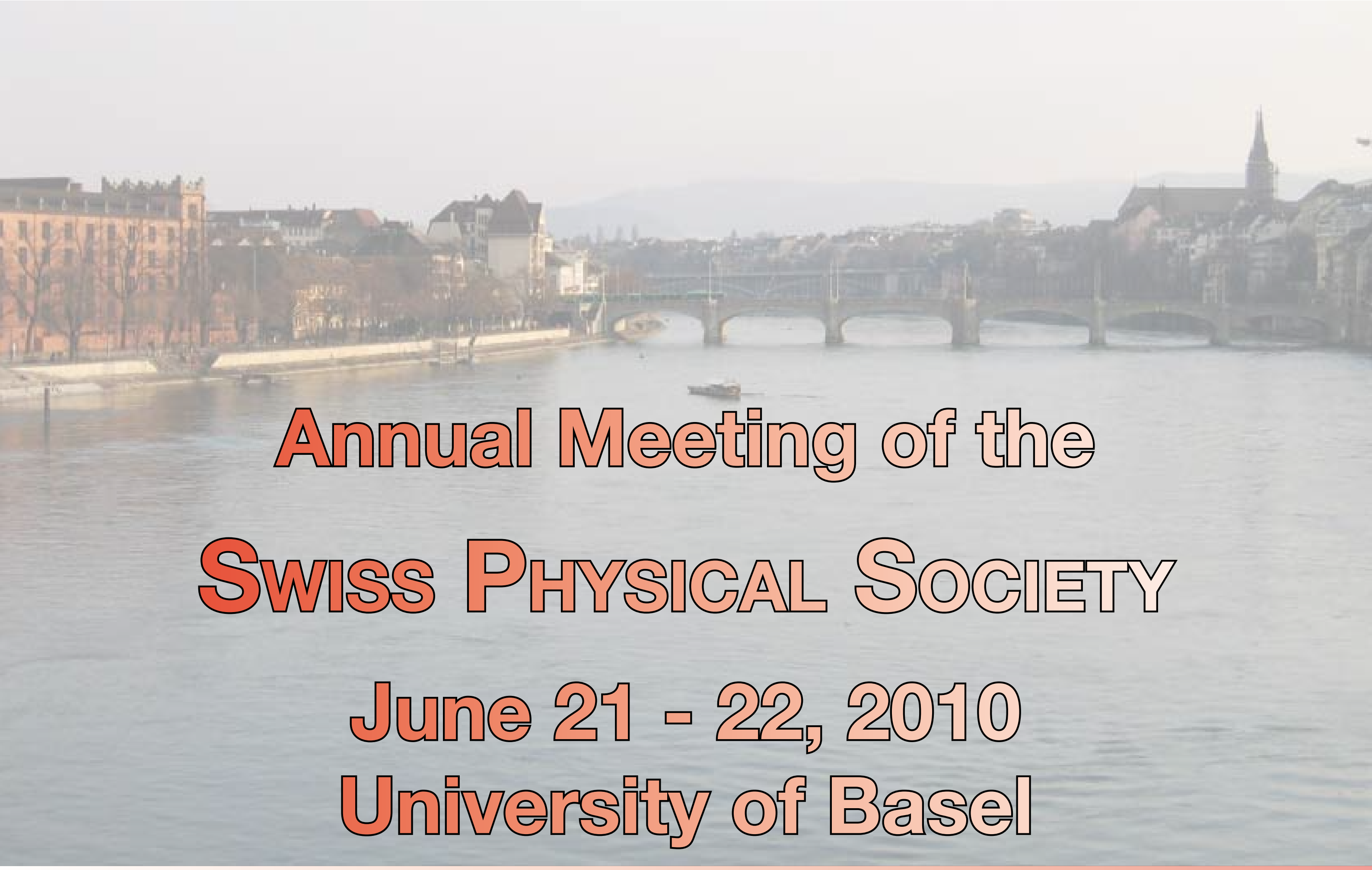
Nr. 30
Januar 2010

swiss physical society

SPG MITTEILUNGEN
COMMUNICATIONS DE LA SSP



Annual Meeting of the Swiss Physical Society

June 21 - 22, 2010
University of Basel

Call for Abstracts:
Submission Deadline March 15, 2010

Detailed information on page 3

Inhalt - Contenu - Contents

Vorstandsmitglieder der SPG / Membres du Comité de la SSP

Präsident / Président
Dr. Christophe Rossel, IBM Rüschlikon, **rsl@zurich.ibm.com**

Vize-Präsident / Vice-Président
Prof. Ulrich Straumann, Uni Zürich, **strauman@physik.uzh.ch**

Sekretär / Secrétaire
Dr. Bernhard Braunecker, Braunecker Engineering GmbH, **braunecker@bluewin.ch**

Kassier / Trésorier
Dr. Pierangelo Gröning, EMPA Thun, **pierangelo.groening@empa.ch**

Kondensierte Materie / Matière Condensée (KOND)
Dr. Urs Staub, PSI, **urs.staub@psi.ch**

Angewandte Physik / Physique Appliquée (ANDO)
Dr. Ivo Furno, EPFL-CRPP, **ivo.furno@epfl.ch**

Astrophysik, Kern- und Teilchenphysik / Astrophysique, physique nucléaire et corp. (TASK)
Dr. Klaus Kirch, PSI Villigen, **klaus.kirch@psi.ch**

Theoretische Physik / Physique Théorique (THEO)
Prof. Dionys Baeriswil, Uni Fribourg, **dionys.baeriswyl@unifr.ch**

Physik in der Industrie / Physique dans l'industrie
Dr. Kai Hencken, ABB Dättwil, **kai.hencken@ch.abb.com**

Atomphysik und Quantenoptik / Physique Atomique et Optique Quantique
Prof. Antoine Weis, Uni Fribourg, **antoine.weis@unifr.ch**

Physikausbildung und -förderung / Education et encouragement à la physique
Dr. Tibor Gyalog, Uni Basel, **tibor.gyalog@unibas.ch**

SPG Sekretariate / Secrétariats de la SSP

Mitgliederverwaltung, Webseite, Druck, Versand, Redaktion Bulletin & SPG Mitteilungen / Service des membres, internet, impression, envoi, rédaction Bulletin & Communications de la SSP
S. Albietz, SPG Sekretariat, Departement Physik, Klingelbergstrasse 82, CH-4056 Basel
Tel. 061 / 267 36 86, Fax 061 / 267 37 84, **sps@unibas.ch**

Buchhaltung / Service de la comptabilité
F. Erkadoo, SPG Sekretariat, Departement Physik, Klingelbergstrasse 82, CH-4056 Basel
Tel. 061 / 267 37 50, Fax 061 / 267 13 49, **francois.erkadoo@unibas.ch**

Administratives Sekretariat / Secrétariat admin.
Susanne Johner, **SJO@zurich.ibm.com**

Impressum:

Die SPG Mitteilungen erscheinen ca. 2-4 mal jährlich und werden an alle Mitglieder sowie weitere Interessierte abgegeben.

Verlag und Redaktion:
Schweizerische Physikalische Gesellschaft
Klingelbergstr. 82, CH-4056 Basel
sps@unibas.ch, www.sps.ch

Redaktionelle Beiträge und Inserate sind willkommen, bitte wenden Sie sich an die obige Adresse.

Druck:
Werner Druck AG, Kanonengasse 32, 4001 Basel

sc | nat
Member of the Swiss Academy of Sciences

SATW
Schweizerische Akademie der Technischen Wissenschaften
Académie suisse des sciences techniques
Accademia svizzera delle scienze tecniche
Swiss Academy of Engineering Sciences

Annual Meeting of the SPS
June 21 - 22, 2010 ; Universität Basel

The SPS will hold its annual meeting 2010 together with the three NCCRs and the "Polymers and Colloids" division of the Swiss Chemical Society in the "Kollegienhaus" of the University of Basel. We are happy that our SPS-board member Tibor Gyalog will lead the local organization team.

Scientific Program

Plenary Session
Six plenary talks will present latest advancements and highlights in their fields of research. The sessions are in the mornings. (Titles are tentative.)

- Felicitas Pauss (CERN): *News from LHC*
- Gerd Leuchs (MPI Erlangen): *50 years Laser*
- Martino Poggio (Uni Basel): *Probing Quantum States Using Ultrasensitive Micro- and Nanomechanical Resonators*
- Vincenzo Savona (EPFL): *Polaritons: Bose-Einstein condensation and quantum correlations in semiconductors*
- NN *(for POLYCOLL)*
- NN *(for NCCR MaNEP)*

Topical Sessions
These parallel sessions will be held in the afternoons:

- Applied Physics
- Astro-, Particle- and Nuclear Physics
- Biophysics
- History of Physics
- Modeling in Material Science
- NCCR MaNEP
- NCCR Nano
- NCCR Quantum Photonics
- Physics and Sustainable Energy
- POLYCOLL (Polymers and Colloids)
- Schülerinnen- und Schülernachmittag

Dependent on the number and contents of the contributed papers, each topical session will be split into special thematic subsessions.

Vendors Exhibition

In parallel to the conference a vendors exhibition will take place. A separate letter will be mailed to interested companies in the next weeks to invite them to join in the meeting. If your company wants to participate, but did not receive a letter from us by end of March, please send an email to: sps@unibas.ch

General Assembly

The general assembly is scheduled for June 22, 2010. The agenda will be released in the next issue of the SPS Communications. We encourage all members to actively participate and contact the committee if you would like to see special topics on the agenda.

Award Ceremony

The award ceremony will be held on June 22, 2010.

Three outstanding scientific works will be honoured as every year by the SPS awards, in the fields of General Physics (sponsored by ABB Research Center), Condensed Matter Physics (sponsored by IBM Zürich Research Laboratory), and Applied Physics (sponsored by OC Oerlikon), each granted with CHF 5000.- .

In the frame of the ceremony we will also acknowledge new honorary members of the SPS.

Poster Session and Conference Dinner

The poster session will be held in the evening of June 21st, as an exciting scientific and social event: Starting with an apéro, the poster presentation of the scientific ideas should stimulate new contacts, which can be further intensified afterwards at a grillparty, most appropriate for the summertime.
The maximum poster size is A0 (portrait).

The conference fee includes food and drinks (see below). On June 22, the poster session will be continued during lunchbreak. A buffet will be available.

Abstract Submission

You can submit abstracts for all topical sessions (see above). Oral and poster contributions are welcome. Because of the limited number of time-slots the session organizers may have to change some oral presentations into posters. If possible, please mark both options in your submission.

The submission of abstracts is done online. Visit our webpage www.sps.ch and follow the link to the submission form. Further explanations are available there.

The full conference program will be available on www.sps.ch in May 2010.

IMPORTANT: The submission deadline for abstracts is March 15, 2010 !

Conference Fees, Registration and Payment

The conference fees cover the participation to all sessions, including coffee breaks (both days), apéro and grillparty on Monday and the lunchbuffet on Tuesday (no "one-day tickets").

Pay your conference fee in time and save money !

The regular prices, as shown in the table below, are valid for payments reaching us before June 1st, 2010. Please make sure that your name and the purpose of the payment are indicated.
Payments can be made to the following account:
Swiss Post - Postfinance, Account 80-8738-5, for Swiss Physical Society, 4056 Basel

Category (all prices in CHF):	*Regular*
SPS members	110.-
Students / Ph.D. Students (*)	80.-
Plenary / invited speakers, awardees	0.-
Other persons	130.-
"Not yet" members special offer (see below)	140.-
Teachers (**)	50.-

(*) Students licence required
(**) only for the session "Schülernachmittag" (apéro / grillparty NOT included), otherwise regular fees apply.

For payments made later than June 1st you have to add a surcharge of CHF 20.-. This applies also for participants paying cash at the conference. Credit cards are not accepted. Attention: Fees are not refundable in case of cancellation.

Registration Deadline: June 1st, 2010

Registration is also done completely online on *www.sps.ch*. The only exception is the admission form for new members, see below.

Group registrations

If several members (≥ 4) of your group or laboratory want to participate in our meeting, you don't have to fill out the online registration form for every person. Please contact the SPS-Secretariat (*sps@unibas.ch*). We will then send you a special electronic form where you can insert the necessary data.

Special offer for non-members:

Do you plan to participate in our meeting and want also to become a member of the SPS ? You can do so now for a very reduced price of only CHF 140.- (CHF 160.- after June 1st) ! This amount covers the conference fee and your new SPS membership for 2010. Do not miss this offer !
Just fill out the online-registration form, choose the option "Special offer", then download, print, fill and sign the admission form for new members, and return it as soon as possible by fax or ordinary mail.

(This offer does not apply for students and Ph.D. students. They still profit from the free first-year-membership and have only to pay the conference fee shown above. The membership admission form is available on www.sps.ch/uploads/media/anmeldeformular_d-f-e.pdf .)

Additional information for selected sessions

Biophysics

Biophysics applies the principles of physics and chemistry, in combination with mathematical analysis and computer modeling, to understand how biological systems work. Biophysical research is thus aimed at explaining biological functions by defining the underlying molecular mechanisms of the key players, biomolecules. One of the central questions is "How do individual molecules cooperate to fulfil complex biological functions?". Towards this goal, understanding the functional interactions between individual molecules is crucial, and visualizing structures of functional units of biomolecules with increasing degree of complexity is a central challenge. Structural approaches cover a large range of length scales, from structures of individual molecules or small assemblies at atomic resolution to lower resolution structures of large assemblies. The development of novel experimental approaches and the advancement of existing techniques are key to progress in biophysics. New developments in microscopy have expanded the possibilities to study interactions of biomolecules and structures of large assemblies. A growing branch of biophysics addresses nano-manipulation. Here, the expanding knowledge on building and working principles of large molecular machines is applied to generate (functional) nanostructures by directed assembly. This session will provide an overview about the current status of biophysical research and its recent achievements.

Contact: Dagmar Klostermeier, Uni Basel (dagmar.klostermeier@unibas.ch)

Geschichte der Physik - Histoire de la Physique

An der SPG Jahrestagung 2009 in Innsbruck wurde auch eine eigene Session "Geschichte der Physik" durchgeführt, die sehr gut besucht war und aufschlussreiche Ereignisse aus der Physik- und Technikgeschichte präsentierte. Erfreulich war die Teilnahme vieler junger Physikerinnen und Physiker, aber auch von Amateurhistorikern. Diese positive Erfahrung bewog uns, an der kommenden Generalversammlung während der SPG-Jahrestagung 2010 am 21/22.Juni in Basel die Gründung einer SPG-Sektion "Geschichte der Physik" zu beantragen. Gleichzeitig wollen wir eine eigene Nachmittagsveranstaltung mit 15-minütigen Vorträgen durchführen. Wir würden uns freuen, wenn Sie eine Teilnahme in Betracht ziehen würden und eventuell auch über ein Ereignis aus der Physikgeschichte berichten würden, sei es über eine Person, eine Institution, eine Formel, ein Messmethode, ….

Lors du colloque annuel de la SSP à Innsbruck, les participants ont pu assister également à une session dévolue à l'Histoire de la Physique où ont été présentés des exposés intéressants sur l'histoire de la physique et de la technique. A en juger d'après le nombre d'auditeurs, l'intérêt pour cette session a été manifeste avec, fait particulièrement réjouissant, la participation des nombreux jeunes physiciens côtoyant des physiciens-historiens amateurs. Cette expérience positive nous incite à vouloir proposer, lors de la prochaine assemblée générale qui se tiendra pendant la réunion annuelle à Bâle le 21/22 juin, la fondation d'une section « Histoire de la Physique » de la SSP. Nous comptons, sur la lancée, organiser, lors de cet événement, une session d'interventions d'environ 15 minutes sur la thématique de l'histoire de la physique, de ses acteurs, de ses institutions, de ses concepts et de ses instruments, etc. Nous serons heureux de vous y accueillir, et, si vous souhaitez contribuer de manière active à cet événement, de vous y entendre.

Contact: Prof. Jan Lacki, Université de Genève (Jan.Lacki@physics.unige.ch) ;
B. Braunecker, Secrétaire de la SSP (braunecker@bluewin.ch)

POLYCOLL (Polymers and Colloids)

The session forms the traditional annual meeting of the Division of Polymers and Colloids of the Swiss Chemical Society. The Division builds on synergies between Chemistry and Material Sciences, providing a network between scientists and technologists in all areas where polymers and colloids are synthesized, manufactured, investigated, transformed or applied:

* Polymer chemistry & physics
* Functional polymers
* Formulation and product design
* Construction polymers, adhesives and coatings
* Colloids and soft condensed matter
* Nanoscience
* Surface science
* Polymers in life science

The annual POLYCOLL meeting informs about latest results and trends, promotes the interaction between academia and industry and provides networking opportunities for scientists working in the different fields.

Contact: Wolfgang Meier, Uni Basel (wolfgang.meier@unibas.ch)

Physics and Sustainable Energy

How are we going to cope with the demand of energy in the future? This session aims to cover the different aspects of the production, transportation and use of energy. One focus will be electrical energy. Possible contributions cover the research for alternatives to fossil fuels, the use of solar energy, energy storage, transportation of electrical energy, smart grids, energy efficiency and mobility.

Contact: Kai Hencken, ABB Dättwil (kai.hencken@ch.abb.com)

Schülerinnen- und Schülernachmittag: Physik - Forschung in der Schweiz heute, morgen und übermorgen

Angemeldeten Schulklassen aus umliegenden Gymnasien bietet sich die Gelegenheit, drei auf gymnasialem Niveau verständliche Vorträge zu aktuellen Forschungsprojekten der Physik zu hören. Anschliessend stehen die Vortragenden den Schülerinnen und Schülern Rede und Antwort zu aktuellen Fragen der Physik, über die Karriere eines Physikers bzw. einer Physikerin und über deren Visionen für die kommende Generation.

Kontakt: Tibor Gyalog, Uni Basel (tibor.gyalog@unibas.ch)

SPG und PGZ verstärken ihre Zusammenarbeit - Attraktive Doppelmitgliedschaft

Die Schweizerische Physikalische Gesellschaft (SPG) und die Physikalische Gesellschaft Zürich (PGZ) werden in Zukunft enger zusammenarbeiten. Die beiden Vorstände haben eine Vereinbarung unterzeichnet, welche zum beiderseitigen Nutzen unter anderem die gemeinsame Organisation von Anlässen, z.B. Vortragsabende, Workshops etc. beinhaltet.

Kernstück der Vereinbarung ist die neue Doppelmitgliedschaft, welche den Mitgliedern beider Gesellschaften ab 2010 angeboten wird. Der Mitgliedsbeitrag für Doppelmitglieder ist gegenüber den jeweiligen Einzelbeiträgen wie folgt vergünstigt (gilt nicht für Mitglieder auf Lebenszeit bzw. Freimitglieder):

- **Reguläre Mitglieder** zahlen CHF 75.- für die Doppelmitgliedschaft anstatt CHF 90.- für zwei Einzelmitgliedschaften.

- **Mitglieder, welche bei der SPG bereits als Doppelmitglied in DPG, ÖPG oder APS** registriert sind, profitieren von der SPG-PGZ Doppelmitgliedschaft nochmals: CHF 60.- anstatt CHF 75.-.

- **Studenten und Doktoranden** bezahlen für den Doppelpack sogar nur CHF 40.- anstatt CHF 55.- (gilt für zweites und drittes Mitgliedsjahr; das erste Jahr ist bei der SPG gratis, bei der PGZ CHF 15.-).

Bestehende Mitglieder einer oder beider Gesellschaften, welche in den Genuß dieser Vergünstigung kommen wollen, füllen einfach den beiliegenden Talon aus und senden ihn baldmöglichst an das SPG-Sekretariat zurück.

Neue Mitglieder verwenden das Anmeldeformular, welches unter *www.sps.ch/uploads/media/anmeldeformular_d-f-e.pdf* heruntergeladen werden kann, und senden es ebenfalls an das SPG-Sekretariat.

Das SPG-Sekretariat übernimmt den administrativen Part, d.h. um die Zahlungsmodalitäten zu vereinfachen, erhalten Doppelmitglieder künftig die Beitragsrechnung nur von der SPG.

Die Vorstände von SPG und PGZ sind überzeugt, mit dieser Zusammenarbeit und der attraktiven Doppelmitgliedschaft die Physikgemeinde in der Schweiz noch besser zu vernetzen, Synergien zu nutzen und sowohl auf regionaler wie auf Landesebene noch besser auf die aktuellen Fragen und Probleme der Physik eingehen zu können.

Progress in Physics (16)

DIRAC* experiment at CERN: Observation and lifetime measurement of dimeson atoms

Jürg Schacher, University of Bern and CERN,
on behalf of the DIRAC collaboration

Introduction

The study of nonstandard atoms has a long tradition in particle physics. Such exotic atoms include positronium, muonic atoms, antihydrogen and also hadronic atoms. In this last category, especially pionic hydrogen has been investigated in different experiments quite extensively, also in Switzerland at CERN and PSI. To the same category, the hadronic atoms [1], are belonging the dimeson atoms, the subject of this article.
Electromagnetically bound mesonic pairs like the atom pionium ($A_{2\pi}$), consisting of π^+ and π^-, or the πK atom ($A_{\pi K}$) are an excellent tool to study the strong interaction theory QCD (quantum chromodynamics) at very low energy, i.e. in the confinement region. The strong interaction leads to a broadening and shift of atomic levels and dominates the lifetime of these exotic atoms.
Pion-pion interaction at low energy, constrained by the approximate chiral symmetry SU(2) for 2 flavours (u and d quarks), is the simplest and best known hadron-hadron process [2]. Since the bound state physics is well understood, a measurement of the $A_{2\pi}$ lifetime provides basic low energy properties in the form of scattering lengths.
Moreover, low energy interaction between the pion and the next heavier and strange meson, the kaon, is a promising probe to learn about the more general 3-flavour SU(3) (u, d and s quark) structure of hadronic interactions – a matter not directly accessible in pion-pion interaction. Hence, data on πK atoms are very valuable, as they provide insights in the role played by the strange quarks in the QCD vacuum.

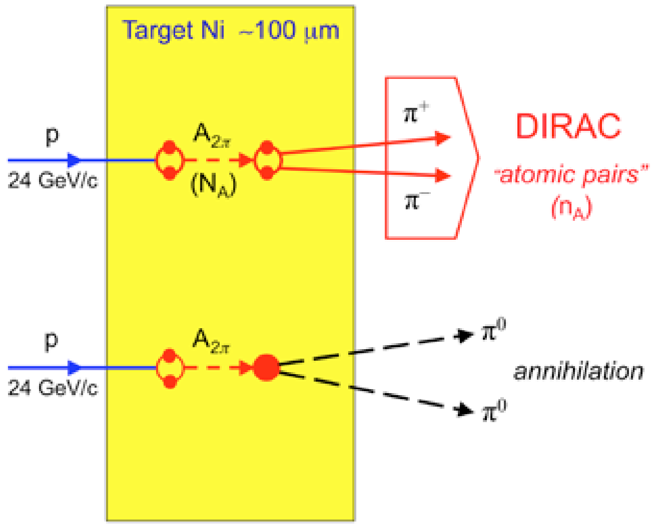


Fig. 1: Pionium ($A_{2\pi}$) production in Ni is detected through its breakup (ionisation). Alternatively it can annihilate (decay).

Method

$A_{2\pi}$ [$A_{\pi K}$] atoms are produced by the Coulomb interaction in final states of oppositely charged $\pi\pi$ [πK] pairs, generated in proton–target interactions [3]. After production these atoms travel through the target and a part of them are broken up due to their interaction with matter: "atomic pairs" are produced, characterized by their small relative momenta in the centre of mass of the pair Q < 3 MeV/c. As shown in Fig. 1, these pairs are detected in the DIRAC setup. The rest of the atoms mainly annihilate into $\pi^0\pi^0$ [π^0K^0], which are not detected. The amount of broken up (ionised) atoms n_A depends on the lifetime τ which defines the decay rate. Therefore, the *breakup probability* P_{br} is a function of the $A_{2\pi}$ [$A_{\pi K}$] lifetime τ.

In addition, proton–target interactions produce also oppositely charged $\pi\pi$ [πK] pairs with Coulomb ("Coulomb pairs") and without Coulomb final state interaction, depending on whether the pairs are produced close to each other or not. The latter category includes meson pairs with one meson from the decay of long-lived resonances ("non-Coulomb pairs") as well as two mesons from different interactions ("accidental pairs"). "Coulomb" and "non-Coulomb pairs" together are called "free pairs". The total number of produced atoms N_A is proportional to the number of "Coulomb pairs" N_C with low relative momenta: $N_A = K \cdot N_C$. The coefficient K is precisely calculable. DIRAC measures the $A_{2\pi}$ [$A_{\pi K}$] breakup probability: $P_{br}(\tau)$ is defined as ratio of the observed number n_A of "atomic pairs" to the number N_A of produced atoms $A_{2\pi}$ [$A_{\pi K}$], calculated from the measured number of "Coulomb pairs" N_C.

Experimental setup

The purpose of the DIRAC setup (Fig. 2) at the CERN proton synchrotron is to record oppositely charged $\pi\pi$ [πK] pairs with small relative momenta Q. The 24 GeV/c proton beam hits a thin target (typically 100 μm thick Ni foil). Emerging charged $\pi^+\pi^-$ [πK] pairs travel in vacuum through the upstream spectrometer part with coordinate and ionisation detectors, before they are split by the 2.3 Tm bending magnet into the "positive" (T1) and "negative" (T2) arm. Both arms are equipped with high precision drift chambers, time of flight detectors, Cherenkov, preshower and muon coun-

* **DI**meson **R**elativistic **A**tom **C**omplex

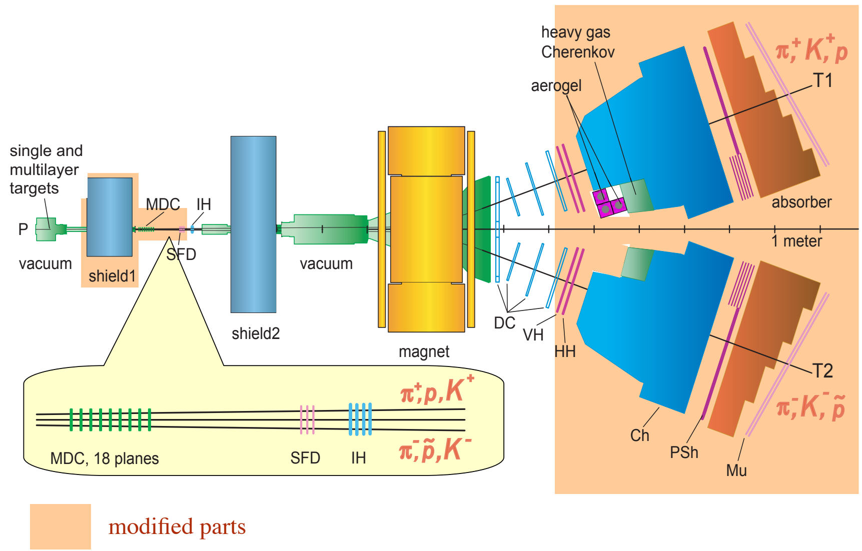


Fig. 2: DIRAC double-arm spectrometer upgraded for K identification.
The microdrift gas chambers MDC, the scintillating fiber detector SFD and the scintillation ionisation hodoscope IH provide initial track data. Downstream of the spectrometer magnet, the drift chambers DC measure final tracks to determine momenta. The vertical VH and the horizontal scintillation hodoscopes HH are used for trigger purposes. The Cherenkov detectors containing nitrogen Ch or heavy gas (C_4F_{10}) or aerogel radiators as well as the preshower detectors PSh and the scintillation muon detectors Mu behiniron absorber help to distinguish pions and kaons from other particles like electrons, muons and protons.

ters. The relative time resolution between the two arms is around 200 ps.
The momentum reconstruction in the double-arm spectrometer makes use of the drift chamber information of the two arms as well as of the measured hits in the upstream coordinate detectors. The resolution on the components of the pair relative momentum Q is ~ 0.5 MeV/c. A system of fast trigger processors selects small Q events.

Observation and lifetime measurement of pionium

Already in 1993 the observation of $A_{2\pi}$ was reported in [4] from an experiment at Serpukhov and ten years later a measurement of the $A_{2\pi}$ lifetime at DIRAC in [5]. Fig. 3 shows a characteristic accumulation of low Q_L events, which are due to $\pi^+\pi^-$ atoms (breakup). In summer 2009 DIRAC presented the most recent value for the $A_{2\pi}$ lifetime $\tau_{2\pi} = (2.82 \pm 0.31)\cdot 10^{-15}$ s [6], based on the statistics of 13300 "atomic pairs" collected in 2001-2003 on the Ni target. Using the relation between lifetime and scattering length [7], the above lifetime corresponds to the scattering length difference $|a_0 - a_2| = 0.268 \pm 0.015$ (m_π^{-1}), where a_0 and a_2 are the S-wave $\pi\pi$ scattering lengths for isospin 0 and 2, respectively. The corresponding theoretical values are 0.265 ± 0.004 (m_π^{-1}) for the scattering length [8] and $(2.9 \pm 0.1)\cdot 10^{-15}$ s for the lifetime [7]. These results show the high precision that can

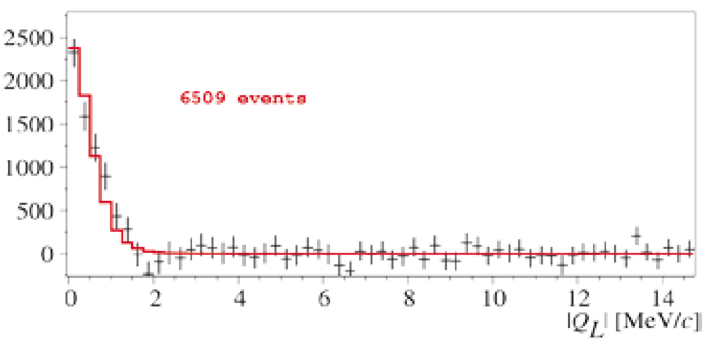


Fig. 3: Q_L distribution measured with DIRAC for signal $\pi^+\pi^-$ pair [5]. The peak at low Q_L corresponds to the residuals, the "atomic pairs", after background subtraction of the „free pairs" ("Coulomb" and "non-Coulomb pairs"): the red line represents the expected atomic signal shape.

be reached in low energy hadronic interactions both in experiments and theory.

Observation and lifetime measurement of πK atoms

First evidence for the observation of the atom $A_{\pi K}$ was published in [9]: πK atoms were produced in a 26 μm thin Pt target, and the oppositely charged πK "atomic pairs" from the atom breakup were analysed in the upgraded DIRAC double-arm spectrometer (Fig. 2). The observed enhancement at low relative momentum corresponds to a production of 173 ± 54 "atomic pairs". From this first data sample DIRAC derives a lower limit on the πK atom lifetime of $\tau_{\pi K} > 0.8\cdot 10^{-15}$ s (90% CL), to be compared with the theoretical prediction of $(3.7 \pm 0.4)\cdot 10^{-15}$ s [10].

Future investigations with DIRAC

In addition to the activities above, DIRAC proposes to measure the pionium energy splitting between *np* and *ns* states („Lamb shift") in 2011 and later. The energy shift for the levels with the principal quantum number *n* and orbital quantum number *l* includes electromagnetic as well as a strong contribution depending on the same scattering lengths a_0 and a_2 as above. Therefore, the observation of such long-lived states would open a novel possibility to measure level splittings and to determine another comscattering lengths, hence allowing a determination of a_0 and a_2 individually.

References

[1] J. Gasser, V. E. Lyubovitskij, A. Rusetzky, Physics Report 456 (2008) 167
[2] S. Weinberg, Phys. Rev. Lett. 17 (1966) 616; G. Colangelo, J. Gasser, H. Leutwyler, Nucl. Phys. B 603 (2001) 125.
[3] L. Nemenov, Sov. J. Nucl. Phys. 41 (1985) 629.
[4] L. G. Afanasyev, et al., Phys. Lett. B 308 (1993) 200.
[5] B. Adeva, et al., Phys. Lett. B 619 (2005) 50.
[6] V. Yazkov, „Investigation of $\pi^+\pi^-$ and πK atoms at DIRAC", 6th International Workshop on Chiral Dynamics, Bern 2009.
[7] J. Gasser, et al., Phys. Rev. D 64 (2001) 016008.
[8] G. Colangelo, J. Gasser, H. Leutwyler, Phys. Lett. B 488 (2000) 261.
[9] B. Adeva, et al., Phys. Lett. B 674 (2009) 11[10] J. Schweizer, Phys. Lett. B 587 (2004) 33.

Progress in Physics (17)

Spintronics without magnetism?

J. Hugo Dil
Physik-Institut, Universität Zürich, 8057 Zürich, and Swiss Light Source, Paul Scherrer Institute, 5232 Villigen PSI
jan-hugo.dil@psi.ch

Introduction

Spintronics is the vision of using the spin of the electron rather than its charge to control information flows, which can be exploited in a future quantum computer. In the field of data storage, spintronics has already become reality; the giant magnetoresistance effect, for the discovery of which Fert and Grünberg received the 2008 Nobel prize, is used in modern memory devices. Currently many researchers are working on systems where small magnetic structures are used to design a complete spintronics ensemble. The magnetic moments of the electrons, i.e. the spin, lead to a net magnetization in these structures. As we know from our basic physics lectures the spin of an electron can in the simplest approach be manipulated by magnetic fields. Here we will discuss a possible alternative which is fully based on non-magnetic materials and utilizes the spin-orbit interaction in low-dimensional structures to control the electron spin. The advantage of this approach is that it can lead to reduced information processing time at even lower energy consumption and is as such highly interesting and promising for future applications.

For any useful spin computer one needs at least the following components:

- (i) The manipulation of the electron spin in a controlled way.
- (ii) The creation of a spin-polarized current from a non-polarized source of electrons; i.e. a spin filter.
- (iii) The coherent transport of spin-polarized electrons over macroscopic distances without the loss of information.
- (iv) The storage of information on macroscopic time scales.

Because spin-orbit interaction is a dynamic process it is diffcult to envisage spin-storage based on such an effect, as data storage requires a steady state solution and thus will most likely remain based on magnetic structures. The possible realization of the other three components without magnetic materials is discussed in the next sections.

Spin manipulation; the Rashba effect

Spin manipulation without magnetic fields relies on spin-orbit coupling. A promising candidate to achieve a controlled manipulation is the Rashba effect, which relies on the breaking of space inversion symmetrie, as will be explained below.

In many cases the surface of a metal (or semiconductor) crystal is not just a truncation of the bulk. For instance at semiconductor surfaces the dangling bonds which are formed due to the sudden truncation of the crystal, induce a rearrangement of the atoms to lift these free bonds. Furthermore due to the confinement between a projected band gap and the image potential, surface states can form, which have totally different properties as the electronic states in the bulk material. In both cases the main cause of the differences is that at the surface the translational symmetry is broken along the surface normal, or, more general, that the space inversion symmetry is broken.

> **Rashba effect**
>
> The Rashba-Bychkov effect is a spin-splitting of bands in a 2D electron gas due to a net electric field and spin-orbit coupling. Although initially described for semiconductor heterostructures it was first observed on the surface of gold. The spin splitting does not result in a net magnetization of the system.

For an electron with a given momentum $\vec{k}$ and spin ($\uparrow$ or $\downarrow$) space inversion symmetry means that it is equivalent whether the electron moves in one direction or the other; i.e. $E(\vec{k},\uparrow) = E(-\vec{k},\uparrow)$. In the absence of a magnetic field, time inversion symmetry holds; i.e. $E(\vec{k},\uparrow) = E(-\vec{k},\downarrow)$. In the bulk of a non-magnetic, centrosymmetric metal both time and space inversion symmetry are observed, resulting in the formation of spin-degenerate states $E(\vec{k},\uparrow) = E(\vec{k},\downarrow)$. For states located at a surface or interface (e.g surface states or quantum well states) the space inversion symmetry is actually broken, which means that the spin degeneracy does not necessarily hold for these states.

That the spin degeneracy is actually lifted for surface states can be understood by the following simple relativistic argument. The sudden termination of the crystal at the surface creates a potential gradient perpendicular to the surface, which can also be regarded as a local electric field. In the rest frame of a moving valence electron this electric field becomes a magnetic field through a Lorentz transformation. This magnetic field causes a Zeeman splitting of the electronic states and thus an energy difference between the states with different spin orientations. The magnitude of this magnetic field and thus also the energy splitting depends on the momentum of the electron and changes sign for opposite momenta. At zero momentum the splitting disappears and the bands are degenerate.

This momentum dependent energy splitting of surface or interface states is typically referred to as the Rashba (or Rashba-Bychkov) effect (see Ref. [1] and references the-

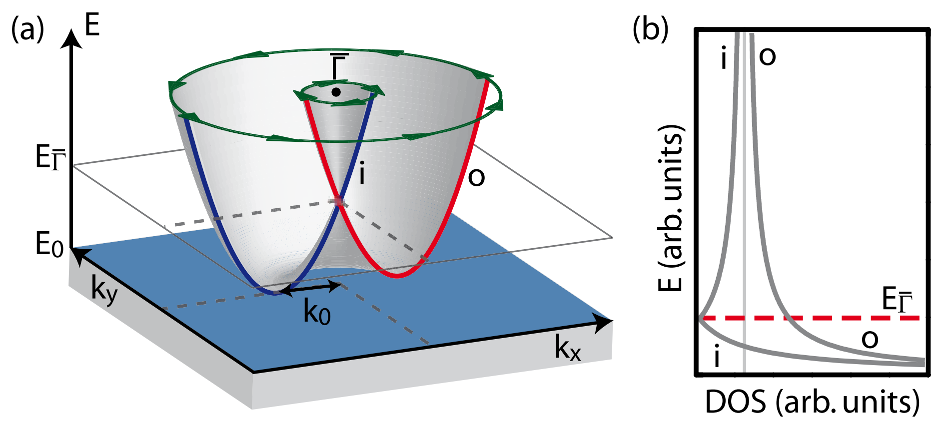


Figure 1: (a) Band splitting of a free-electron-like parabola due to the Rashba effect. (b) Corresponding density of states, where i and o refer to the inner and outer part of the bands respectively.

rein). The detailed mathematical description of this effect goes beyond the scope of this article but the effect on the band structure of a two-dimensional nearly free electron gas is shown in Fig. 1(a) and can be summarized as follows. The original spin-degenerate parabola is split in two spin-polarized parabolae which are shifted by k_0 from the zone centre. A cut along a constant energy plane shows two concentric circles with opposite spin rotation directions. In this simple model the spin will always be perfectly tangential to the constant energy contour, for more complex systems the spin may however deviate from this and can even show a sizeable out-of-plane polarization.

The use of this Rashba-type spin-splitting to manipulate the spin of an ensemble of electrons is based on basic quantum mechanical arguments and follows the lines of a proposal from 1990 [2]. An electron with its spin along the positive z axis can be decomposed into electrons with spins along the y axis, reading

$\sqrt{2} \cdot \langle z^{\uparrow}| = (1,1) = (1,0) + (0,1) = \langle y^{\uparrow}| + \langle y^{\downarrow}|$

Similarly, a spin along x can be written as

$\sqrt{2} \cdot \langle x^{\uparrow}| = (1,-i) = (1,0) + e^{i3\pi/2}(0,1)$

A phase difference between $\langle y^{\uparrow}|$ and $\langle y^{\downarrow}|$ thus causes a rotation in the xz plane. This phase difference is exactly what is accumulated along an electrons path through a solid due to the different $\vec{k}_{\parallel}$ vectors at a given energy (typically Fermi energy) of the bands with opposite spin. As a result, the spin of an electron travelling through this Rashba medium will rotate as a function of distance travelled, where the amount of rotation depends on the momentum difference between the two parabolae; i.e. $2k_0$. The goal is now to manipulate this momentum splitting by an external parameter so that one can directly control the spin of an electron at the end of this medium. While this can be done by a gate voltage for some structures, we will here discuss the influence of structural changes. In our group we have shown by spin and angle-resolved photoemission that the Rashba splitting can be tuned by mixing different amounts of Pb and Bi on a Ag(111) surface [3]. Furthermore we have found that the spin-splitting of quantum well states in thin Pb films on Si(111) shows a strong dependence on the interface barrier [4] and may thus be tuned through the charge density in the substrate.

Spin injection and transport

A spin injector or spin filter can be defined as a medium which creates a current with a certain degree of spin-polarization from an initially unpolarized current. In a magnetic material this is achieved through the difference in density-of-states (DOS) of the majority and minority spin states at the Fermi level. As a result of the Rashba effect the density-of-states of the nearly two-dimensional electron gas is no longer constant, but shows a strong energy dependence as depicted in Fig. 1(b). Between the crossing point of the two parabolae and the band apex the DOS shows a Van Hove type singularity, which is predicted to have substantial influence on the electronic properties through the enhanced electron-phonon coupling. An other interesting situation arises exactly at the crossing point $E_{\bar{\Gamma}}$, here the DOS of one spin orientation vanishes whereas the other spin direction has a large DOS. At the interface between a Rashba medium and a normal metal the spin polarization of a current accross this interface can be as large as 80% [3]. Depending on the polarity of a voltage accross the interface, a Rashba-spin-degenerate metal interface can either be used as a spin injector or acceptor.

This mechanism functions even better if the DOS of one spin direction would not only go to zero, but if the band would not be present around the Fermi level at all. This is exactly what happens for the novel class of materials called topological insulators [5]. In a simple picture a topological insulator is a band insulator with a metallic surface which supports an odd number of spin polarized states for any momentum direction. Although some of these spin channels will "cancel" with channels with opposite spin, there will always be at least one spin polarized channel left over. Because time-inversion symmetry still hold this state forms a pair (Kramers pair) with a state with opposite momentum and spin. If an electron encounters an impurity it is typically forced to partly reverse its direction of motion, which causes an decrease in conductance. For an electron tra-

Van Hove singularity

The density-of-states of a 3D free electron gas shows a square root dependence on the energy. For a 2D system the DOS is constant or steplike. For a 1D system the DOS scales with $1/\sqrt{(E_0 - E)}$, this type of behaviour is refered to as a Van Hove type of singularity after the Belgian physicist Léon Van Hove (1924-1990).

Topological Insulator

Topological insulators are band insulators with one or more metallic surface states which are spin-polarized due to the Rashba effect. These states are topologically protected, meaning that they can not be destroyed by continuous deformations. The spin orbit coupling thus takes the role of the magnetic field in the integer quantum Hall effect. See also S.-C. Zhang Physics 1, 6 (2008) for an informal description.

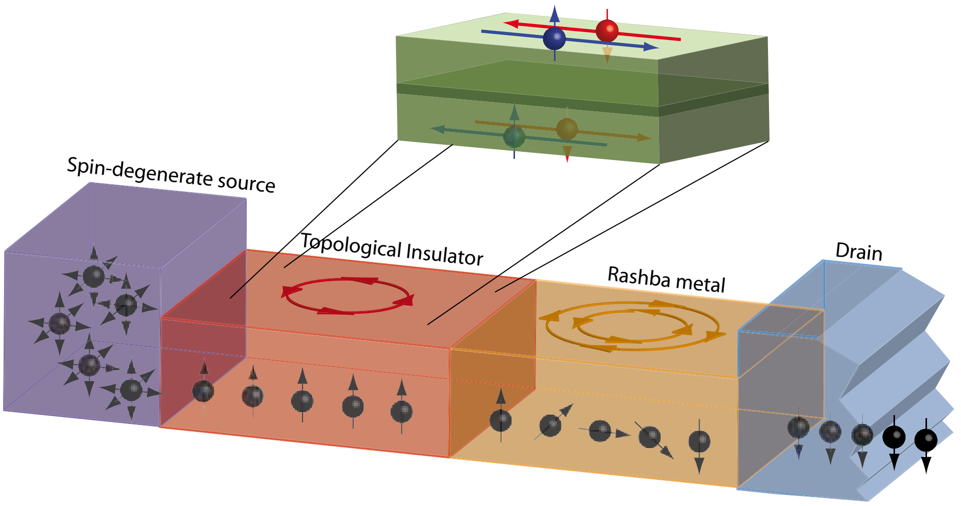


Figure 2: Schematic picture of a spin injector, loss free spin transport and spin manipulation based on non-magnetic materials. From a spin-degenerate source the electrons are spin filtered and transported through a topological insulator, where the electron can only change direction if it flips its spin or passes through the insulating bulk. The spin direction can afterwards be tuned in a Rashba medium and utilized according to need.

velling in one of the channels of a topological insulator a reversal of direction means that it would also have to flip its spin, which is extremely unlikely in the absence of magnetic impurities. As a result, the conductance is hardly influenced by non-magnetic impurities and one could expect a very efficient spin transport, without the loss of information.

In our group we have studied several topological insulators or their parent compounds using spin and angle resolved photoemission. The advantage of this technique is that one can directly identify the number of Fermi level crossings including their spin polarization. First conclusive results were obtained for pure Sb and a BiSb alloy [6], where the correct topology could be identified but which has only a bulk band gap of 50 meV and as much as five Fermi crossings. The next generation of topological insulators is formed by BiSe and related compounds with only one spin polarized state at the Fermi level and a bulk band gap of 350 meV [7]. The advantage of the latter compounds is that through bulk and surface doping the bands can be aligned such as to achieve the required conditions.

In these materials the electrons can move in the full two-dimensional plane of the surface yielding a finite scattering probability in directions where the spin is not orthogonal, which might eventually lead to a loss of information and an increase of resistance. We have taken a first step to also overcome this limitation by the identification of a one-dimesional topological metal; i.e. a topological surface with metallic bulk properties. It was found that the stepped surface of Bi(114) contains only two clearly one-dimensional spin polarized states, and each state contains electrons with exactly opposite momentum [8]. If a similar situation can be created at the surface of a bulk insulating system, such as for example BiSb, a one-dimensional topological insulator will be obtained with loss free unidirectional spin transport. Furthermore such a system will show a one-dimensional Quantum Spin Hall Effect and as such could open a whole new realm of intriguing physics.

Figure 2 schematically summarizes the subjects addressed in this article. An unpolarized flow of electrons can be aligned using a Rashba system with the crossing point at the Fermi level or with a topological insulator. Coherent, loss free spin transport can be achieved through a topological insulator. Afterwards the spin can be manipulated according to need in a Rashba medium by tuning an external parameter.

In this article the direct implications of topological insulators on fault free quantum computing and their link to particle physics in condensed matter have not been discussed for the sake of simplicity. Furthermore, the systems described here most likely can't directly be implemented in practical applications and some should primarily be regarded as model systems. However, the knowledge which is gained from our research and similar studies by other groups, does show that solutions based on spin-orbit interaction could provide an alternative to magnetic materials in many spintronic components.

References

[1] J. H. Dil, J. Phys.: Condens. Matter **21**, 403001 (2009).
[2] S. Datta and B. Das, Appl. Phys. Lett. **56**, 665 (1990).
[3] F. Meier, V. Petrov, S. Guerrero, C. Mudry, L. Patthey, J. Osterwalder and J. H. Dil, Phys. Rev. B **79**, 241408 (2009).
[4] J. H. Dil, F. Meier, J. Lobo-Checa, L. Patthey, G. Bihlmayer and J. Osterwalder, Phys. Rev. Lett. **101**, 266802 (2008).
[5] C. L. Kane and E. J. Mele, Phys. Rev. Lett. **95**, 146802 (2005).
[6] D. Hsieh et al. Science **323**, 919 (2009).
[7] D. Hsieh et al. Nature **460**, 1101 (2009).
[8] J. W. Wells et al. Phys. Rev. Lett. **102**, 096802 (2009).

Physics and Society

Marietta Spiekerman-Middelplaats is one of the pioneers and major promoter of the IDEA League program. It all began 1999 when she, in the company of the Rector of TU Delft Karel Wakker, visited Rector Konrad Osterwalder at the ETH in Zürich, to discuss various ideas for new strategic collaboration. In the following she describes the state of the art, and the expectations for the next decade of this rather unique and fascinating project.

Bernhard Braunecker, SPS Secretary

The IDEA League

Marietta Spiekerman-Middelplaats, TU Delft/NL

Strategy

The idea of closer cooperation was born in 1999 between Delft University of Technology (TU Delft) and the ETH in Zürich. Both universities had already spent many decades working together in the area of research and student exchange. Both universities have a lot in common and are more or less organised along the same lines: both specialise in technology programmes and both are inspiring, open minded, academic communities with a strong international focus and a keen awareness of and responsibility for societal demands.

TU Delft and ETH Zürich decided to extend their working relationship to the strategic level. They wanted to join in with international developments (such as the arrival of the Bachelor-Master structure), but they did not want to compromise the academic quality of their education programmes. Neither university welcomed the idea of American scenarios, whereby 75 percent of students leave the university after the Bachelor's phase.
TU Delft and ETH Zürich searched for ways of maintaining the high quality of their programmes within this new structure. In view of European developments in higher education they realised that a system of quality assurance would have more impact if embedded into a larger-scale partnership. So they invited RWTH Aachen and Imperial College London to join the collaboration. Like TU Delft and ETH Zürich, these two universities rank among the top in Europe. Aachen and London soon agreed and a number of years later, Paris Tech applied and was admitted to join the IDEA League.

Ten Years of IDEA League

This year (2009) marks the IDEA League's tenth anniversary. In those ten years, the IDEA League has undertaken a wide and varied range of strategic activities, including student and staff exchanges and the realisation of a common quality assurance system, which for instance also addresses the topic of learning outcomes and the specification of criteria required for the qualification profile of the degree programmes. This was a complex task, which required the universities to share their "trade secrets" and show each other how quality is realised and guaranteed within their organisation. Although this degree of openness did not always come naturally, looking back, everyone is pleased

The board of IDEA league (from left to right): Ralph Eichler - ETH, Roy Anderson - Imperial College, Rolf Rossaint - RWTH Aachen, Yves Poilane - Paris Tech, and sitting in the front, Dirk Jan van den Berg - TU Delft (President)

with this step. The five members learned a lot from each other's good practices and were all forced to think long and hard about their perception of academic quality in a university degree programme. This is valuable information, which is also useful when designing new programmes. All members of the IDEA League score consistently high in various international rankings (despite all the changes in the area of education), and a shared vision on the standard of quality assurance has certainly helped. Students from within and outside Europe can be assured that the five affiliated universities do not only pursue high-level scientific research, but also provide education that satisfies all the quality criteria.

Another very different type of IDEA League activity that I would like to mention here is the organisation of various summer schools for students, including the one on 'ethics and technology'. Not only do these kinds of short courses form a valuable contribution to the academic background of our future scientists and engineers, but they are also very popular among the students who enjoy the international focus and atmosphere of these summer schools.

Marietta Spiekerman with members of the IDEA Operations Board: left Dr. Thanh-Tâm Le of Paris Tech, and right the former Rector of RWTH Aachen, Prof. Burkhart Rauhut.

Networks & Outlook

Over the last few years, we have been facing massive global challenges in the area of environment, climate, energy, health and infrastructures. They require drastic solutions that can only be realised by bringing together the smartest brains from all over the world to work on this together. And universities will play a major role to establish and support these scientific teams which are of paramount importance to create step changes that will contribute to solutions for these enormous challenges. It is high time for creative and pioneering new ideas, for cutting edge research and results. It is up to universities and knowledge institutes to think about new technological ways, and working together within the IDEA League is a good first step. As an example, the IDEA League along with related industrial partners and a number of other knowledge institutions submitted a proposal to the EU outlining ideas for coping with the consequences of climate change. If the proposal is accepted, this so called Knowledge Innovation Community will be awarded substantial annual funding, which will put us in a position to spend the next six years to join in and work on solutions to this global problem.

The current issues regarding for instance sustainability and climate extend beyond the European borders, which is why it is so important to create knowledge networks stretching across the world. In this respect, the IDEA League is really proving its worth. In Asia, for example, there are similar developments where leading universities of technology form new knowledge networks that will give impetus to their traditional cooperation in research and education. At the same time, these universities in Japan, China, Korea or Singapore are also looking to Europe in search of suitable universities or collaborations to enhance their networks. A network like the IDEA League, consisting of five leading European universities, is an attractive partner. The first steps in this direction have already been made. Upon the invitation of the "Asian Consortium of Leading Universities of Technology" IDEA League recently signed an agreement to confirm the mutual intent for closer cooperation.

The annual joint sports event of IDEA League.

IDEA League today

The IDEA League is a network of five leading universities of technology and science, Imperial College London, TU Delft (Technische Universiteit Delft), ETH Zürich (Eidgenössische Technische Hochschule Zürich), RWTH Aachen (Rheinisch-Westfälische Technische Hochschule Aachen) and Paris Tech (Grandes Ecoles d'Ingenieurs de Paris). In a world of accelerating globalisation of research and technology, the IDEA League aims to make an active contribution to the European agenda, and to participate in the programmes and actions of the EU (most notably the framework programmes), the platforms and the European Institute of Technology (EIT). This is the framework in which the IDEA League anchors its strategy on research, education and innovation. Established as a highly selective university network based on excellence, the IDEA League sees its task as paving the way for urgently-needed technological breakthroughs in Europe.

Der Weg in die Exaflops-Ära

David Müller, Supercomputing Systems AG

Die Leistung der schnellsten Rechner der Welt ist über die letzten Jahrzehnte exponentiell gestiegen – von einem GigaFlops (1 Milliarde Fliesskoma-Operationen pro Sekunde) 1988 zu einem TeraFlops in 1999 und zu mehr als einem Petaflops in 2008. In einem langfristig angelegten Effort bereitet sich die "Supercomputing Community" auf die Exascale - Ära (10^{18} Flops) vor, deren Beginn auf circa 2018 prognostiziert wird. Ausgerüstet mit diesen Werkzeugen etabliert sich die rechnergestützte Simulation neben Experiment und Theorie zunehmend als drittes Standbein in den Naturwissenschaften. Im folgenden Artikel sollen sowohl der wissenschaftliche Nutzen wie auch die technischen Herausforderungen und Lösungsansätze solcher Superrechner beschrieben werden.

Die Top 500 Liste

Auf der Top 500 Liste (www.top500.org) wird alle 6 Monate ein Ranking der leistungsstärksten Rechner erstellt. Seit November 2009 wird die Liste angeführt von "Jaguar" – einer CRAY XT5 mit insgesamt 224'000 AMD x86 Prozessorkernen und fast 450 TB Arbeitsspeicher. Die Maschine hat eine theoretische "Peak Performance" von 2.3 PFlops, wovon hervorragende 1.7 PFlops von der wissenschaftlichen Applikation DCA++ genutzt werden können. Für die Entwicklung dieser Applikation sind Prof. Dr. Thomas Schulthess – mittlerweile Direktor des Swiss National Supercomputing Centre CSCS in Manno/TI – und sein damaliges Team am Oak Ridge National Laboratory 2008 mit dem Gordon Bell Award ausgezeichnet worden. Sie haben als Erste gezeigt, dass Petaflops-Maschinen effizient für reale Applikationen eingesetzt werden können, um neue Einsichten in physikalische Grundlagen, speziell von magnetischen Materialien, zu ermöglichen.

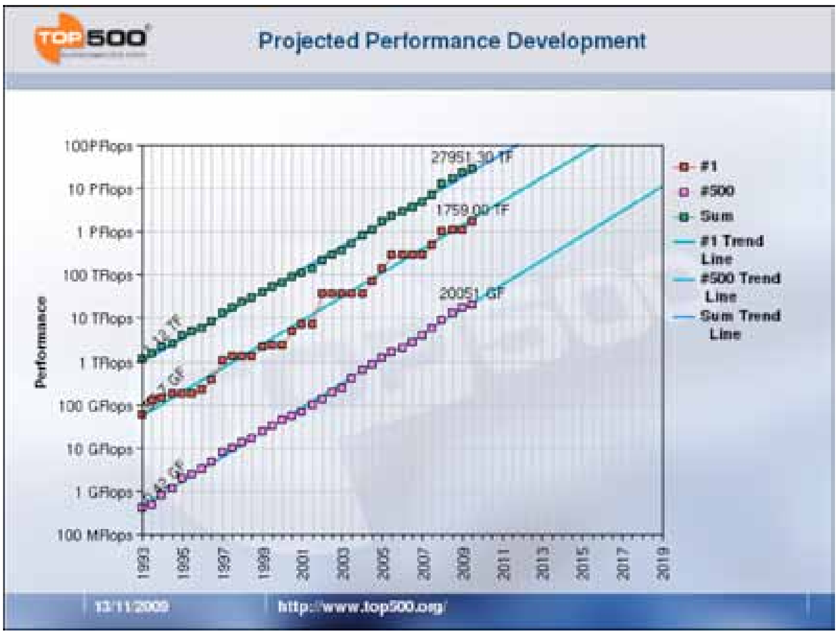


Abbildung 1 Die exponentielle Entwicklung der Leistungsfähigkeit der schnellsten Rechner der Welt (www.top500.org)

Die Exaflops-Skala

The Case from Science

Die Anwendung DCA++ simuliert das Verhalten von Hochtemperatur-Supraleitern. Das Verständnis der ihnen zugrunde liegenden Mechanismen konnte dank der hohen Effizienz des Codes und der Leistung des "Jaguar" entschieden verbessert werden. Ein weiteres wichtiges Anwendungsgebiet wird die Klimafrage sein. Eine verlässliche Klimamodellierung erfordert eine hohe Maschendichte an Realtime Messdaten auf der Erde und in der Atmosphäre. Die nächste Generation geostationärer Wettersatelliten MTG (MeteoSat Third Generation) mit neuartigen "Imager-" und spektralen "Sounder-" Sensoren wird die Konzentration von klimabestimmenden Gasen wie CO_2, Ozon, Wasser in der Atmosphäre mit 1 km Höhenauflösung in Quasi-Echtzeit für Bodenpixel < 1 km bei weitgehend globaler Abdeckung angeben. Die Verarbeitung dieser Datenflut durch eine grosse Nutzergemeinde wird eine der Hauptanwendungen für kostengünstige Superrechner in den nächsten Dekaden sein.

Technische Herausforderungen

Power Wall

Die offensichtlichste Limitierung für weitere Leistungssteigerungen der Rechner ist deren Verlustleistung, die "Power Wall". Eine Leistungsaufnahme um 3 W pro GFlops ist heute typisch; ein Exaflops-Rechner würde, basierend auf heutiger Technik, somit mehrere GW verbrauchen und ist so nicht umsetzbar. Die Verbesserung der Silizium-Prozesstechnologie wird zwar weitere "Shrinkings" der Strukturen ermöglichen, wobei die Leistungseffizienz aber nicht mehr stark verbessert werden kann, da die Leckströme in den Siliziumstrukturen zu zunehmenden Verlusten führen. Ein grosses Potential liegt hingegen in der Prozessorarchitektur. Gängige CPUs sind vor allem auf die maximale Geschwindigkeit in der Ausführung eines sequentiellen Ablaufes optimiert (single thread performance) – dazu sind Verfahren wie "Out-of-Order-Execution", "Branch Prediction" oder "Speculative Execution" eingeführt worden. Durch diese wird jedoch ein wachsender Anteil der Chipfläche und der verbrauchten Energie für Operationen eingesetzt, deren Resultate in der Folge wieder verworfen werden müssen. Ganz andere Prinzipien sind beispielsweise bei der Entwicklung von Graphikkarten ("Graphics Processing Units", GPU) angewendet worden. GPUs werden heute unter dem Begriff "General Purpose GPU" (GPGPU) auch für wissenschaftliche Anwendungen im grossen Stil eingesetzt.

Eine GPU verfügt über bis zu 240 sehr einfach ausgestaltete Prozessorkerne. Die Ausführungsgeschwindigkeit eines sequentiellen Programms auf einem solchen Prozessor ist bescheiden, da im Gegensatz zu den CPUs auf Verfahren zur Steigerung der "Single Thread Performance" verzichtet wird. Um die GPU trotzdem gut auszulasten, werden daher auf jedem Prozessor viele voneinander unabhängige Anweisungsstränge ("Threads") gestartet. – Muss ein "Thread" auf die Ergebnisse des vorhergehenden Schrittes warten, kommt ein anderer Thread zur Ausführung, so dass das Rechenwerk immer ausgelastet ist. Ein grosser Vorteil dieser Strategie liegt darin, dass viel weniger Verwaltungsaufgaben pro Floating Point Operation ausgeführt werden müssen, was die Energieeffizienz (MFlops/W) wesentlich verbessert.

Parallelismus / Concurrency

Um eine GPGPU effizient einsetzen zu können, muss eine Rechenaufgabe also auf tausende von parallel verarbeitbaren Threads aufgeteilt werden, zwischen welchen keine Datenabhängigkeiten bestehen dürfen. Für Supercomputer ist mit Zehntausenden von GPGPUs zu rechnen, so dass die Applikationen auf 10^6 oder 10^7 parallele Threads verteilt werden müssen. Die Programmiermodelle, welche ein effizientes Programmieren mit einem derart hohen Grad an Parallelität erlauben, sind aber selber noch in Entwicklung und ein aktives Forschungsgebiet der Informatik.
Ähnlich wie Graphikprozessoren können auch FPGAs (Field Programmable Gate Arrays) oder Prozessoren mit anwendungsspezifischen Instruktionssätzen massiv zur Erhöhung der Recheneffizienz beitragen. Solche Verfahren werden von der Firma SCS im Embedded Bereich regelmässig eingesetzt.

Widerstandsfähigkeit / Resilience

Heutige Supercomputer verfügen über möglichst wenig fehleranfällige Elemente. Ein permanentes Monitoring sämtlicher relevanter Komponenten macht sie resistent gegen einzelne Ausfälle von Massenspeichern (Festplatten). Um bei Ausfällen einzelner CPUs oder bei Mehrfach-Bitfehlern im Hauptspeicher nicht sämtliche Zwischenresultate zu verlieren, wird regelmässig der gesamte Zustand einer Berechung als "Checkpoint" gesichert, ab welchem bei Bedarf ein "Restart" gemacht werden kann. Mit dem für die "Exa-Scale" erwarteten Anstieg der Anzahl Komponenten wird die statistische Häufigkeit von Fehlern so stark ansteigen, dass ein Checkpoint-Restarting nicht mehr praktikabel ist. Als Gegenmassnahme werden sowohl die Fehlerresistenz wie auch die Fehlertoleranz der Systeme weiter gesteigert werden müssen. So sind beispielsweise gegen Mehrfach-Bitfehler stärkere Prüfsummen als das heute übliche "ECC" denkbar.

Memory Wall

Die Speicherbandbreite ist in den vergangenen Jahrzehnten wesentlich weniger gesteigert worden als die Rechenleistung. Durch den Trend zu immer mehr Prozessorkernen mit einem geteilten Memory Bus wird dieser "Memory Gap" weiter verstärkt. Beim "Caching" werden die zuletzt verwendeten Daten auf dem Prozessorchip vorgehalten, so dass sie bei einem erneuten Zugriff sehr schnell verfügbar sind und keine Last auf dem Memory Bus entsteht. Dieses Verfahren ist bei vielen Anwendungen sehr effektiv. Bei wissenschaftlichen Rechnungen werden hingegen gigantisch grosse Matrizen und Vektoren sequentiell abgearbeitet. Die Grösse dieser Datenstrukturen übersteigt den Platz im Cache um ein Vielfaches. In der Folge muss jeder Wert direkt aus dem Hauptspeicher nachgeladen werden; der Memory Bus muss mehrere Bytes pro Floating Point Operation liefern. Längerfristig versprechen das 3D-Stacking von Prozessor- und Memory-Chips oder die funktionale Verschmelzung der beiden Bausteine zum "Processor in Memory" einen massiven Zuwachs der Speicherbandbreite bei reduziertem Energieverbrauch.

Ausblick

"The race for Exaflops" hat begonnen. Mit der HP2C Initiative am CSCS ist die Schweiz in einer guten Ausgangslage, um an dieser Entwicklung teil zu nehmen. Der Fokus dieser Initiative liegt auf der Optimierung der Anwendungen, damit die Rechnerleistung effizient in wissenschaftliche Erkenntnisse umgemünzt werden kann. Ähnlich wie der in der Box zur Firma Supercomputing Systems AG erwähnte Fahrassistent den Automobilisten beim Bremsen und Ausweichen vor einem Hindernis unterstützt, sollen die kommenden Supercomputer neue Einsichten für die wissenschaftliche Gemeinschaft ermöglichen und der Gesellschaft Herausforderungen wie den Klimawandel frühzeitig aufzeigen.

Supercomputing Systems AG

Seit der Gründung von Supercomputing Systems AG (SCS; *www.scs.ch*) durch Prof. Dr. Anton Gunzinger vor 16 Jahren hat die Firma als Dienstleister für verschiedene namhafte Computerhersteller Beiträge zur Entwicklung heute eingesetzter Verfahren und Systeme leisten können. SCS ist mit 50 Elektro- und Informatikingenieuren sowie Wissenschaftern vor allem als Entwicklungspartner für die Industrie tätig – Maschinensteuerungen, industrielle Sensorik, Kamerasysteme oder massgeschneiderte betriebsunterstützende Software sind typische Anwendungen. Für die Automobilindustrie konnte SCS zum Beispiel äusserst rechenintensive Bildverarbeitungsalgorithmen so weit optimieren, dass deren kommerzieller Einsatz in Bremsassistenz-Systemen machbar geworden ist.

Dr. David Müller (*david.mueller@scs.ch*) schloss seine Ausbildung am Physik-Institut der Universität Zürich 1998 mit der Promotion in experimenteller Hochenergiephysik ab. Seither ist er bei SCS als Department Head "High Performance Systems" unter anderem für die Planung und Durchführung der Projekte im Bereich Supercomputing verantwortlich.

On the need of a network of experts on energy issues within the SPS

Christophe Rossel, SPS President

The world community, and not least Europe, is confronted with converging crises, economic, environmental, employment and social. Energy – its availability at acceptable economic and environmental cost and with the prospect of sustainability – is a key factor in confronting these crises. Many European organizations share the conviction that fundamental scientific aspects of energy research and development will be substantially more efficient, with faster progress, through an interaction of their specialist disciplines, chemistry, material sciences and physics. The European scientific community has not only the potential to optimize interdisciplinary cooperation and communication in energy research, but also to help recognizing the political, economic, social and environmental aspects of energy supply and consumption. Sustainable development is ultimately a social and community imperative, which can only be accomplished within a larger context.

In the last few years the European Physical Society has become a rather active player in the field of energy under the impulsion of its former president Prof. Friedrich Wagner, from the Max-Planck- Institut für Plasmaphysik, in Greifswald, Germany.

After the initial support of the EPS Technology Group, an Energy Working Group (EWG) was created a couple of years ago and became an independent entity, as decided at the last EPS Council 2009. Its main goal is to organize workshops and promote the exchange of information on the recent scientific and technological developments in the field of energy between its EPS member societies. As such, the Swiss Physical Society is also challenged in contributing actively to this exchange of information and expertise. This is the reason why I address this few lines to our SPS members, in particular those who are professionally concerned with the problems of energy production, distribution and conservation. We need to have Swiss experts willing to present to the international community their views and opinions on the energy situation in our country and form an action group within the SPS.

Among recent actions undertaken at the EPS level one can mention a position paper written by the Environmental Division on "Energy and Environment", which is available on the EPS website (www.eps.org). Another EPS position paper entitled "The Nuclear Option" was published in 2007. In the same year, an energy conference was held together with the French Physical Society in Les Houches and in 2008 a large conference was organized with the Italian Physical Society in Varenna on the "Energy Perspectives in Europe". Its summary is also available under www.eps.org/activities/projects/eps_energy_perspectives.pdf/view .

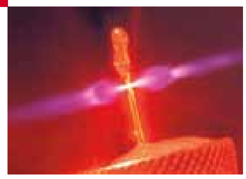
On October 13-14, 2009 an EPS symposium on "Wind Energy" took place in Greifswald, Germany, as a follow-up of the Varenna conference. It was organized by the EPS EWG in co-operation with the Energy Working Group (AKE) of the German Physical Society (DPG) and the Max-Planck-Institut für Plasmaphysik (IPP) (www.ipp.mpg.de). Among the different topics presented, were a review of the progress of UK wind power (onshore and offshore), a report on today's investments into wind energy and their help to the climate, a presentation on the chances and challenges of offshore wind energy in Germany, as well as a study on grid stability and the integration of wind energy into the existing supply net. Viewgraphs of this meeting can be found under www.eps.org/activities/projects/eps-symposium-wind-2009 .

The symposium was followed by a meeting of the EWG of the EPS and its member societies with contributions from the EPS, DPG, and IOP's Energy Groups as well as from Belgium, the Czech Republic, France, Italy, Poland, and Switzerland. In this latter case, the management of radioactive wastes in Switzerland was presented by an expert of the NAGRA.

More information on this meeting can also be found under www.eps.org/activities/projects/ewg-meeting-2009 .

As already announced, the first joint European Energy Conference, "A New Forum for Energy Research", will take place on 19-23 April 2010 at the NH Constanza Hotel and AXA Auditorium, Barcelona, Spain (www.e2c-2010.org). It is organized by the EPS, the European Association for Chemical and Molecular Sciences (EuCheMS), the European Materials Research Society (EMRS) and European Science Foundation (ESF). The conference will cover chemistry, physics and material sciences related to energy technologies. In addition to plenary keynote presentations on diverse energy themes, parallel sessions will deal with energy sources, storage and conversion of energy and end-use including energy conservation. This first European Energy Conference will not be an isolated event; it launches an ongoing forum of communication and cooperation promoting energy-related research.

Hopefully Switzerland, with its excellent expertise and know-how in the field will actively participate to this effort. In my view, the role of the SPS is not to create its own group of specialists but to set up a Swiss network of experts in order to reinforce the links to the EPS Energy Working Group and to the other national societies. If you are interested, please contact me.



Fotos: Max-Planck-Institut für Quantenoptik, Granichen, D

Prix A. F. Schläfli SCNAT 2010

Preissumme CHF 5000.–

Die Akademie der Naturwissenschaften Schweiz (SCNAT) verleiht den Prix A. F. Schläfli 2010 für hervorragende Arbeiten auf dem Gebiet

Quantum Science and Technology

(cold atom gases; physics of single electrons, photons, phonons; quantum information etc.)

Bewerben können sich junge Forscherinnen und Forscher Schweizerischer Nationalität; die obere Altersgrenze für Bewerbende ist 35 Jahre. Es können experimentelle und theoretische Originalarbeiten eingereicht werden; auch bereits publizierte Arbeiten werden akzeptiert. Bei letzteren muss der/die Bewerbende Erstautor/in sein.

Für die Bewerbung sind folgende Unterlagen einzureichen: Die Arbeit, eine kurze (max. eine A4 Seite) selbst verfasste Erklärung der wissenschaftlichen Bedeutung der Arbeit, ein Curriculum Vitae sowie ein kurzes Empfehlungsschreiben einer mit der Arbeit vertrauten Person (nicht Ko-Autor/in im Falle, dass eine bereits publizierte Arbeit eingereicht wird).

Die Dokumente sollen je als ein gedrucktes Exemplar und als PDF-Dokument bis zum **31. März 2010** beim Generalsekretariat der Akademie eingereicht werden.

Die Kandidatinnen und Kandidaten werden im Juli 2010 über die Entscheide der Jury informiert.

Die «Platform Mathematics, Astronomics and Physics» und das Generalsekretariat der Akademie stehen für weitere Fragen zur Verfügung.

Auskünfte:
Geschäftsleiter der
«Platform Mathematics, Astronomics and Physics»
Christian Preiswerk
Akademie der Naturwissenschaften Schweiz (SCNAT)
Schwarztorstrasse 9, 3007 Bern
Tel. 031 310 40 22
E-mail: preiswerk@scnat.ch

Einreichen der Unterlagen:
Generalsekretariat SCNAT
Dr. Anne Jacob
Schwarztorstrasse 9, 3007 Bern
Tel. 031 310 40 26
E-mail: jacob@scnat.ch
www.scnat.ch/d/Preise/Prix_Schlaefli/Ausschreibung/

sc | nat

Swiss Academy of Sciences
Akademie der Naturwissenschaften
Accademia di scienze naturali
Académie des sciences naturelles

La version française de cette annonce est disponible sur: www.scnat.ch/f/Preise/Prix_Schlaefli/Ausschreibung/ .