high-density regions, and consist of stars that are older and more enriched in heavy elements than those of the other subclasses. Even when taking into account possible transitions between the subclasses, this diversity in the galaxy properties cannot be explained with just a single formation scenario responsible for all dwarf ellipticals [2]. Instead, there must be at least two different mechanisms creating these galaxies. One might be the combined physical processes acting in galaxy clusters, continuously producing new dwarf ellipticals through gas stripping and structural transformation of infalling galaxies. The other one might simply be cold dark matter structure formation, which should have yielded a large number of small dark matter "halos" that today are found deep within the gravitational potential of the galaxy cluster, each one being illuminated by its own little dwarf galaxy.

[1] T. Lisker, E. K. Grebel, B. Binggeli, and K. Glatt, "Virgo Cluster Early-Type Dwarf Galaxies with the Sloan Digital Sky Survey. III. Subpopulations: Distributions, Shapes, Origins", The Astrophysical Journal 660, 1186 (2007)
[2] T. Lisker, E. K. Grebel, and B. Binggeli, "Virgo Cluster Early-Type Dwarf Galaxies with the Sloan Digital Sky Survey. IV. The Color-Magnitude Relation", The Astronomical Journal 135, 380 (2008)

Two winners of the SPS awards and the president of the award committee:
Dr. Lorenz Meier, Prof. Hans Beck and Dr. Thorsten Lisker.
The third winner, Dr. Andea Guarino, was unfortunately not able to attend the award ceremony personally.

SPS Award for Condensed Matter Physics, sponsored by IBM

Lorenz Meier has been what we call a "mobile student": he studied physics at ETH Zürich and at the University of Lund in Sweden. His PhD work for which he gets his prize was done in the framework of a joint research project between the Laboratory of Solid State Physics at ETH in Zürich and the IBM Research Lab in Rüschlikon (I can garantee you that the IBM member in the prize committee took a very neutral point of view when we evaluated the different candidates…).

I can imagine that electrons in quantum wells are really afraid of Lorenz Meier since they have to dance according to his will ! He has developed methods allowing to manipulate the spin of these electrons, either by magnetic or – what is less obvious – by electric fields. The latter case is more promising for practical applications, particularly in computing and information processing. He is using basic physics that tells us that – in the reference frame of a moving electron – electric fields transform into magnetic fields which then influences the electronic spin degree of freedom.

His work is already internationally recognized and a Nature Physics paper presents his achievements in electric-dipole-induced spin resonance. However, his CV shows that his interests go far beyond physics: he has been a useful employee of his home canton of St. Gallen for a couple of years by programming software for tax calculation and staff management, and our SBB company has profited from his implementation and testing of the braking parameters for a new high speed train line running with the European Train Control System (ETCS). This is perhaps not so surprising, since, as a good student, Lorenz knows what European Credit Transfer System (ECTS) means and then easily switched to ETCS…

Manipulation of electron spins in quantum wells with magnetic and electric fields

We report on the manipulation of electron spins confined in a GaAs/InGaAs quantum well with magnetic stray fields from ferromagnetic structures and with electric fields via the spin-orbit interaction.

The coherent precession of electron spins in the magnetic stray field below an array of Fe stripes is measured. Comparing with reference stripes made of non-magnetic Au, we find an enhancement of the spin precession frequency proportional to the Fe magnetization, which we can attribute to the effect of the magnetic stray field emanating from the magnetized Fe bars. By applying a gate voltage to an interdigitated grating of Fe stripes, the electrons are displaced within the inhomogeneous magnetic stray field and we achieve electric control of the spin precession frequency.

Electric fields can manipulate the electrons spin via the spin-orbit interaction. We present a method that allows the separate determination of both Rashba and Dresselhaus contributions to the effective spin-orbit magnetic field. We use an external a.c. electric field to bring the electrons into an in-plane oscillatory motion. Depending on the orientation of this motion with respect to the crystal lattice, the electrons are subject to a varying spin-orbit magnetic field. By investigating the electron spin precession frequency as a function of their movement direction, the strength of the Rashba and Dresselhaus spin-orbit magnetic fields, and their coupling constants, can be extracted. In another experiment, we use these spin-orbit fields to trigger electron spin resonance with solely electric fields, in this context referred to as "electric–dipole–induced spin resonance".

References:
L. Meier, G. Salis, N. Moll, C. Ellenberger, I. Shorubalko, U. Wahlen, K. Ensslin, E. Gini, "Optimized stray-field-induced enhancement of the electron spin precession by buried Fe gates", Appl. Phys. Lett 91, 162507 (2007).
Lorenz Meier, Gian Salis, Ivan Shorubalko, Emilio Gini, Silke Schön, Klaus Ensslin, "Measurement of Rashba and Dresselhaus spin–orbit magnetic fields", Nature Physics 3, 650– 654 (2007).

SPS Award for Applied Physics, sponsored by OC Oerlikon

Andrea Guarino, of Swiss and Italian nationality, obtained his university degree in nuclear engineering – with mathematical-physical option – at the Politecnico di Milano. With his well equilibrated background in theoretical and applied aspects of science he performed his PhD work in the Nonlinear Optics Group at the ETH in Zürich, dealing with "Electro-optic microring resonators in inorganic crystals for photonic applications". Dr. Guarino is now investing his skills and knowledge into applied projects: he has a "High Power Laser Engineer" position in the R&D Department of the Bookham company in Zürich.

The optical microresonators studied by Dr. Guarino, with the shape of a ring with dimensions of 100 µm, have a light transmission spectrum that can be tuned by the size and the optical properties of the material. Using new technology he has succeeded, for the first time, to produce such resonators made of lithium niobate. This is already a well known and appreciated material for different kinds of optical applications, but Dr. Guarino's innovation consisted in using the "ion slicing" technique in order to put submicrometer thin films of the material onto all kinds of substrates. This allows to produce a large difference in refractive index between the wave guide and the cladding material. This achievement opens fascinating new prospects for integrated nonlinear photonic devices.

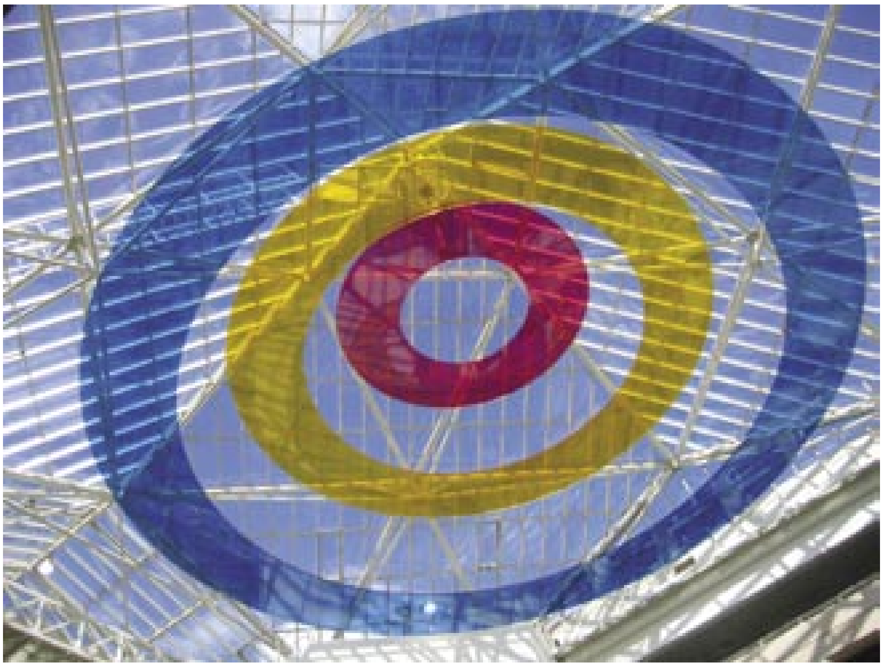
Andrea Guarino says in his CV: "I love physics, optics and technology in general". No doubt he will continue with great enthusiasm to build a bridge between basic quantum physics and useful technological applications.

Electro-optic microring resonators in inorganic crystals for photonic applications.

Optical microring resonators are one of the essential tools for the development of new highly integrated photonic applications. The resonator consists of a waveguide bent in a ring-shape of micrometric size, coupled to an external straight waveguide which carries the light signal to and from the cavity. These resonators can be used as ultrafast compact filters and switches for telecommunication appications, as sensors, or as miniaturized wavelength generators. Very attractive features can be obtained by embedding electrooptical and nonlinear optical properties in the cavity. This work investigates the fabrication of microring resonators in ferroelectric crystals, which have outstanding electro-optical and nonlinear optical coefficients. In particular, the first realization of an electro-optic microring resonator in lithium niobate is presented. The ring is structured on a submicrometric crystalline film of lithium niobate obtained by an improved crystal ion slicing and bonding technique. The slicing of a virgin crystal is obtained by a proper combination of light ion implantation and heat treatment of lithium niobate, whereas the bonding of the thin film on a low-refractive index substrate is ensured by an adhesive polymer. The method allows for high refractive index contrast thin films, the ultimate requirement for ultra-small bent resonators. The preservation of the electro-optical properties of the thin film is shown by tuning the resonance frequency of the resonator by applying an external electrical field.

Reference: A. Guarino et al, Electro-optically tunable microring resonators in lithium niobate, Nature Photonics, 1, p. 407 (2007).

Review of the Annual Meeting 2008 in Genève

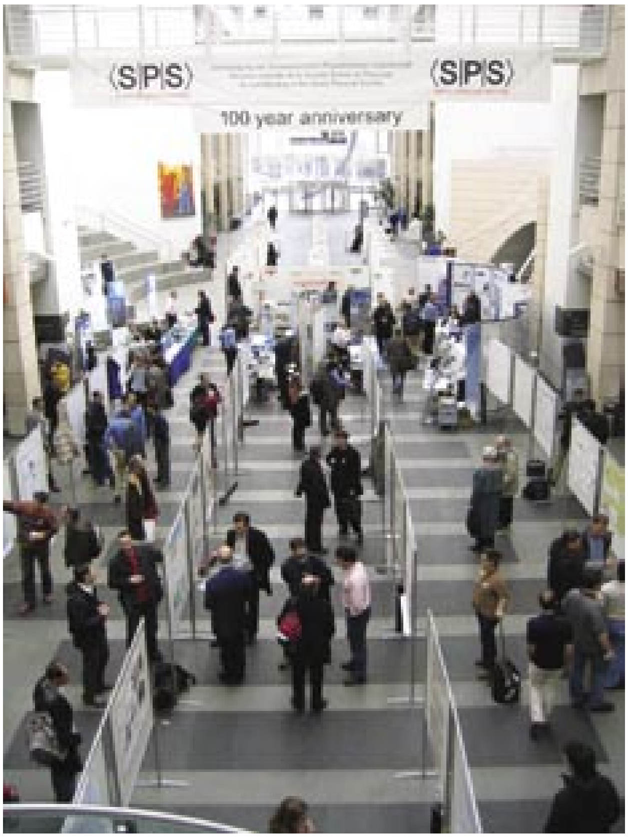


A nice piece of art under the roof of the Uni Mail hall.

This year annual meeting took place on Wednesday 26 - Tuesday 27 March 2008 at the Université de Genève, in the building of Uni Mail. Thanks to the joint organization with the three NCCR programs of MaNEP, NANO and Quantum Photonics about 500 persons attended the meeting. This large number was confirmed by very well attended sessions. The plenary session was a great success with 4 outstanding talks by Tilman Esslinger (ETHZ) on Bose-Einstein Condensation, Christian Schönenberger (UNIBS) on Molecular Electronics, Albert Fert (Université Paris Sud, Nobel laureate 2007) on Spintronics and finally by Gaetano Mileti (UNINE) on recent advances on time and frequency measurements. In addition to the sessions on Astro- Particle and Nuclear Physics (TASK), Condensed Matter Physics (KOND) and Applied Physics (ANDO), sessions on the physics of atoms and lasers, on plasma physics and newly on theoretical physics (cf. below) were organized. Noteworthy was also the program on multiferroics organized within MaNEP jointly with PSI-SLS.

Prof. Albert Fert, Nobel laureate 2007, gave an interesting talk in the plenary session.

The SPS General Assembly took place on Wednesday and the SPS Award Ceremony on Thursday with the attribution of the three 2007 SPS prizes followed by the best papers awards of the "Annales Henri Poincaré" for 2005 and 2006.



The lively poster sessions and the scientific exhibition with 12 companies were located in the large main hall of Uni Mail and professionnally set up by the local organizers. More then hundred participants went to visit the Science History Museum of Geneva on Wednesday night, enjoying the interesting guided tour, the apéro and the beautiful view on the lake.

Then the whole group gathered at the restaurant “Vieux-Bois – Ecole Hotelière” where an excellent dinner was enjoyed in a convivial atmosphere.

We would like to thank here all the organizers of this meeting, the University of Geneva for allowing us to use its lecture halls, the Swiss Academy of Sciences, the Swiss Academy of Engineering Sciences, and the various sponsors (ABB, IBM, OC Oerlikon) who made it possible and successful as it was. We are very grateful to the local organizers of the meeting, in particular Dook van Mechelen and Renald Cartoni who took care with great engagement of all the details.

Summary of the Session "Theoretical Physics"

In the past SPS meetings, theoretical physics has often not had a separate session. Instead, theoretical talks were part of the respective sessions on the different subfields. Theoretical physics research is often located on the boundaries of different subfields, and frequently methods are shared. It was believed that theoretical physics should become an independent session at the SPS meeting. For the session senior speakers from different subfields were invited and young researchers from all areas of theoretical physics encouraged to submit abstracts. As a result, the 'Theoretical Physics' session at SPS 2008 brought together a wide variety of high-quality talks from different subfields.

Invited talks were given by Charalampos Anastasiou (ETHZ) on the upcoming LHC particle physics programme at CERN and by Ruth Durrer (UNIGE) on the status and open questions of precision cosmology. Moreover, the session hosted the invited presentations of the best paper winners of the "Annales Henri Poincaré Prize" for 2005 (A. V. Sobolev) and 2006 (G. Benfatto, A. Giuliani, V. Mastopietro) on developments in mathematical physics.

The winners of the AHP Prizes 2005 and 2006 and two representatives from the Birkhäuser Verlag (left) and Institut Henri Poincaré (right).

In addition to the invited talks, a total of 22 talks by young researchers were presented during the session, with topics from particle theory, astrophysics, cosmology, mathematical physics, complex systems and condensed matter theory. With 25 to 50 people in the audience the whole session was very well attended. It was a unique opportunity to bring together theoretical physics researchers from different subfields and different institutions across Switzerland. Very often, the talks sparked lively discussions, illustrating that theoretical physics research is not restricted to specific subfields.

Thomas Gehrmann, Uni Zürich

Some impressions from the "Musée d'histoire des sciences": Gathering at the entrance and a few exhibits.

The conference dinner took place in the restaurant "Vieux Bois - Ecole Hotelière.

Notes from the General Assembly 2008

The annual assembly of the SPS took place on Wednesday March 26, 2008. After the presentation and acceptation of the financial results 2007 of the Society, the renewal of the committee was next on the agenda. A new member was elected for the committee. Indeed after one-year vacancy a chairman of the condensed matter section was found in the person of Dr. Urs Staub from the PSI in Villigen. At the head of the Society, Dr. Tibor Gyalog and Dr. Christophe Rossel have been reelected by the assembly but will switch function. In order to ensure continuity of the preparation of the 100th Anniversary Ceremony in Bern on June 27, 2008, Tibor Gyalog will remain president until that date. After that Christophe Rossel takes over the presidency and Tibor Gyalog becomes vice-president. All other committee members have been confirmed in their respective position, in particular Dr. Bernhard Braunecker as secretary and Pierangelo Gröning as treasurer for another 2-year term.
Next, information on the planning of the centennial ceremony in Bern was provided followed by the announcement of the date and place of the annual meeting 2009.

New SPS Committee member: Dr. Urs Staub (Condensed Matter Section)

Urs Staub was born in 1964 in Männedorf, Switzerland. In 1989 he received his diploma in Physics from the ETH Zürich. The PhD he obtained in 1993 from the ETH Zürich, with work concerned with the crystalline-electric field in high-T_c superconductors studied with neutrons at the Paul Scherrer Institut. In the years 1993-1994, he worked at Argonne National Laboratory in the f-chemistry group, supported by a grant of the Swiss National Science foundation. There he extended his knowledge on experimental techniques from neutron to x-rays, performing experiments mainly at the National Synchrotron Light Source in Brookhaven and at the Intense Pulsed Neutron Source at Argonne, studying electronic and magnetic properties of cuprates. End of 1994 he returned to Paul Scherrer Institute, where he joined for half a year the Laboratory for Neutron Scattering before he joined the Swiss Light Source Project. Today he still works for the Swiss Light Source, where he built an experimental station for soft x-ray diffraction. His research is concerned with strongly correlated systems, in particular he is interested in the entanglement of charge, magnetic moments and orbitals in materials exhibiting metal-insulator transition or multiferroics.

With pleasure I join the Committee of the Swiss Physical Society as the representative of the Condensed Matter section. Condensed matter remains a very interesting and important field in science, in particular as it links the applied research and development of new technologies with that of fundamental understanding of dynamic and structure of matter and electronic and magnetic processes. It is of crucial relevance for our highly developed country to further strengthen the understanding of processes on the atomic level and in physics in general. I hope that I can contribute to communicate the relevance and needs for this research to society, as well as to our young generation. I also feel that even in a small country as Switzerland, it is important that physicists express there visions and needs in a common way. I therefore hope that ideas from the (condensed matter) physicists will be brought up to me (us) so that the SPG/SPS can be of better help to strengthen physics in Switzerland.

Neue SPG-Reihe: Physik Anekdoten

Mit dieser neuen Reihe möchten wir in loser Folge interessante Ereignisse aus der Physikgeschichte präsentieren. Da die Physik traditionsgemäss Denkanstösse mit den benachbarten Gebieten der Philosophie und der Technik austauscht, werden wir uns auch mit Begebenheiten aus diesem Umfeld auseinandersetzen. Wir denken dabei an das Wirken grosser Naturforscher, an ihre Begegnungen mit interessanten Zeitgenossen, aber auch an ihren Einfluss auf das damalige Zeitgeschehen. Wenn Sie dabei als Autor mitwirken möchten, um z.B. über Aristoteles, Kepler, Newton, Pauli, etc. und ihre Zeit zu berichten, oder auch, um über einen aktuellen, geschichtsrelevanten Anlass einen Artikel zu verfassen, würden wir uns sehr freuen, ihn für die Serie in Betracht zu ziehen. Also, bevor Sie Ihren Beitrag bei ‚Wikipedia' einreichen, kontaktieren Sie bitte jemand aus dem SPG-Vorstand.

Im ersten Beitrag berichten wir über eine Begegnung der besonderen Art von Albert Einstein, der sowohl als Physiker, Philosoph, aber auch als Techniker brillierte. Nachdem die Hektik des Einstein-Jahres abgeklungen ist, kann man sich ihm wieder ungezwungen nähern und bislang unbekannte Tatsachen entdecken. Im Folgenden werden bis anhin vermutlich nicht erkannte Parallelen zwischen Albert Einstein und Heinrich Wild geschildert. Wild gilt als der Pionier der modernen Vermessungstechnik und gründete 1921 die Wild Heerbrugg, die Vorläuferin der heutigen Leica Geosystems AG. Einstein und Wild haben unsere Kenntnisse über die Vermessung der Erde entscheidend beeinflusst, und man fragt sich, ob aufgrund ihrer Gemeinsamkeiten beide Pioniere eventuell sogar im Dialog standen?
Dem Autor Fritz Staudacher sind einige dieser Parallelen schon vor längerer Zeit als Leiter der Kommunikationsabteilung der Leica Geosystems AG in Heerbrugg aufgefallen. Er hatte aber erst nach seiner Pensionierung Zeit, ihnen nachzugehen und in einem Buchprojekt zusammenzufassen [1]. Sein und unser spezieller Dank gilt der Bibliothek der ETHZ für die Überlassung eines sensationellen Fotos.

Bernhard Braunecker, SPG-Sekretär

Neu entdeckte Wild-Einstein-Relation

Albert Einstein und Heinrich Wild, Bundesexperten III. Klasse

Nicht nur beide Relativitäts- und wesentliche Teile der Quantentheorien nahmen vor einem Jahrhundert in der Schweizer Bundeshauptstadt Bern ihren weltweiten Anfang, sondern auch die modernen Technologien der Erd- und Landesvermessung. Der als Bundesexperte III. Klasse in der Eidgenössischen Landestopographie tätige Heinrich Wild (1877-1951) verbesserte mit seinen neuartigen optisch-mechanischen Instrumentenkonstruktionen die Vermessung und Kartierung der Erde. Der zur gleichen Zeit im Eidgenössischen Patentamt ebenfalls als Bundesexperte III. Klasse tätige Albert Einstein (1879-1955) schuf mit seinen Theorien die Grundlagen für die heutigen Laser-, GPS- und Digitalsensor-Vermessungstechnologien.

Einstein und Wild schrieben damit völlig unabhängig voneinander vor einem Jahrhundert ein zentrales Kapitel der Vermessungsgeschichte neu. Doch so unglaublich es klingen mag: trotz zahlreicher verblüffender biografischer Parallelen – einschliesslich gleicher Wohnorte und Arbeitswege – kannten sich gemäss den bisher bekannten Dokumenten diese beiden Koryphäen ihrer Gebiete anscheinend nicht einmal. Oder vielleicht doch?

Gleichzeitig an Zürcher Hochschulen, in Bern und in Deutschland

Wie Albert Einstein hatte sein zwei Jahre älterer Zeitgenosse Heinrich Wild die Schule vorzeitig verlassen und sich wie Einstein im Jahre 1896 an einer Zürcher Technischen Hochschule zum Studium eingeschrieben; wie Einstein arbeitete Wild vor einem Jahrhundert als Bundesbeamter III. Klasse in Berner Amtsstuben und entwickelte hier bahnbrechende neue Ideen; wie Einstein heiratete Wild als 23jähriger in Bern, wohnte mit seiner Familie zur selben Zeit wie Einstein in der Berner Thunstrasse und verliess sieben Jahre später, genau wie der Patentbeamte Einstein, die Schweizer Bundeshauptstadt als genau Dreissigjähriger; folgte wie Einstein schon vor Ausbruch des Ersten Weltkrieges einem beruflichen Ruf nach Deutschland und lebte auch während der Hungerzeit des eisigen „Kohlrübenwinters“ und dem Zusammenbruch des Deutschen Kaiserreiches dort; wie beim Nobelpreisträger Albert Einstein wurden die Leistungen Heinrich Wilds im Jahr 1930 von der Eidgenössischen Technischen Hochschule Zürich mit der Auszeichnung zum Doktor 'honoris causa' gewürdigt.

Albert Einstein: Physiker und Kreiselkompass-Konstrukteur

Immer wieder beeinflussten Landvermesser und Mathematiker mit ihrem Wissen Einsteins Theorien. Grossen Einfluss auf Einsteins Gedankenwelt und speziell auf die Relativitätstheorie hatten bereits in Zürich und Bern die Arbeiten von Henri Poincaré. Dieser Physiker und Mathematiker war Direktor des weltbekannten Büros der Länge in Sèvres, dessen Urmeter auf Meridianberechnungen der französischen Geometer beruhte. Die mathematische Formulierung der Relativitätstheorie gelang Einstein durch Verwendung von Ansätzen aus der Nicht-Euklidschen Theorie gekrümmter Räume des Mathematikers und Landvermessers Carl Friedrich Gauss. Doch reichen Einsteins Beziehungen zur Vermessung weit über die theoretischen Aufgaben des Universitätsphysikers hinaus. Als Instrumentenkonstrukteur entwickelte er ein Kreiselkompassgerät, das auf seinen Namen patentiert war und in Kiel in so grosser Anzahl gefertigt wurde, dass es ihm beträchtliche Einnahmen bescherte. Einstein war so fasziniert von der Entwicklung, dass er nicht nur 1915 die Arbeiten an der Allgemeinen Relativitätstheorie unterbrach, sondern auch das Funktionsprinzip des Kreisels als Modell seiner atomaren Beschreibung des Permanentmagnetismus benutzte [2].

Heinrich Wild: Vermessungsgeräte-Konstrukteur und Unternehmer

Mit seinen wesentlich verkleinerten und verbesserten Vermessungsgeräten war Heinrich Wild nicht nur der geniale Erfinder technischer Innovationen, sondern auch der Generator wirtschaftlicher Organisationen. Wie niemand sonst gestaltete und prägte er alle drei bedeutendsten Unternehmen des Vermessungs- und Photogrammetrie-Gerätebaus des 20. Jahrhunderts und damit die Welt der Erdvermesser bis hin zur Satellitentechnik. So baute er bereits 1908 in Deutschland bei Zeiss in Jena die Abteilung Geodäsie auf, gründete 1921 in der Schweiz mit zwei Partnern sein eigenes Unternehmen, die heutige Leica Geosystems, und initiierte später auch noch bei der Firma Kern in Aarau den Photogrammetriegerätebau, sowie eine neue Generation geodätischer Instrumente. In ihrem Nachruf bezeichnete eine deutsche Fachzeitschrift den Schweizer Heinrich Wild als den „bedeutendsten Konstrukteur geodätischer Instrumente, der jemals gelebt hat“ [3].

Weltweite Bedeutung und Marktführerschaft

Mit ihren Landeskarten und Gebirgsdarstellungen bis hin zum Mt. Everest geniesst die Schweizer Kartographie einen international erstklassigen Ruf. In der Fachwelt behaupten seit Wilds Erfindungen Schweizer Vermessungsinstrumente ein Hochleistungs-Image und die internationale Marktführerschaft. Während diese rein optisch-mechanisch realisierten Erfindungen die erste Hälfte des letzten Jahrhunderts prägten, waren es ab der zweiten Jahrhunderthälfte die von Physikern auf der Basis von Einsteins Photoeffekt entwickelten und in Wilds Basiskonstruktionen integrierten Laser- und Digitalsensor-Technologien, sowie die mit relativistischen Korrekturen versehenen GPS-Systeme [4].

Erst jetzt wurde aufgrund meiner Recherchen im ETH-Archiv eine Fotografie entdeckt, die diese beiden Initianten der Entwicklung der modernen Vermessungstechnologien auf einem Bild dokumentiert. Diese bis anhin auch Einstein-Connaisseurs unbekannte Aufnahme zeigt die beiden Schweizer inmitten anderer Laureaten beim Festakt der Eidgenössischen Technischen Hochschule Zürich am 7. November 1930 als frisch gewürdigte ETH-Ehrendoktoren. Diese Fotografie illustriert den Kulminationspunkt einer verblüffenden dreissigjährigen Parallelität zwischen Einstein und Wild. Leider nicht zu finden war bis jetzt eine von Heinrich Wild während der gemeinsamen Berner Jahre auf dem Amt für geistiges Eigentum eingereichte Patentschrift, die von Albert Einstein geprüft worden wäre.
Es ist schon beachtlich, was vor einem Jahrhundert in Bern geschah: Die Weiterentwicklungen der Erkenntnisse Einsteins und der Schöpfungen Heinrich Wilds verbesserten unser Wissen und unsere Orientierung auf der Erde, aber auch auf dem Mond und im Weltraum. Die grössten Gipfel der Kontinente tragen ebenso das Mass der aus ihren Theorien und Konstruktionen entwickelten Instrumente, wie die bedeutendsten Bauwerke des 20. Jahrhunderts und zahlreiche Landeskarten rund um den Globus.

Fritz Staudacher

Heinrich Wild

Albert Einstein *Othmar Amman*

Foto: © Bildarchiv ETH-Bibliothek [m]

Einstein, Ammann und Wild vor 77 Jahren

Dieses neu entdeckte Bild zeigt im Ausschnitt den Nobelpreisträger Albert Einstein als 51-jährigen, zusammen mit weiteren ETH-Ehrendoktoren des Jahres 1930. Es wurde am 7. November 1930 im Stadttheater Zürich anlässlich des Festaktes zum 75-jährigen Jubiläum der Eidgenössischen Technischen Hochschule aufgenommen. Das Kuvert eines Kinderbriefes an Einstein war einmal mit „Chefkonstrukteur des Universums" angeschrieben: auf diesem Bildausschnitt ist der Nobelpreisträger zusammen mit dem Chefkonstrukteur der Vermessungswelt (Wild) und dem Chefkonstrukteur des Brückenbaus (Ammann) zu sehen. Zwischen Albert Einstein (links unten) und Heinrich Wild (rechts oben) bildet in der ersten Reihe (dritter von rechts) der Konstrukteur der New Yorker George-Washington-Bridge Othmar Ammann gewissermassen visuell einen „Brückenpfeiler". Es ist das einzige gemeinsame Bild dieser weltbekannten Schweizer Einstein, Ammann und Wild – ein historisches Zeugnis dreier grosser internationaler „Chefkonstrukteure".

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[2] Peter Galison, Harvard University, “Jubiläumsfeier 150 Jahre ETH Zürich“, Zürich, 21. April 2005
[3] Edwin Berchtold, Allgemeine Vermessungs-Nachrichten AVN 1953, Nr.3 (17578)
[4] **GPS: Relativistische Effekte**

GPS Satelliten bewegen sich mit v = 3’880 m/s in einem Orbit mit Radius r_S = 26’000 km.
Gemäss Spezieller Relativitätstheorie (SR) führt dies zu einer Zeitkorrektur

$$\Delta t/ \Delta t' = \sqrt{1 - v^2/c^2} = 1 - 0.835 \times 10^{-10};$$

Gemäss Allgemeiner Relativitätstheorie (AR) zu

$$\Delta t/ \Delta t' = 1 + \Delta U/c^2 = 1 + 5.28 \times 10^{-10};$$

wobei $\Delta U = G M^*(1/r_E - 1/r_S)$ mit r_S = 26’000 km; r_E = 6’378 km und $G M = 3.986 \times 10^{14}\ m^3/s^2$ ist.

Die Uhr geht somit im Tag gemäss SR um 7.2 µs nach, bzw. gemäss AR um 45.9 µs vor. In 38.7 µs fliegen die Satelliten 15 cm weit, und die Erde dreht sich am Äquator um 17 mm. Ohne Einsteins Korrekturen wäre daher das System innerhalb von wenigen Tagen unbrauchbar!

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Progress in Physics (5)

Electronic Structure of Quasicrystals

Pierangelo Gröning, EMPA Thun

Since their first public report by the end of 1984 [1], quasicrystals (QCs) have attracted a lot of scientific interest due to their extraordinary crystal structure and their unusual physical properties. QCs are characterized by the absence of translational symmetry, however in combination with a well defined atomic arrangement and rotational symmetry, which situates this class of materials between crystalline and disordered solids. QCs exhibit very particular mechanical, magnetic, electronic transport and surface properties, which have been partly associated whit the aperiodic atomic structure. The aperiodicity of QCs has triggered particular interest with regard to the valence electronic structure as the Bloch Theorem, fundamental to the electron band picture of classical crystalline solids, cannot be applied anymore and the concept of a well defined Brillouin zone and associated zone-folding breaks down. It has been suggested by theory that the valence electron states of QC should exhibit, due to the absence of translational symmetry, a new character lying in between the extended states of a classical periodic crystal and the localized states of a random atomic arrangement [2]. These new class of states was denoted as "critical states", neither being extended nor localized. Associated with these critical states a so-called "spiky" density of states (DOS) was postulated showing a fractal-like appearance of peaks and pseudo gaps. However this spiky DOS could not be corroborated by experiments.

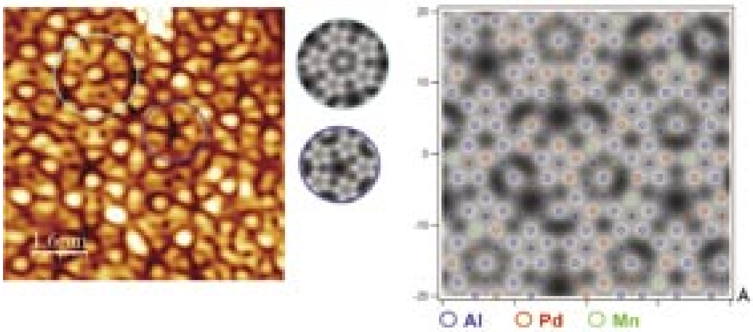

Figure 1

a) High-resolution STM image of the 5-fold surface of icosahedral $Al_{70}Pd_{21}Mn_9$.

b) Model structure according to the Kastner-Papadopolos model. Characteristic features being the "white flower" (deep blue circle) and the "starfish" (light blue circle) have been highlighted and compared to the structure model.

We have to best of our knowledge for the first time investigated the local density of states (LDOS) of different QCs using low temperature (5.3 K) Scanning Tunnelling Spectroscopy (STS) with sub-nanometer resolution. Figure 2 shows differential conductance spectra measured at different positions in the "starfish" region (Fig.1). The spectra show a clear variability in peak and pseudogap position in this very small 2 nm wide area. In general we observe peaks in the LDOS of 30-50 meV FWHM confined to regions of 1 nm or less. We think that this is a strong indication of the spiky DOS predicted by the theory, which has not been observed before as the spiky aspect is lost when the LDOS is averaged over surface areas as small as some tens nm^2.

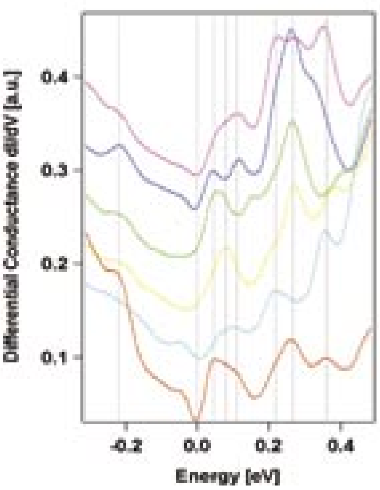

Figure 2

Differential conductance spectra (dI/dV vs. bias voltage) measured on 6 positions (central star + 5 surrounding pentagons) in the so-called "starfish" structure (Fig. 1).

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Progress in Physics (6)

Science Opportunities at the Proposed PSI-XFEL

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The Paul Scherrer Institut is planning the construction of an X-ray Free Electron Laser. The PSI-XFEL will produce 60 fs pulses of coherent X-rays in the wavelength range 0.1 – 10 nm, with a peak brightness approximately 10^{10} times that of a third-generation synchrotron. The brightness, coherence and short pulses provide opportunities for performing novel science in the fields of chemistry, biochemistry, solid state physics and materials science. The PSI-XFEL could be operational in the year 2016.

What is an XFEL, and how is the PSI-XFEL special?

The active medium in an X-ray free electron laser consists of a 100 femtosecond pulse of 10^9 relativistic electrons moving in the sinusoidal field of an undulator: a periodic linear array of alternately-poled permanent magnets. As in a synchrotron light source, the transverse acceleration from the Lorentz force causes the electrons to emit X-radiation, but in an XFEL, the undulator is sufficiently long that the growing radiation field influences the trajectory of the electrons. At the "resonance condition", where the radiation overtakes an electron by exactly one wavelength per undulator period, certain of the electrons gain energy and others lose energy, thus splitting the pulse into 10^5 "microbunches". As it moves along the undulator, the microbunched electron pulse then radiates as if it were a single charge of 10^9 e, producing an intense, coherent pulse of "superradiant" X-rays.

Besides the PSI-XFEL there are presently three other projected XFELs worldwide: in Stanford, USA (2009), Hyogo, Japan (2011) and Hamburg, Germany (2014). The maximum electron energy and hence the overall XFEL length (800 m) are significantly lower at PSI than for the other projects. This is made possible by PSI innovations in the high-brightness electron source technology, including nanometer-scale field-emitting tips and initial acceleration in a pulsed field of 1 MV across a 4 mm gap, followed by a novel two-frequency RF-cavity. The individual X-ray pulses will be very similar to those of the larger projects (see Table 1). While the Swiss, US and Japanese XFELs will emit 60-120 pulses per second, the Hamburg machine, due to the use of superconducting accelerator technology, will produce 10 trains of 3000 pulses per second, with a minimum pulse spacing of 200 ns.

With sufficient resources, the PSI-XFEL could have enhanced capabilities which are not presently foreseen at the other projects. These include: rapid tuning of the XFEL wavelength for spectroscopic investigations, the option of circular polarization for magnetic studies, additional beams of pulsed, broadband spontaneous radiation for time-resolved Laue crystallography and wavelength-dispersive spectroscopy, extension of the maximum photon energy to the ultra-narrow Mössbauer resonance of ^{57}Fe at 14.4 keV, and modification of the electron pulses by "seeding" and / or "slicing" to yield substantially narrower spectral widths and / or pulse lengths than those given in the Table. Rapid switching of the electrons will allow the simultaneous operation of three PSI-XFEL branches, covering the photon energies 12.4 – 4.0, 4.4 – 0.4 and 1.2 – 0.13 keV.

Table 1: PSI-XFEL specifications

Maximum electron energy	6 GeV
Photon wavelength	0.1 – 10 nm
Photon pulse length (FWHM)	60 fs
Spectral width (FWHM)	0.1 – 0.9 %
Beam size at undulator exit (FWHM)	25 – 35 μm
Peak brilliance	10^{33} – 10^{31} ph/s/mm^2/mrad^2/0.1 % bw
Flux	2 x 10^{11} – 5 x 10^{12} ph/pulse
Pulse repetition rate	100 Hz

Proposed applications

The bright pulses and high degree of coherence of the XFEL radiation will allow time-resolved lensless imaging to be performed on a variety of systems, including ferroelectric and magnetic domains in thin films, biomolecular conformations in solution and molecular diffusion on surfaces. Time-dependent changes can be triggered by a switched electric or magnetic field (see Fig. 1) or by a fs optical laser pulse which is synchronized to the X-ray pulse. On the other hand, *equilibrium* fluctuations on the fs – ns time scale can be studied as a function of wavevector using X-ray Photon Correlation Spectroscopy [3]. All of these techniques require the rapid collection of high-resolution 2D-images and the stepwise variation of a pulse delay. Furthermore, the excited sample must relax to equilibrium before the next pump-probe cycle is initiated. Such processes are compatible with the 100 Hz repetition rate of the PSI-XFEL.

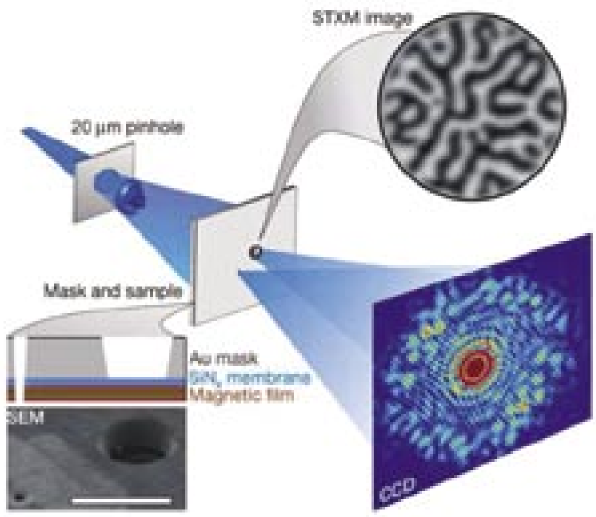

Fig. 1: Static holographic imaging of the sub-µm domain structure in a thin magnetic film, performed at the BESSY synchrotron. Magnetic contrast is provided by using circularly-polarized X-rays at the L_3 absorption edge of the magnetic Co ion. At the XFEL, such a pattern can be measured with a single X-ray pulse, allowing sub-ps pump-probe studies of magnetization dynamics.
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With a tunable XFEL wavelength, X-ray absorption spectroscopy (XAS) can also be used to follow a time-dependent process. For example, it is proposed that a chemical reaction be "gently" initiated on a catalytic surface by using a sub-ps pulse of coherent terahertz radiation [4]. After a variable time delay, the chemical or electronic environment of the reactive species is determined by near-edge (XANES) or far-edge (EXAFS) absorption spectroscopy. It is also foreseen to use time-resolved pump-probe XAS to follow laser-initiated photo-chemical reactions in solution [5].

The time-dependent behavior of solid materials following excitation by a sub-ps laser pulse is a wide field of inquiry, including topics such as non-equilibrium melting, the coherent creation and control of phonons, local structural changes upon the photo-excitation of chromophores, etc. Since the advent of "sliced" synchrotron beams, sub-ps X-ray pulses [6-8] have become available, albeit with very low intensities. At the sliced "FEMTO" beamline of the Swiss Light Source, it has been possible to coherently create and control phonons in a bismuth crystal [8]. Because the PSI-XFEL will deliver vastly more photons per pulse, such pump-probe experiments in solids will become orders of magnitude easier to perform.

The XFEL will also provide several new tools to biochemists. The time-dependent behavior of photosensitive biomolecules in crystalline form can be studied by time-resolved, pump-probe Laue crystallography. Using isolated, 100 ps pulses at a synchrotron, structural changes accompanying the photodetachment of CO from the heme group in myoglobin have been recorded in the ns – µs regime [9] (see Fig. 2). With spontaneous radiation from an incoherent undulator downstream from the XFEL, the same number of broad-bandwidth photons now available in a 100 ps synchrotron pulse will be available in a 100 fs pulse, thus extending time-resolved Laue crystallography into the sub-ps regime.

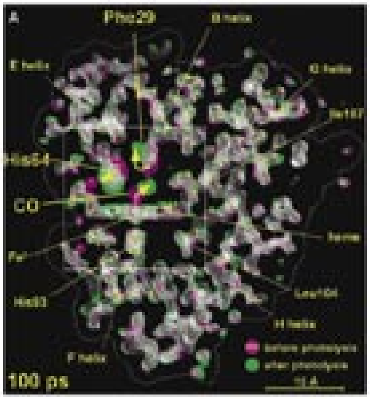

Fig. 2: A comparison of the local structure of a myoglobin molecule before and after the photodetachment of CO from the heme group, produced using 100 ps time-resolved Laue crystallography. The PSI-XFEL, with an additional spontaneous undulator, will extend such investigations to the sub-ps regime.
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The "holy grail" of XFEL-based structural biology is the structural determination, with atomic resolution, of large, *individual* biomolecules, without the requirement of crystallization. Indeed, the highly-important membrane proteins can generally not be crystallized, and hence their structures remain largely unknown. It is proposed that the hard X-ray XFEL beam be focused down to 100 nm, and that individual protein molecules be synchronously injected, one-by-one, into the XFEL pulses. Of course, the intense X-ray pulse will quickly destroy the molecule (see Fig. 3), but from sliced pulses shorter than several fs, sufficient scattered photons may possibly be obtained to allow a structural determination. Even with the XFEL in operation, many hurdles must be overcome before this goal can be achieved: pulse shaping and focusing, particle preparation and injection, data collection and, importantly, combining the data from many individual, randomly-oriented molecules.

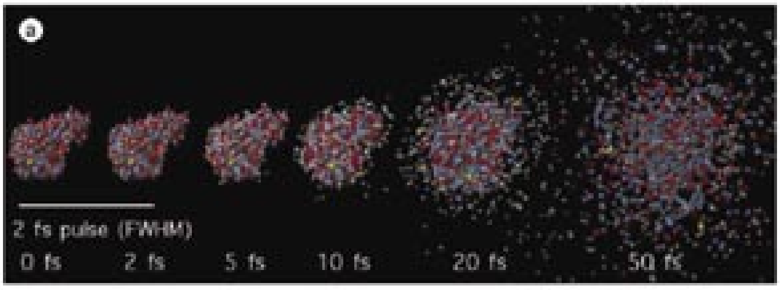

Fig. 3: The simulated "Coulomb explosion" of a protein molecule in a 2-fs XFEL pulse. Scattered photons yield information on the unperturbed molecule.
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Conclusion

The qualitative advances in performance by an X-ray free electron laser over all existing X-ray sources make accurate predictions of the relevant photon-matter interactions difficult. Nonetheless, novel science will certainly be made possible by the enormous increases in peak brightness, coherence and time resolution. The Paul Scherrer Institut welcomes input from interested parties inside and outside of Switzerland regarding the conceptual design of the PSI-XFEL facility.

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Pre-Announcement: Annual meeting 2009

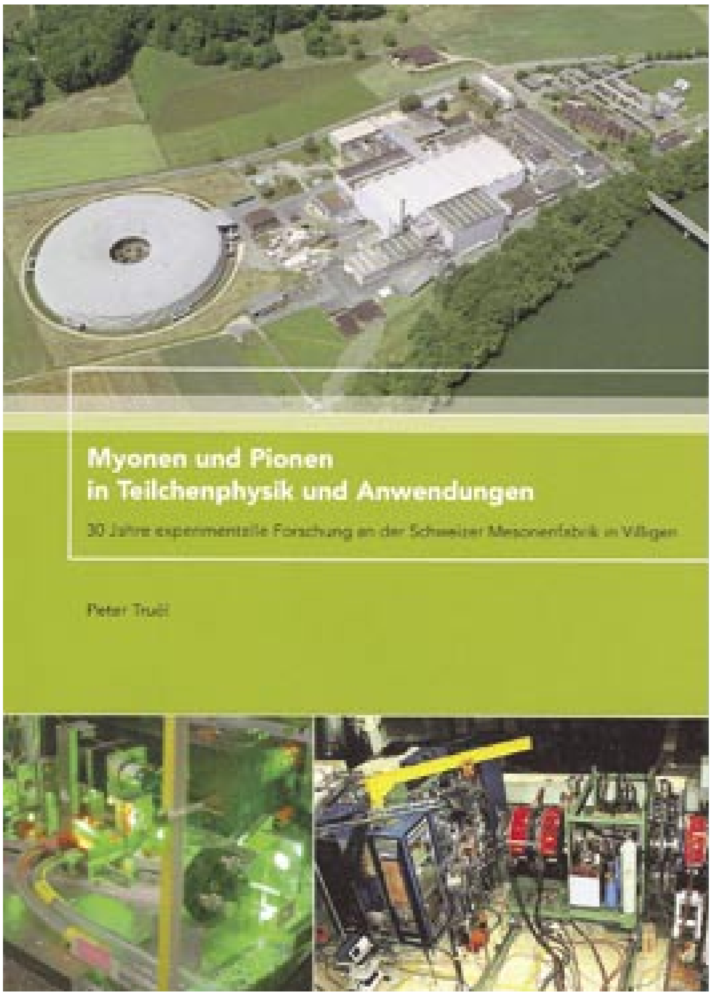
The next annual meeting of the SPS in 2009 will be organised jointly with the Austrian Physical Society (ÖPG). It will take place in the first week of September 2009 in Innsbruck. We decided on this exception from the "spring meeting routine" to ensure that both societies are able to mobilize their members to participate without time-conflicts, since Austria's and Switzerland's semester periods are not the same.

Myonen und Pionen in Teilchenphysik und Anwendungen

30 Jahre experimentelle Forschung an der Schweizer Mesonenfabrik in Villigen

Prof. Dr. Peter Truöl, Physik-Institut der Universität Zürich

Die Naturforschende Gesellschaft Zürich hat ihr diesjähriges Neujahrsblatt zum 20-Jahr Jubiläum des Paul Scherrer Institutes (PSI) der PSI-Elementarteilchenforschung gewidmet. Es gibt eine Übersicht über die experimentelle Forschung am 590 MeV-Protonen-Ringbeschleuniger seit 1977, die wegen ihrer Präzision massgebend zur Entwicklung der Teilchenphysik beigetragen hat. Der Protonen-Beschleuniger am PSI ist zu einem der intensivsten der Welt geworden, was - begleitet von kontinuierlicher Verbesserung der anspruchsvollen Detektortechnologie - eine grosse Zahl von Experimenten durchzuführen erlaubte, die wesentliche Aussagen über die fundamentalen Wechselwirkungen und Eigenschaften von Pionen und Myonen lieferten.



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