

europysicsnews

THE MAGAZINE OF THE EUROPEAN PHYSICAL SOCIETY

An eye-witness of the birth of CD
How does light move?
Scientific consensus on climate change
Physics funding at the DFG
Where are the women in physics?

44/6
2013

Volume 44 • number 6
European Union countries price:
95€ per year (VAT not included)



edp sciences

Available at <http://www.europysicsnews.org>

Built for Science. Rock Solid Performance.



Lock-In Amplifiers That Take You Further



Designed for pioneering science

When you're pushing back the frontiers of knowledge, you need the best available instrumentation. We went the extra mile in designing our 50 and 600 MHz models with fully digital signal processing to give you top performance.

Streamlined, efficient and unique to you

With multiple functions fully-integrated in a single elegant box, your setup complexity and everyday hassles are significantly reduced. And the powerful, intuitive graphical user interface keeps things simple – or program it the way you want, in the language of your choice.

www.zhinst.com

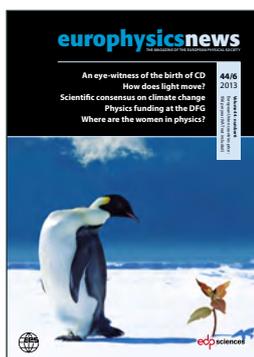
Publish sooner, publish better

All this adds up to highly precise results, an increase in your publication rate and important steps forward for science. Discover more at www.zhinst.com.

Your Application. Measured

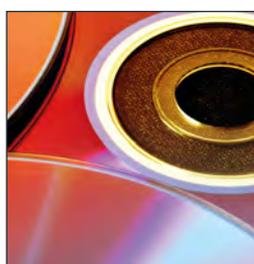


Zurich
Instruments



euromphysicsnews

Cover picture: Global warming, see article "the scientific consensus on climate change" p.25. ©iStockPhoto



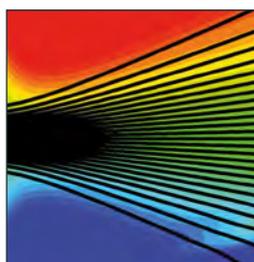
▲ PAGE 21

An eye-witness of the birth of CD



▲ PAGE 29

Physics funding at the DFG



▲ PAGE 33

How does light move?

EPS EDITORIAL

- 03 Goodbye and good luck EPN! // C. Sébenne

NEWS

- 04 The LAL-LURE accelerator complex
06 European Programme for Research and Innovation Horizon 2020
08 The Energy Network, Norway 2005-2013
09 Øystein Håkon Fischer, (March 9, 1942 – September 19, 2013)
10 The Hven Island in Øresund
12 Comment on the 2013 Nobel Prize in Physics
14 EPS Liquid Matter Prize 2014

HIGHLIGHTS

- 16 Hydrodynamics of the fractional quantum Hall effect
A multi-object spectral imaging instrument
X-rays emitted in neutron-induced fission of $^{238}\text{U}(n,f)$
17 Electron wave packet after tunnel ionization
Universality in the symmetric exclusion process
Copenhagen interpretation as an emergent phenomenon
18 Multilayer Memristive/Memcapacitive Devices
Magnetic hyperthermia for tumour reduction
Pulsating dust cloud dynamics modelled
19 Green photon beams more agile than optical tweezers
Antimony variations in GaAs/GaAsSb nanowires
20 Semiclassical propagation up to the Heisenberg time
Atom-based analogues to electronic devices

FEATURES

- 21 An eye-witness report on how the CD came about // J. Heemskerk
25 The scientific consensus on climate change // J. Cook
29 Physics funding at the German Research Foundation // K. Zach
32 Letter to the editor: About 'Crossing borders' // G. Benedek
33 How does light move? // M.D. Davidović and A.S. Sanz

OPINION

- 37 Where are the women in physics? // E. Rachlew
Last minute information: EPS constitutional changes?

ANNUAL INDEX

- 38 Volume 44 - 2013

Magnetic Field Instrumentation



Three-Axis Helmholtz Coil System

- Field generated up to $500\mu\text{T}$ for DC and up to $100\mu\text{T}$ at 5kHz
- 0.1% homogeneous field of 4.5cm^3
- DC compensation up to $100\mu\text{T}$
- Control unit incorporating NI PXI system running LabVIEW™ based software



Mag-13 Three-Axis Magnetic Field Sensors

- Noise levels down to $<4\text{pTrms}/\sqrt{\text{Hz}}$ at 1 Hz
- Measuring ranges from $60\mu\text{T}$ to 1mT
- Bandwidth to 3kHz
- Mag-14 version: bandwidth to 12kHz



Mag670/Mag690 Low Cost Sensors

- Single and three-axis versions
- Unpackaged options available
- Noise levels $<20\text{pTrms}/\sqrt{\text{Hz}}$ at 1Hz



www.bartington.com

Bartington Instruments Limited
5,10 & 11 Thorney Leys Business Park
Witney, Oxford, OX28 4GE, England.

T: +44 (0)1993 706565
F: +44 (0)1993 774813
E: sales@bartington.com

Bartington[®]
Instruments



[EDITORIAL]

Goodbye and good luck EPN!

The job of magazine Editors is to keep eyes wide open to the actuality, to feel what the readers will be interested in and to invite the most talented authors to tell the stories. It is exactly the opposite of the Editors' job in research journals who receive supposedly original material from authors and have to decide if it is worth publishing or not. So, it is journalism rather than research. After being on both sides for many years, time comes to go for good: the present issue of Europhysics News is the last I am in charge of.

Let me take a look at the past and into the future in my second EPN editorial.

My first one was published in EPN 36/4 (August 2005). I had to present myself while becoming Editor of the journal. I wrote about my age, saying I was old (and experienced?) enough to take the job. It was only partly a joke. The EPS is a multinational affair and the way it has to show to its members, both individual and collective, that they belong to one family is through its letters and magazines, reaching everybody in all corners of Europe. Their contents make the European cement and so their Editors occupy highly strategic positions. I regret that the printed EPN remains accessible only to a small fraction (about 20%) of the European Physicists. Fortunately, EPN is available freely on the web, and although printed versions of EPN are not distributed to the members of the British and German Physical Societies, they can have access to web version of EPN. However, who reads something several pages long on the web? I don't. I spend too much time on my computer from which I get too many things! My only effort is to extract and store the web-only journals and magazines... and forget them. To me, a magazine has to be printed for pleasant reading and useful storage. Do you agree? I hope this will remain the case for

EPN, even if costly. It is so important to get one's own copy, to have it ready to be enjoyed anytime, even in an arm-chair at home! My dream would be to get it eight or even ten times a year... It is fun to compare the 2013 issues to the 2005 ones: more illustrations now, less text, wider variety of subjects, new structures with Highlights, Opinions and Letters. The driving force for the whole team is to make the readers eager to open the new issue.

Three persons, who have been the same for the last 6 years, work at making EPN a more magazine-like journal. Two volunteers (the Editor and the Science Editor) have launched the editorial and structural changes while the EPS designer took care of the presentation changes. They were delighted by the birth, in 2011, of the monthly web-letter, e-EPS, which freed them of ephemeral news. I wonder if the name "Europhysics News" remains appropriate. The EPN title should reflect its present role and could be simply "The EPS Magazine" (figure). I hope my successor Victor¹ will raise the question, the decision remaining at the highest level of the EPS.

As one of the three let me thank with all my heart the two others, Jo and Xavier, with whom it has been a great pleasure to work in such a confident and friendly atmosphere. They stay

¹ Prof. Victor R. Velasco, CSIC, Madrid (SP)

and I am sure that they will go along well with Victor who, I know, will bring new ideas for an ever more attractive EPS magazine.

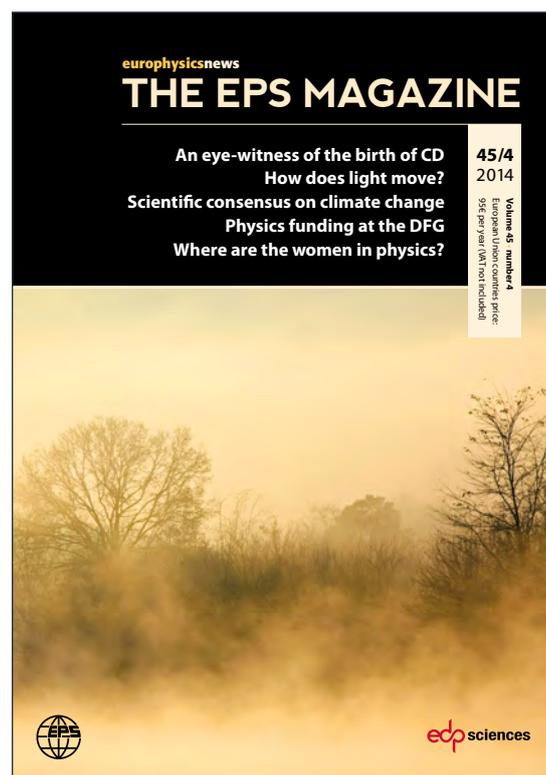
Thanks also to the EPS and its Secretary General for respecting our perfect independence all along these years.

You may still ask how old I am. Well, old enough to be replaced! ■

■ Claude Sébenne

*Europhysics News Editor
(until 31 December 2013)*

▼ Possible new
head for EPN



europhysicsnews

2013 - Volume 44 - number 6

Europhysics news is the magazine of the European physics community. It is owned by the European Physical Society and produced in cooperation with EDP Sciences. The staff of EDP Sciences are involved in the production of the magazine and are not responsible for editorial content. Most contributors to Europhysics news are volunteers and their work is greatly appreciated by the Editor and the Editorial Advisory Board.

Europhysics news is also available online at: www.europhysicsnews.org

General instructions to authors can be found at: www.eps.org/publications

Editor: Claude Sébenne (FR)
Email: claude.sebenne@impmc.upmc.fr

Science Editor: Jo Hermans (NL)
Email: Hermans@Physics.LeidenUniv.nl

Executive Editor: David Lee
Email: d.lee@eps.org

Graphic designer: Xavier de Araujo
Email: x.dearaujo@eps.org

Director of Publication: Jean-Marc Quilbé

Editorial Advisory Board:
Guillaume Fiquet (FR), Adelbert Goede (NL),
Agnès Henri (FR), Martin Huber (CH),
Peter Liljeroth (FI), Charles de Novion (FR),
Malgorzata Nowina Konopka (PL),
Mirjana Popović-Božić (RS),
Stephen Price (UK), Christophe Rossel (CH),
Markus Schwöerer (DE), Marc Türlér (CH).
© European Physical Society and EDP Sciences

EPS Secretariat

Address: EPS - 6 rue des Frères Lumière
68200 Mulhouse - France
Tel: +33 389 32 94 40 - **fax:** +33 389 32 94 49
www.eps.org

Secretariat is open 09.00–12.00 / 13.30–17.30 CET
except weekends and French public holidays.

EDP Sciences

Chief Executive Officer: Jean-Marc Quilbé

Publishing Director: Agnès Henri
Email: agnes.henri@edpsciences.org

Production: Thierry Coville

Advertising: Jessica Ekon
Email: jessica.ekon@edpsciences.org

Address: EDP Sciences
17 avenue du Hoggar - BP 112 - PA de Courtabœuf
F-91944 Les Ulis Cedex A - France
Tel: +33 169 18 75 75 - **fax:** +33 169 28 84 91
www.edpsciences.org

Subscriptions

Individual Members of the European Physical Society receive Europhysics news free of charge.

Members of EPS National Member Societies receive Europhysics news through their society, except members of the Institute of Physics in the United Kingdom and the German Physical Society who have access to an e-version at www.europhysicsnews.org. The following are 2013 print version subscription prices available through EDP Sciences (Prices include postal delivery cost).

European Union countries: 95 € (VAT not included, 19.6 %). **Rest of the world:** 113 €

Contact: EPN Europhysics News - BP 95 -
92244 Malakoff Cedex - info@route66-agence.com
or visit www.edpsciences.org

ISSN 0531-7479 - ISSN 1432-1092 (electronic edition)

Printer: Fabrègue - Saint-Yrieix-la-Perche, France

Dépôt légal: December 2013

**EPS HISTORIC SITES**

The LAL-LURE accelerator complex, a new EPS historic site

The 'Laboratoire de l'Accélérateur Linéaire' (LAL), CNRS-IN2P3 and Université Paris-Sud, was set up at Orsay in 1956 to build and operate a state-of-the-art linear accelerator ('linac') that would provide high intensity electron and positron beams of 1 GeV or more. Later on, in the early 70's, the 'Laboratoire pour l'Utilisation du Rayonnement Electromagnétique' (LURE) was set up in close technical connection to LAL to make full use of the synchrotron light available at the *Anneau de Collisions d'Orsay* (ACO) storage ring built by LAL in 1962-65, and to develop a wide research programme including such fields as materials science, chemistry or structural biology.

The linac operation started in 1959 and ended 44 years later. In the meantime, many upgrades were performed to improve its performance and major facilities were added, ranging from lepton colliders to synchrotron light sources.

In 1962, the AdA collider, designed and built in Frascati under the leadership of Bruno Touschek, was brought to Orsay as the LAL linac allowed a higher particle injection rate. A year and a half later, the first ever electron-positron collisions were observed and the machine studies performed with AdA opened an entirely new field in accelerator science. In particular, the so-called Touschek effect, which is still limiting the performances of today's low energy and high current accelerators as well as synchrotron light sources, was discovered and understood while AdA was running at LAL.

The ACO stored its first beam in 1965. ACO, built by the LAL in collaboration with a team from CEA-Saclay, was an electron-positron collider of 1100 MeV total center-of-mass energy which led to important discoveries in accelerator physics and to many pioneering measurements of vector meson properties. Until 1975, six particle detectors were operated in turn at ACO, in particular the first detector that ever featured a longitudinal magnetic field.

Following an idea of Orsay Professor Yvette Cauchois a first synchrotron light beam was turned on at ACO in 1973, making it the first storage ring in



Europe available to synchrotron light users. In June 1983, a free-electron laser was successfully operated at ACO; the second in the world, it was the first one in the visible bandwidth and the first at a storage ring.

Until the mid-80's, particle physics and synchrotron light experiments ran in parallel on site, all were making use of the LAL linac either as an accelerator or as an injector. The former field was driven by the DCI collider where three detectors operated between 1976 and 1984. Close to nine million J/ψ particles were collected – the world largest sample at the time. Then, DCI was fully dedicated to hard X-ray production, while the successor of ACO, Super ACO, specifically designed as a synchrotron source started operating in 1987. Both were using positron beams.

▲ The unveiling of the EPS “Historic site” plate in front of the ACO collider. From left to right, on the front row: A. Stocchi, LAL director; G. Senzacqua, Frascati deputy mayor; S. di Tommaso, Frascati mayor; D. Ros, Orsay mayor; J. Dudley, president of the European Physical Society; M. Ducloy, a former EPS and SFP president. Two such plates are on display on site: one at the LAL main entrance, the other in the ‘Pierre Marin’ experimental hall that hosts the Science ACO museum.

Super-ACO provided twenty light beams to a large international user community working in atomic and molecular physics, solid state and surface physics, protein structure studies, among others. It featured six undulators and a free electron laser that produced a coherent beam in the visible-300 nm range.

Finally, in 1991, the CLIO free electron laser was commissioned. This facility, still in use today, allows one to investigate non-linear phenomena and ultra-fast processes in the infrared domain. These achievements, covering five decades of basic science, have motivated the European Physical Society to award its “Historic Label” to the LAL-LURE accelerator complex, making it the 8th such site in Europe and the second in France after the ‘Observatoire des Cosmiques’ in the Chamonix valley. The ceremony took place on September 13,

2013, in the ‘Pierre Marin’ experimental hall which hosts ACO, now registered French historical monument and one of the main attractions of the ‘Science ACO light and matter’ museum. This presentation was part of a series of events organized that day and the following weekend – on the occasion of the European Heritage Days – to celebrate the 50th anniversary of the collisions observed at AdA and to cement the LAL collaboration with the INFN Frascati laboratory (LNF), as well as a scientific twinning between the Orsay and Frascati cities.

LURE has given birth to SOLEIL, the French third generation synchrotron located a few kilometers away from Orsay, on the Saclay plateau. LAL is still a major laboratory whose research activities range from the infinitely small to the infinitely large, from the LHC to the Planck satellite. Its accelerator department is presently involved in many projects: the local and state-of-the-art PHIL photo-injector and the THOMX compact X-ray source; international projects like XFEL in DESY (Germany) and ELI-NP in Romania; or basic science developments at CERN, KEK, etc. ■

■ Nicolas Arnaud,
Jacques Haïssinski,

Laboratoire de l'Accélérateur
Linéaire (CNRS/IN2P3 and
Université Paris Sud), Orsay France

EUROPEAN PHYSICAL SOCIETY – EPS HISTORIC SITE
The LAL-LURE ACCELERATOR COMPLEX

THE “LABORATOIRE DE L'ACCELERATEUR LINEAIRE” (LAL, CNRS/IN2P3 AND PARIS-SUD UNIVERSITY) WAS SET UP IN 1956 TO OPERATE AN ELECTRON “LINAC” DESIGNED FOR NUCLEAR PHYSICS AND PARTICLE PHYSICS EXPERIMENTS. FROM 1958 TO 2003, THIS LINAC WAS THE HEART OF A COMPLEX OF STATE-OF-THE-ART FACILITIES INCLUDING: AN ELECTRON-POSITRON CONVERTER, SPECTROMETERS, COLLIDERS AND STORAGE RINGS FOR SYNCHROTRON LIGHT. PART OF THESE FACILITIES WERE SHARED WITH THE “LABORATOIRE POUR L'UTILISATION DU RAYONNEMENT ELECTROMAGNETIQUE (LURE)” WHICH WAS SET UP IN 1973.

MAJOR ACHIEVEMENTS AT LAL-LURE WERE:

- 1962-1964: FIRST OBSERVATION EVER OF ELECTRON-POSITRON COLLISIONS WITH THE AdA RING (BUILT IN FRASCATI) AND DISCOVERY OF THE TOUSCHEK EFFET.
- 1965: COMMISSIONING OF THE ACO ELECTRON-POSITRON COLLIDER WHERE PIONEERING MEASUREMENTS IN ACCELERATOR PHYSICS AND IN VECTOR MESON PHYSICS WERE PERFORMED.
- 1973: OPENING AT ACO OF A SYNCHROTRON BEAMLINE, THE FIRST EVER TO BE FED BY A STORAGE RING.
- 1983: FIRST LIGHT AMPLIFICATION EVER OBTAINED WITH A FREE ELECTRON LASER FED BY A STORAGE RING BEAMLINE (ACO).
- 1979-1984: RECORD PRODUCTION OF 9 MILLION J/ψ BY THE DCI ELECTRON-POSITRON COLLIDER, LATER CONVERTED INTO A HARD X-RAY SOURCE.
- 1987: SUPER-ACO SUPERSEDING ACO (SUPER-ACO WAS PHASED OUT IN 2003, SOLEIL TOOK OVER IN 2006).
- 1991: COMMISSIONING OF THE CLIO FREE ELECTRON LASER TO EXTEND IN THE INFRARED RANGE THE SPECTRUM PROVIDED BY THE ORSAY LIGHT SOURCES.

ORSAY, 13 SEPTEMBER 2013



European Programme for Research and Innovation Horizon 2020:

Opportunities for research and commitment to society

If you ask a member of the public about the meaning of FP7 or H2020, they might wonder, 'What on earth this has to do with us?'. Indeed, not so long ago scientists were considered a closed society living in ivory towers, spending much of their time in exotic laboratories and academic institutions.

Now, there is a growing commitment of scientists to share our knowledge and opinions with society. Indeed, it is our duty to explain how we use public funds invested in the development of basic science and technology. Investment in scientific research and education is essential for sustainable economic development. This is a basic principle, which motivated the goal established in 2000 by the European Council in Lisbon for Europe to become the world's most competitive and dynamic knowledge-based economy. Achieving this requires a firm commitment from the European Union, and each country in Europe, to continue to invest in scientific education and research, and to work to implement a unified research policy. The European Physical Society (EPS) strongly supports this view and moreover affirms its belief that re-focusing Europe as a knowledge-based society is the best way to deal with present and future social and economic challenges.

Horizon 2020 opportunities for research

The European research programme Horizon 2020 is a unique opportunity to reinforce the vital relation between basic science and technological applications, and thus to advance Europe's position in both research and innovation. Funding priorities and mechanisms in Horizon 2020 are founded on the principles that basic science and technology are interdependent, they drive each other in a synergetic way, and that both must be supported [1].

Horizon 2020 is an opportunity for both researchers and policy makers to recognise and expand Europe's scientific and technological strength. Europe has a dynamic culture of research creativity and diversity, and leads the world in areas ranging from fundamental particle physics to communications and aerospace technologies. But there is much room for improvement: for example, reducing research fragmentation and bureaucracy will improve use of public resources; simplifying academic-industry linkages will reduce time to market for new technologies; strengthening public-private partnerships will better promote growth and create jobs. Horizon 2020 has potential to support Europe's strengths and address Europe's

weaknesses. Investment in research is essential for economic growth, and reaffirms Europe's commitment to its future.

Horizon 2020 funding structure

The European Research Programme Horizon 2020 (H2020) will provide funding (in the range of €70 billion) for research and innovation from 2014 to 2020, bringing together all EU research and innovation funding provided through the Framework programme for Research and Technological development (FP), the Competitiveness and Innovation Framework Programme (CIP) and the European Institute of Innovation and Technology (EIT), with three strategic objectives [table 1]:

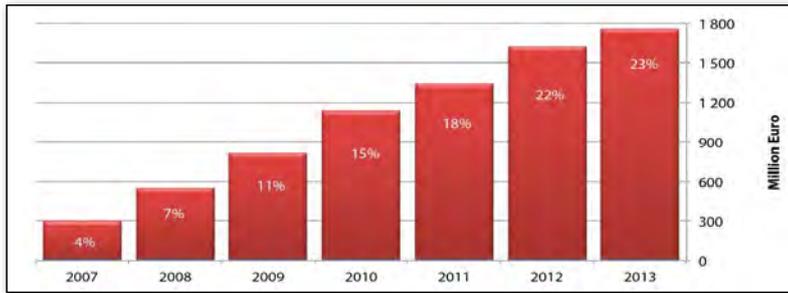
'**Excellent science**' including European Research Council grants to top-level individual researchers working in Europe, investment in emerging technologies to open up new fields of research and Marie Curie Actions to develop research and innovation skills through the training, mobility and career development of young researchers.

'**Industrial leadership**' including major investments in key industrial technologies such as, Information and Communication Technologies, Industry and Societal challenges, Nanotechnologies, Biotechnology and Space.

'**Societal challenges**' focusing on key areas like health and ageing, food security, clean and efficient energy, climate and smart transport where there is a need to involve the general public in the debate as well as in the scientific and political institutions. Societal challenges, as

▼ Table 1:
Foreseen
distribution
of H2020
budget

I. Excellent Science	31.73 %
1. European Research Council	17.00
2. Future and Emerging Technologies	3.50
3. Marie Curie actions	8.00
4. Research infrastructures	3.23
II. Industrial Leadership	22.09 %
1. Leadership in enabling and industrial technologies	17.60
2. Access to risk finance	3.68
3. Innovative small and medium-size enterprises	0.80
III. Societal Challenges	38.53 %
1. Health, demographic change and wellbeing	9.70
2. Food quality and marine research	5.00
3. Energy	7.70
4. Transport	8.23
5. Climate action, resources and raw materials	4.00
6. Inclusive societies	1.70
7. Secure societies	2.20
Spreading excellence and widening participation	1.06
Science with and for society	0.60
European Institute of Innovation and Technology-EIT	3.52
Joint Research Centre	2.47
Total	100%



◀ Fig 1: ERC budget evolution during FP-7 [<http://erc.europa.eu/about-erc/facts-and-figures>]. The ERC represents 15% of the overall FP7 budget (€ 7.51 billion of € 50.5 billion) as compared with 17% of the H2020 budget.

powerful drivers of change in economy, require cooperation along the whole chain from research to solutions.

The H2020 goal is to bring excellent research results to market with benefits to citizens by strengthening innovation with bottom-up activities, allowing Europe's brightest minds to propose their own solutions, reversing brain-drain and attracting talent from around the world and retain researchers in Europe, developing industrial leadership and competitiveness and promoting science education.

The European Research Council (ERC) has fulfilled the high expectations placed on it by the research community during the short time since it was established at the beginning of the 7th Framework Programme (FP-7). Thus, we are pleased with the increased funding in H2020 as compared to FP-7 [fig. 1]. The ERC is a successful pan-European funding organisation for frontier research that has funded, through both ERC Starting and Advanced Grants, over 3,600 frontier research projects throughout Europe [2] and has become a reference of the competitiveness and excellence of national research and innovation systems, complementing existing funding schemes at national and European levels. The last ERC call under FP-7, saw an increase in the demand for these grants, which is a continuing trend. The next Starting Grant calls will fall under the new Framework Programme, H2020. Providing clean and efficient energy is a key strategic challenge in Europe, with the H2020 programme bridging previous FP7 and CIP programmes (e.g. Fuel Cells and Hydrogen, Intelligent energy Europe programme) and the Strategic Energy Technology Plan-SET [3] (e.g. European Industrial Initiatives, European Energy Research

Alliance) initiatives [table 2]. The H2020 funds for energy (in the range of 7 %) and climate action (4%) are symbols of the importance of these challenges worldwide [4].

Europe 2020 financial instruments

We believe that current austerity measures in many countries in Europe should not jeopardise the future of Europe as a knowledge-based society. It is more important than ever that Horizon 2020 maintain its ambitious objectives, including support for: infrastructure and new facilities; both team-driven research and individual researchers; mobility, training and education. The European H2020 funding must be also supported with actions at national level for re-launching Europe as knowledge based society.

In addition, synergy is required between Horizon 2020 and the structural funds as financial tools set up to implement the regional policy of the European Union. The full commitment of EU and national politicians is essential, as key pillars in our democratic societies, with a truly European Research and Education global policy.

FP7	Horizon 2020
Energy	Challenge: secure, clean and efficient energy
Fuel Cells and Hydrogen-Joint Undertaking (www.fch-ju.eu)	Challenge: Secure, Clean and Efficient Energy. Alternative fuels and mobile energy sources (Reducing time to market for hydrogen and fuel cells technologies)
Competitiveness and Innovation Framework Programme (CIP)	Horizon 2020
Intelligent Energy Europe Programme (IEE)	Robust decision making and public engagement. Market uptake of energy innovation, empowering markets and consumers.
Strategic Energy Technology Plan (SET Plan Initiatives)	Horizon 2020
European Industrial Initiatives (EII) - EII Solar, Wind, Carbon capture and storage (CCS), Bioenergy, Smart Grids.	It may be envisaged that existing European Industrial Initiatives of the SET Plan are turned into formalised public-private partnerships to increase the level and coherence of national funding and to stimulate joint research and innovation actions among Member States.
European Energy Research Alliance (EERA) (www.eera-set.eu)	Further support may also be provided to the EERA established under the Strategic Energy Technology Plan (SET Plan).

▼ Table 2: H2020 programme bridging previous FP7, Competitiveness and Innovation Framework (CIP) Programmes and the Strategic Energy Technology (SET) Plan

Outlook

Science and education provide the tools to understand current social challenges. They provide citizens with the capability of critically examining options presented to them. This free thinking enables independent and well-founded views on the difficult social and economic issues that lie ahead of us.

We urge research policy makers at the European level to support European research and development through a coherent and inclusive European and regional policy that strengthens the mutually beneficial relationship between education, research and innovation. Research and education provide the opportunities for innovation that Europe needs. ■

■ C. Hidalgo, D. Lee and J. Dudley,
European Physical Society

References

- [1] http://ec.europa.eu/research/horizon2020/index_en.cfm
- [2] <http://erc.europa.eu/statistics-0>
- [3] http://ec.europa.eu/energy/technology/set_plan/set_plan_en.htm - http://ec.europa.eu/energy/technology/fp7_en.htm
- [4] A "Supplementary Research Programme" under the EURATOM Treaty will provide the EU contribution to the ITER project from 2014 to 2018 to fund this contribution outside the Multi-annual Financial Framework after 2013. The Supplementary Research Programme will ensure that Europe is able to honour its international obligations to the ITER project aiming to demonstrate fusion as a viable and sustainable source of energy.

The Energy Network

Norway 2005-2013

In the year 2005 Vest-Telemark high school got a challenge from Statkraft region East. Statkraft is the biggest Hydro Power Company in Norway. They wanted Vest-Telemark upper secondary school to coordinate energy activities at the secondary schools in the region.

The National Centre for Science Education found the idea so good, that they wanted it to be a national network. The idea was to have regional networks with one upper secondary school as focal point in a network of secondary schools. Together with Statkraft and The Ministry of Education, they decided to finance the project. The project was launched as a part of the World Year of Physics with a big celebration in The Oslo University's Aula. The first year the network consisted of 11 local networks and a total of 39 schools. At the same time we invited separate schools to join a weather station network. In the final project year of 2012/13 we were 12 local networks with a total of 46 schools.

The main idea in the project has been to create enthusiasm among the students through:

- **Teaching physics themselves**

Students from upper secondary school function as teachers for the students in a secondary school. For example could students organize an Energy Day or an Energy Camp.



▲ The winner of the Energy Camp 2012 at Hardangervidda, Høydalsmo school

- **The use of modern weather stations**

The upper secondary schools form a network of Davis weather stations throughout Norway. The data from these stations can be used in different subjects like natural science, physics, mathematics and geography,

The Energy Week

Every year since 2008 we have organised what we call The Energy Week. In this week all schools in the network organise energy activities at their own school. The schools were free to define what they wanted to do. The network provided some ideas like The Energy Detective, Solar Energy activities and The Energy Game.

Teacher network and workshops

One of the strong motivations for the teachers to participate in the network has been to be a part of a national teacher network. A network of teachers that share the same interest in energy issues. In addition they get in direct contact with scientists from the participating institutions [The Norwegian University of Life Sciences (UMB), Royal Norwegian Naval Academy, The University of Oslo (UIO), The Norwegian Radiation Protection Authority (NRPA) and Statkraft].

Every year all the teachers, two from each school, meet to discuss the project and present new ideas. At this yearly workshop we invite scientists to present a specific topic related to energy. These workshops have been important in many ways:

- It gives the project management an opportunity to meet the participants in person and get feedback
- It gives the teachers an ownership of the project
- It gives new ideas and new inspiration
- It gives all participants new and updated knowledge about energy issues.

EXPLANATORY CAPTION

The Physics Education Division awards a prize every second year for outstanding contributions to secondary school teaching. This year, Karl Torstein Hetland, West Telemark Secondary School, Norway, was selected "for his leadership in national and international school networks, in particular the Norwegian Energy network".

Mr Hetland led various other teaching projects in Norway as well, and was the Norwegian co-ordinator of a number of international projects involving schools in Estonia, Latvia and the Czech Republic, as well as of the Eratosthenes Experiment during the World Year of Physics. Mr. Hetland received the award at the International Physics Education

Conference, held together with the European Physics Education Conference on August 5 in Prague, Czech Republic. The picture shows Mr.Hetland with Gorazd Planinsic, chair of the Physics Education Division, and Urbaan Titulaer, chair of the award committee. This article describes the Energy Network, for which the prize was awarded. ■



All final reports from the individual networks you will find here. You will find a lot of ideas just by looking at the pictures in the reports.

Statistics

The total number of schools involved in the project, in shorter or longer periods, has been 16 upper secondary schools, 45 secondary schools and 8 primary schools. A total of 223 teachers and about 25000 students have participated. ■

Acknowledgement

The project management group will give a big thank you to Statkraft, The Norwegian Centre for Science Education and The Ministry of Education for their financial support. A big thank you to The Norwegian University of Life Sciences (UMB), The University of Oslo (UIO), Royal Norwegian Naval Academy and The Norwegian Radiation Protection Authority (NRPA), for their scientific and practical support. And at last, but the most important: A big thank you to all the teachers and students who have participated in the project.

Links

www.naturfagsenteret.no/energinettverket

<http://verstasjon.net/verstasjonskart.htm>

<http://miljolare.no/aktiviteter/by/ressurs/br31/>

www.naturfagsenteret.no/c1519048/artikkel/vis.html?tid=2006157&within_tid=1514653

www.statkraft.com



Øystein Håkon Fischer

(March 9, 1942 – September 19, 2013)

Prof. Øystein Fischer, Honorary Professor at the University of Geneva, initiator and founding Director of the Swiss National Center of Competence in Research, MaNEP, dedicated to exploring electronic materials of the future, passed away on 19 September 2013 at the age of 71.



Øystein Fischer was born on March 9, 1942 in Bergen, Norway. He obtained a Diploma degree in theoretical physics at the Swiss Federal Institute of Technology in Zurich in 1967 and his PhD degree in experimental physics at the University of Geneva in 1971 where he was appointed full professor in 1977. Øystein Fischer dedicated much of his career to studying superconductors and their applications. In 1975, he synthesized the first superconducting compounds (Chevrel phases) containing a regular lattice of magnetic ions - a discovery which launched a decade of international research concerning the interaction between magnetism and superconductivity. This research culminated in 1984 with his discovery of magnetic field induced superconductivity in these same materials. He also initiated a sustained effort growing the first artificial superlattices of HTS cuprates which contributed to the now rapidly developing fields of oxide thin film heterostructures and oxide interface physics. The last two decades of his research mainly focused on applying the scanning tunnelling

microscope (STM) to studying HTS materials. This enabled his team to observe the vortex cores and the pseudo-gap in cuprate high-critical-temperature superconductors, highlighting some of the key differences between these novel systems and classic superconductors.

In addition to his remarkable activities in research, Øystein's relentless commitment to physics in Geneva, and condensed matter physics in Switzerland and internationally was known to all. His leadership as MaNEP director led to a remarkable development of collaborations between scientists in academia and with industry.

Committed to promoting Geneva's development, Prof. Fischer initiated the Geneva Creativity Center, to stimulate exchanges between the academic and industrial sectors and 'The Centre of astronomical, physical and mathematical sciences', one of the leading projects of the University of Geneva. His vision and the energy he was able to put towards causes he championed were exceptional.

A very talented and much appreciated teacher, Øystein Fischer trained many undergraduates, PhD students and postdocs. He received numerous awards and distinctions, including 'Doctor honoris causa' from the Universities of Rennes (1990) and Neuchâtel (2005); the Gunnar Randers Research Award (2005); the endowed 'Tage Erlander' Chair from the Swedish Council for Research (2009) and the prestigious Kamerlingh Onnes prize (2012). ■



EPS HISTORIC SITES

The Hven Island in Øresund, The sound between Sweden and Denmark

On the 11th September 2013 a ceremony took place to unveil an EPS Historic Site plaque at the place where the world famous astronomer Tycho Brahe during the years 1577 to 1597 made his famous observations of the planetary system. The place is on the Hven Island situated in Øresund, the sound between Sweden and Denmark. Hven is today part of the municipality of Landskrona in Sweden. The work done there played an essential part in shaping our modern world picture. This is the 7th EPS Historic Site ceremony.

At the castle Knutstorp's Borg in what was once part of Denmark, but is now south of Sweden, Tycho Brahe was born in 1546. Sixteen-years-old Brahe began to keep a logbook of his own astronomical observations. The 11th November 1572 Brahe discovered a "new star" in the constellation Cassiopeia. It was brighter than any other star or planet in the sky. The discovery is in

▼ The statue of Tycho Brahe surrounded by ceremony attendees at Hven Island in Øresund, seen far away in the landscape (photo R. Hellborg)

detail described in his book "*De Stella Nova*". It was in all probability a type I supernova, the explosion of a "white dwarf"! The book aroused widespread attention and firmly established Brahe's reputation as an astronomer. His conclusion that the new heavenly body was a star was in conflict with the views of space as unchangeable. King Frederick of Denmark regarded the impressive young astronomer

with heightened interest and offered Brahe the Hven Island. Frederick also offered to pay, out of the royal coffers, all expenses for building a suitable residence on Hven and for founding and maintaining a research establishment. Brahe could not refuse this offer. On Hven Brahe built the first completely purpose-built observatory in Europe, he named it Uraniborg. It was a combination of observatory, chemistry lab and living house for students and Brahe's family. Starting the winter of 1577, Brahe began to make systematic observations from Hven. Brahe had his own instrument shop at Uraniborg and he supervised the manufacture closely. After a few years Uraniborg was too crowded with students arriving from nearly all over Europe and with instruments in use and in various stages of construction. Brahe therefore decided to build a second observatory. It was named Stjerneborg and was designed with five great cellars or amphitheatres to house giant instruments. Brahe organized it such that nearly everything needed could be produced on the island, including a paper mill and a printing office. The observations of the planets continued



nearly daily with unprecedented accuracy until March 1597. This was made possible by Brahe's ingenuity in improving astronomical instruments and designing new ones. One has to remember the telescope had yet to be invented. That spring of 1597 Brahe and his family left Denmark after a dispute with the new king Christian, son of Frederick. By the end of 1597 Brahe, temporary staying in Germany, was busy writing a book *Astronomiae Instauratae Mechanica* about his Hven instruments. He also worked with his star catalogue. Brahe dedicated these two volumes as a gift to the Emperor Rudolph II of the Holy Roman Empire. This was ruled from the court in Prague. Brahe was soon invited to Prague and in July 1599 he arrived. Johannes Kepler living in Graz in Austria heard about Brahe's triumphal entry into Prague. Kepler was looking for some hint in the geometry of Mars' movements that was responding to a force coming from the Sun. A continuation of Kepler's work seemed to him increasingly to depend on being able to consult observations that only Brahe could provide. Late in 1599 Brahe offered a stipendium insisting that Kepler must come to Prague. Kepler could not withstand this offer. After arriving in Prague Kepler started using Brahe's Mars observations in an innovative way to study Earth's orbit. He found that Earth like the other planets speed up as they come nearer the Sun and slow down as they move further away. This was really a breakthrough. Kepler had - as a mathematician - the potential to do the analysis. Brahe was the great instrument builder and experimentalist. Soon Brahe introduced Kepler to the Emperor Rudolph and made a proposal: Brahe and Kepler would compile a new set of astronomical tables based on Brahe's observations. With the Emperor's permission these tables would be named the *Rudolfine Tables*. Only a few weeks after the meeting with the Emperor, Brahe died. Kepler's analysis of Brahe's



▲ The Rector of Lund University Per Eriksson and the Vice President of EPS Luisa Cifarelli unveiling the Hven plaque. The text on the plaque, in Swedish and English, is:
European Physical Society – EPS Historic Site, The Observatory of Tycho Brahe
 Here, from 1577 to 1597, the astronomer Tycho Brahe - born in 1546, at Knutstorp Castle, Kågeröd, died in 1601, in Prague - made his famous observations of the planetary system. His observatory was the most advanced astronomical research centre in Europe. His work, the summit of the period of systematic visual sky observation without telescope, played an essential part in shaping our modern knowledge of the world. (Photo Sayed Khatib)

Kepler's laws contributed to Newton's formulation of his laws

observations led after some years Kepler to formulate his three laws of planetary motion. Three-quarters of a century later Kepler's laws contributed to Newton's formulation of his laws.

Following Tycho Brahe's departure from Hven, his installations rapidly fell into disrepair and today only fragments survive. Extensive sections of the ramparts are still to be seen at Uraniborg, as well as parts of the foundations of the main building. Smaller remains of the observatory crypts of Stjerneborg can be seen.

About 45 persons took part in the unveil ceremony. It was honored by the presence of the Mayor of Landskrona, the Rector of the Lund University, the president of the Swedish Physical Society, the former president of the Danish Physical Society and many other guests. After the unveiling of the plaque set up at the entrance of the museum a guided tour to the sites of the Uraniborg and Stjerneborg,

and a visit to the museum – housing finds made during excavations of the observatory area - took place. After transport to a nearby restaurant an outstanding lecture on Brahe's life on Hven and his scientific achievement was given by Professor John R Christianson, followed by a presentation of the EPS Historic Sites initiative by EPS vice-president Luisa Cifarelli. Finally a dinner was served before people returned to Landskrona by ferry. ■

■ **Ragnar Hellborg,**
Department of Physics,
Lund University

ERRATUM

The photograph of Saturn and Titan published in EPN 44/5, p.16 was erroneously attributed to the Hubble Telescope. It was made by NASA's Cassini spacecraft on May 6th, 2012. ■

The Brout-Englert-Higgs mechanism in perspective:

a comment on the 2013 Nobel Prize in Physics

In 1964, two, almost simultaneous, papers [1,2], by Robert Brout* and François Englert and by Peter Higgs offered a solution to the clash between vector boson masses and renormalizability, paving the way to a predictive unified electroweak theory [3]. The key concept was spontaneous symmetry breaking, a notion originating from condensed matter physics and introduced in particle physics in 1961 by Yoichiro Nambu and Giovanni Jona-Lasinio [4]. In this article, I would like to illustrate the role of the fundamental work recognized this year with the Nobel Prize in the perspective of the unification of fundamental forces.

At the beginning, it was proton and neutron, with a mass difference of less than 2 per mill. It was natural to assume, with Werner Heisenberg [5], that strong interactions were exactly symmetric under p-n transformations – the Isospin symmetry – and that the electromagnetic interaction was responsible for the small mass difference, although the neutron heavier than the proton could have cast some doubt. The idea was supported by the discovery of mesonic and baryonic isospin multiplets with similar mass differences.

Then came the Eightfold Way [6] of Murray Gell-Mann and Yuval Ne'eman, a symmetry encompassing strange and non strange mesons and baryons, and the successful prediction of the Ω^- . One had to admit, however, that “some” part of the strong interaction, with a strength of about 30 percent of the total, did break the global SU(3) symmetry. Quarks brought a significant clarification: we could attribute the breaking of the symmetry to the unequal values of the up, down and strange quark masses, the latter being some 150 MeV heavier than the former.

One of the reasons why this picture was accepted is that, in field theory, mass terms have dimension less than four, the maximum renormalizable



▲ Peter Higgs
© PhotoCERN.

► François Englert
© PhotoCERN.

* R. Brout was born in 1928 (New York) and passed away in 2011 (Bruxelles).

dimension. The symmetry breaking induced by mass differences does not spoil the renormalization properties of a theory of quarks and neutral gluons [7,8]. The concept of “partial conservation” of the symmetries associated to the global, chiral SU(3)×SU(3) vector and axial vector currents could be introduced and it was the basis of the

successful Cabibbo theory, unifying the beta decays of strange and non strange particles [9].

In 1961, Sheldon Glashow [10] proposed a unified gauge theory of the weak and electromagnetic interactions, a line of thought initiated by his mentor Julian Schwinger. Glashow’s theory considered the interactions of the electron-neutrino doublet in a Yang-Mills theory with a non abelian gauge symmetry and V-A weak interactions. The starting point had two important consequences.

Extending Schwinger’s work based on the group O(3), the gauge group had to be SU(2)×U(1), including a fourth, neutral, intermediate boson, Z⁰, in addition to the usual charged bosons, W[±], and the photon. New, neutral current weak interactions were predicted, mediated by the Z⁰.

Secondly, the left-handed electron and neutrino fields were classified in an SU(2) doublet, leaving the right-handed electron in a singlet. Thus the electron mass term, which couples left-handed with right-handed electrons, had to break the gauge symmetry.

Glashow introduced a symmetry-breaking mass term for the vector fields as well, to account for a massless photon and massive intermediate bosons. Assuming electric charge conservation, Z and γ are superposition

of the triplet and singlet $SU(2)\times U(1)$ vector fields, with a mixing angle, θ_w , which determines the structure of neutral current processes.

A mass term for gauge vector fields, however, has dramatic consequences. In the exact symmetry limit, gauge fields have only two helicity components, like the photon, while the mass term provides an helicity zero component as well, which, in turn, makes more singular the high energy behaviour of the vector field propagator. The ultraviolet properties of the theory become of the non-renormalizable kind, unless the longitudinal component decouples. In fact, it has become more and more clear, particularly through the work of Martin Veltman [11], that the massive Yang-Mills theory had to be non-renormalizable, unlike massive QED or the neutral gluon theory. As an alternative to explicit symmetry breaking, a spontaneously broken symmetry envisages an exactly symmetric lagrangian and exactly conserved currents. In a relativistically invariant field theory, the symmetry is broken by the non invariance of the vacuum state.

For global symmetries, following the Nambu and Jona-Lasinio's paper, the situation had been analysed by Goldstone [12], resulting in the so-called Goldstone theorem that affirms the existence of a massless spin zero particle for each symmetry generator which does not leave the vacuum invariant, at odds with the notable absence of spin zero massless particles in the particle spectrum. The work of Brout, Englert and Higgs resolved the conundrum and marked a crucial turn in the road towards the unification of forces.

Starting from the Goldstone example of a theory invariant under a $U(1)$ global symmetry, based on self-interacting field $\phi = (\phi_1 + i\phi_2)/\sqrt{2}$, they introduced a massless gauge field minimally coupled to ϕ , thereby promoting the global symmetry to a local gauge symmetry. The symmetry is broken by a non-vanishing vacuum expectation value (VEV) of ϕ_1 . In this situation, one obtains a



▲ Peter Higgs and François Englert at the seminar at CERN when the discovery was announced (July 4th 2012). © PhotoCERN.

vanishing mass-term for ϕ_2 , in line with the Goldstone theorem. However, now the would-be Goldstone field can be completely eliminated by a space-time-dependent gauge transformation and, at the same time, the VEV of ϕ_1 produces a non-vanishing mass term for the vector field.

What has happened is a sort of miracle, since known as the “Brout-Englert-Higgs mechanism”, whereby two paradoxes (a massless vector field and a massless Goldstone boson) annihilate with each other, to produce the desired massive vector field and no Goldstone bosons at all! Another way to describe the mechanism is to say that the would-be Goldstone field, ϕ_2 , has provided the longitudinal component needed to promote the massless gauge field into a massive spin 1 field. The transition massless to massive is non-singular, since the number of degrees of freedom is unchanged, unlike the previous case where the mass is produced by adding a symmetry-breaking term in the Lagrangian. The scalar field does not disappear entirely, however, in that the field ϕ_1 remains a physical spin zero field with a mass, M , determined by the coupling of the original scalar interaction. This field is coupled to the vector field in a non minimal way, with a coupling proportional to the very same mass acquired

by the vector field, a characteristic signature of the BEH mechanism itself. Three years later, the BEH mechanism was taken by Steven Weinberg [13] and Abdus Salam [14], independently, as a basis for their unified model of the electron-neutrino weak and electromagnetic interactions, using Glashow's $SU(2)\times U(1)$ gauge symmetry. The scalar field introduced by Weinberg and Salam is a $SU(2)$ doublet, which has the advantage that it may couple the left-handed (ν_e, e) doublet to the right-handed electron (a singlet), so that the VEV of ϕ is able to produce a mass for the electron as well. As in the BEH case, after elimination of the would be Goldstone bosons, one is left with a single, neutral, scalar field coupled to fermions and gauge fields in a characteristic way, proportional to their masses. This particle, by an abuse of language, is since universally known as “the Higgs boson”.

At the end of his paper, Weinberg commented on the open problems of the theory so far constructed. *Is this model renormalizable? We usually do not expect non-Abelian gauge theories to be renormalizable if the vector-meson mass is not zero, but our A and B mesons get their mass from the spontaneous breaking of the symmetry, not from a mass term put in at the beginning. Indeed, the model Lagrangian we*

start from is probably renormalizable, so the question is whether this renormalizability is lost in the reordering of the perturbation theory implied by our redefinition of the fields. And if this model is renormalizable, then what happens when we extend it to include the couplings of A and B to the hadrons? Indeed, if one tried to extend the theory to the hadrons using the three quarks introduced by Gell-Mann and the Cabibbo description of the weak currents, the exchange of Z^0 would produce strangeness-changing neutral current processes to a level firmly excluded by the then available experiments. But in 1970, Sheldon Glashow, John Iliopoulos and myself [15] showed that the introduction of a fourth quark, coupled to the superposition of down and strange quarks orthogonal to the Cabibbo, would produce, in lowest order, only strangeness-conserving neutral current processes, in agreement with data. As for renormalizability of the BEH mechanism for a non-Abelian gauge theory, a first proof was given in 1972, by Gerard 't Hooft and Martinus Veltman [16], with the final proof of the cancellation of the Adler-Bell-Jackiw anomalies among quarks and leptons of each generation obtained

by Claude Bouchiat, John Iliopoulos and Philippe Meyer [17] in 1973.

In 1973, with the discovery of asymptotic freedom [18] and the proposal of a third generation by Makoto Kobayashi and Toshihide Maskawa [19] to describe CP violation, the Standard Model was essentially completed and a season opened of great experimental discoveries, which have made SM into one of the greatest and better controlled constructions of modern physics: neutral current neutrino processes (CERN, 1973), the observation of the charm quark (Brookhaven and SLAC, 1974), the observation of the first particles of the third generation with the τ lepton (SLAC, 1976) and the b quark (FermiLab, 1976), the W^\pm and Z^0 bosons (CERN, 1982) and the t quark (FermiLab, 1994).

After that, the long Higgs boson hunting at LEP, Tevatron and finally at the LHC, where its discovery has been announced in July 2012, by the international ATLAS and CMS collaborations.

We are now looking forward to the physics to find beyond the Standard Model. ■

■ **Luciano Maiani,**

E. Fermi Chair, Sapienza University of Roma, Roma, Italy

References

- [1] F. Englert, R. Brout, *Phys. Rev. Lett.* **13**, 321 (1964)
- [2] P. W. Higgs, *Phys. Rev.* **145**, 1156 (1966)
- [3] related work was done by G.S. Guralnik, C. R. Hagen, and T. W. B. Kibble, *Phys. Rev. Letters* **13**, 585 (1964)
- [4] Y. Nambu and G. Jona-Lasinio, *Phys. Rev.* **122** (1961), 345; *Phys. Rev.* **124**, 246 (1961). The first presentation of the model was made at Midwest Conference on Theoretical Physics: "A superconductor model of elementary particles and its consequences", in the Proceedings, eds. F. J. Biedenharn *et al.*, Purdue University, 1960, p. 1.
- [5] W. Heisenberg, *Zeitschrift für Physik* **77**, 1 (1932)
- [6] M. Gell-Mann and Y. Ne'eman, "The Eightfold Way", W.A. Benjamin, Inc. Publishers (1964).
- [7] see M. Gell-Mann, *Phys. Rev.* **125**, 1067 (1962); non renormalization of the weak currents in the gluon theory have been studied in G. Preparata and W. I. Weisberger, *Phys. Rev.* **175**, 1965 (1968).
- [8] S. Coleman, "Aspects of Symmetry", Cambridge University Press (1985).
- [9] N. Cabibbo, *Phys. Rev. Lett.* **10**, 531 (1963).
- [10] S.L. Glashow, *Nucl. Phys.* **22**, 579 (1961)
- [11] M. Veltman, *Nucl. Phys.* **B7**, 637 (1968); H. Reff and M. Veltman, *ibid.* **B13**, 545 (1969).
- [12] J. Goldstone, *Nuovo Cimento* **19**, 154 (1961); J. Goldstone, A. Salam, and S. Weinberg, *Phys. Rev.* **127**, 965 (1962).
- [13] S. Weinberg, *Phys. Rev. Lett.* **19**, 1264 (1967)
- [14] A. Salam, in N. Svartholm: Elementary Particle Theory, "Proceedings of the Nobel Symposium 1968", 367 Lerum Sweden (1968)
- [15] S.L. Glashow, J. Iliopoulos, L. Maiani, *Phys. Rev. D* **2**, 1285 (1970).
- [16] G. 't Hooft, M.J.G. Veltman, *Nucl. Phys. B* **44**, 183 (1972)
- [17] C. Bouchiat, J. Iliopoulos and P. Meyer, *Phys. Lett. B* **42**, 91 (1972)
- [18] D.J. Gross and F. Wilczek, *Phys. Rev. D* **8**, 3633 (1973); *Phys. Rev. D* **9**, 980 (1974); H.D. Politzer, *Phys. Rev. Lett.* **30**, 1346 (1973)
- [19] M. Kobayashi and T. Maskawa, *Prog. Theor. Phys.* **49**, 652 (1973)

EPS LIQUID MATTER PRIZE 2014 AWARDED TO PROF. ROBERT EVANS

The Liquid Matter Prize 2014 of the European Physical Society, awarded every three years for outstanding contributions to the science of liquid matter, will go to Prof. Robert Evans of the University of Bristol, UK.



The prize will be presented at the 9th Liquid Matter Conference, 21-25 July 2014, in Lisbon, Portugal. Previous awardees were J-P. Hansen (2005), H.N.W. Lekkerkerker and P.N. Pusey (2008), and David Chandler (2011). Prof. Evans, a world-leading scientist in the broad field of statistical mechanics of liquids and colloidal dispersions, receives the prize "for seminal works applying density functional theory to the statistical mechanics of liquid matter, including highly

original and lasting contributions to understanding interfaces and phenomena such as criticality, wetting, capillarity, and phase transitions of simple and complex fluids".

Bob Evans was born near Durham in 1946. He received a BSc degree in Mathematical Physics from the University of Birmingham in 1967, and continued his studies at the University of Bristol, where he obtained a PhD in 1970 under the supervision of John Ziman. Evans has remained

affiliated to Bristol ever since, climbing the academic ranks to become H.O. Wills Professor of Physics. In 2005 he was elected Fellow of the Royal Society. Since 2011 he has been Professor Emeritus at the University of Bristol.

9th Liquid Matter Conference: www.fc.ul.pt/en/conferencia/liquids-2014 ■

M.M. Telo da Gama,
Chair EPS Liquids Board
C. Dellago,
Chair Prize Committee

Journal of Space Weather and Space Climate

An international, open access and peer-reviewed journal

A link between all the communities involved in Space Weather and in Space Climate such as (but not limited to) space, solar, and atmospheric scientists, engineers, forecasters, social scientists, economists, physicians, insurance experts...

www.swsc-journal.org



OUR STATE OF THE ART ARPES SYSTEM MBS A-1 SYS GIVES YOU THE SOLUTION!

Launched Products

Sub-meV ARPES System: MBS A1SYS **NEW!**

Sub-meV PES analyser: MBS A-1

Super intense Low Energy Photon Source: MBS T-1

He lamp: MBS L-1

Spin detector: MUSPIN etc.

For Detailed Information **Please Contact Us:**

MB SCIENTIFIC AB



MBS T-1

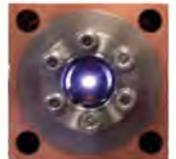
Seminariegatan 29B, SE-752 28, Uppsala, SWEDEN

Tel: +46 18 290960

Fax: +46 18 572683

info@mbscientific.se

www.mbscientific.se



Goodfellow

www.goodfellow.com

Your partner for metals and materials

Goodfellow Cambridge Limited
Ermine Business Park
Huntingdon PE29 6WR UK
Tel: +44 (0) 1480 424 800
Fax: +44 (0) 1480 424 900
info@goodfellow.com

ON-LINE CATALOGUE



FAST DELIVERY



CUSTOM MADE ITEMS



SMALL QUANTITIES



MACHINING

Highlights from European journals

CONDENSED MATTER

Hydrodynamics of the fractional quantum Hall effect

Many features of the Fractional Quantum Hall effect (FQHE) can be understood by considering electrons on the surface of semiconductors as a very peculiar, charged, two-dimensional fluid in the presence of a strong magnetic field. In this paper a classical hydrodynamic model of such a fluid is presented. The model incorporates a relation between the vorticity and density of the fluid specific for FQHE and exhibits the Hall viscosity and Hall conductivity found in FQHE liquids. The relation of the model to previous effective models such as the Chern–Simons–Ginzburg–Landau theory of FQHE is explained. It is also shown how the Laughlin's wavefunction is annihilated by the quantum velocity operator. ■

■ **A.G. Abanov,**

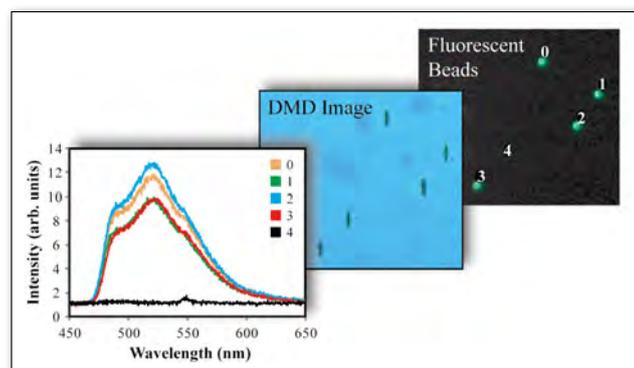
'On the effective hydrodynamics of the fractional quantum Hall effect', *J. Phys. A: Math. Theor.* **46**, 292001 (2013)

OPTICS

A multi-object spectral imaging instrument

Imaging spectrometers acquire three-dimensional spectral data cubes (x, y, λ) to enable chemical imaging in fields ranging from microscopy and biomedicine to remote sensing. Traditional systems, employing time-sequential recording of the complete data cube, cannot record time-varying phenomena and are

▼ Fluorescent microbeads are tracked using a camera. A series of slits displayed on a DMD deflect light into a spectrometer and are updated to follow the microbeads. Spectra are obtained in real time from a CCD image of the slits after dispersion from a prism.



optically highly inefficient. Our technique enables spectra to be recorded in real time from a programmable sparse array of spots within a microscope sample. Real-time computer-controlled manipulation of the spot array enables tracking and video-rate spectroscopy of these points with the very high optical efficiency. This is achieved with a digital micro-mirror device (DMD) that deflects light from the sparse multiple points in the sample into a slitless spectrometer consisting of a dispersive prism and CCD camera. We demonstrate real-time spectra of multiple fluorescent microbeads in aqueous solution as they diffuse in the sample. ■

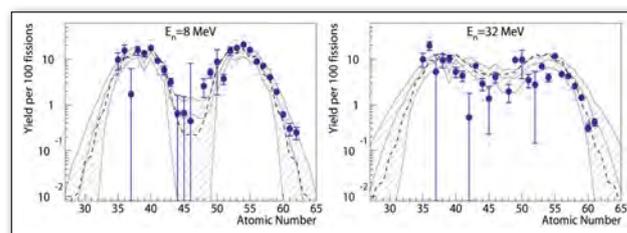
■ **G.M. Gibson, M. Dienerowitz, P.A. Kelleher, A.R. Harvey and M.J. Padgett,**

'A multi-object spectral Imaging Instrument', *J. Opt.* **15**, 085302 (2013)

NUCLEAR PHYSICS

X-rays emitted in neutron-induced fission of $^{238}\text{U}(n,f)$

Prompt x-rays emitted in neutron-induced fission help unveil the evolution of fission fragment charge yields as a function of incident neutron energy.



▲ Charge distribution determined from the x-ray yield measurements (symbols) for different incident neutron intervals. For more detail see text.

Nuclear fission is accompanied by the prompt emission of neutrons, gamma rays and x-rays. It has been known since the sixties that fission prompt x-rays originate essentially as a consequence of the internal conversions occurring in the prompt gamma deexcitation cascades of fission fragments.

This work presents for the first time a measurement of the prompt fission x-ray yields in $^{238}\text{U}(n,f)$ for average incident neutron energies ranging from 3 to 200 MeV. Fission fragment charge distributions are derived from the measured x-ray yields using x-ray emission probabilities per fragment obtained in an earlier work on low energy fission. The results are found to be in a remarkable agreement with the Wahl

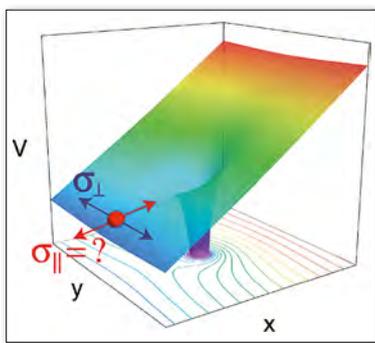
phenomenological systematics for fission product yields, as well as with the more sophisticated GEF fission model. More detailed comparisons demonstrate that x-ray emission evolution with increasing incident neutron energy tends to be dominated by the transition towards lighter fragments which on average are closer to closed-shell nuclei and are thus less subject to internal conversion. ■

■ **T. Granier, R.O. Nelson, T. Ethvignot, M. Devlin, N. Fotiades, P.E. Garrett and W. Younes,**
'Measurement of prompt X-rays in $^{238}\text{U}(n,f)$ from threshold to 400MeV', *Eur. Phys. J. A* **49**, 114 (2013)

ATOMIC AND MOLECULAR PHYSICS

Electron wave packet after tunnel ionization

The dynamics of electron ionization are an important topic in attosecond science. Applying a strong laser pulse, electrons can quantum mechanically tunnel through the potential barrier created by the combined Coulomb field of the atom and the laser field. At the tunnel exit, it is commonly assumed that the electron velocity parallel to the electric field is zero, contrary to the well-described distribution of transverse momenta.



▲ Coulomb potential tilted by the laser field. More accurate theoretical descriptions are necessary to account for the longitudinal spread.

Monte Carlo simulations with zero initial longitudinal momentum agree with the theoretical predictions of acquired spread, while simulations that include a longitudinal momentum spread at the tunnel exit are compatible with experimental data. The authors introduced a new method to investigate electron velocity spreads after ionization. Applying this method to experimental data leads to a more accurate reconstruction of the electron wave packet immediately after tunnelling. ■

■ **C. Hofmann, A.S. Landsman, C. Cirelli, A.N. Pfeiffer and U. Keller,**
'Comparison of different approaches to the longitudinal momentum spread after tunnel ionization', *J. Phys. B: At. Mol. Opt. Phys.* **46**, 125601 (2013)

After ionization, electrons propagate in the remainder of the laser pulse, where they acquire a momentum spread due to the different phases of the field at their individual exit time. However, the longitudinal momentum spread measured in experiments on helium is considerably larger than that.

CONDENSED MATTER

Universality in the symmetric exclusion process

A system connected to two sources of heat or particles reaches, in the long time limit, a non-equilibrium steady state characterized by a non-vanishing and fluctuating current. Its study is an active topic in both classical and quantum systems. A relevant observable is the number Q_t of particles flowing through the system during a time t . It can be calculated for simple models such as the symmetric simple exclusion process (SSEP), which describes two reservoirs at fixed densities connected by an L -site chain on which particles diffuse with a same site hard core repulsion. The corresponding cumulants of Q_t are exactly known in one dimension and they coincide with those computed for the transport of free fermions through a mesoscopic conductor. We have generalized these results to arbitrary large but finite d -dimensional domains or graphs. Our numerical results indicate that, for large enough lattices and contacts to the reservoirs, the ratios of the cumulants of Q_t take universal values, independent of the domain dimension and shape. ■

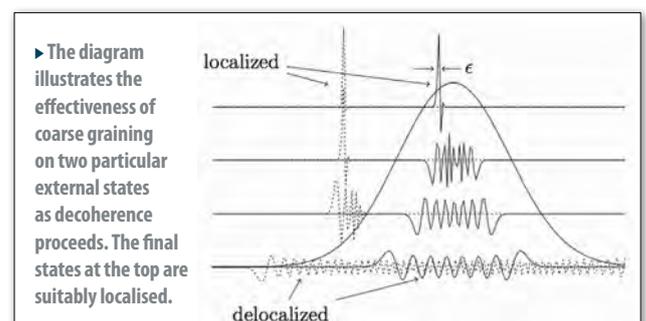
■ **E. Akkermans, T. Bodineau, B. Derrida and O. Zeitner,**

'Universal current fluctuations in the symmetric exclusion process and other diffusive systems', *EPL* **103**, 20001 (2013)

QUANTUM PHYSICS

Copenhagen interpretation as an emergent phenomenon

This work shows that a successful interpretation of quantum mechanics can be seen to emerge by taking the actual, or internal, states of a sub-system to correspond to one of the eigenvectors of its reduced density matrix. Previous work has highlighted serious objections to such a modal type interpretation because it apparently leads to macroscopic superpositions and physically unacceptable instabilities near degeneracies. We show that both these problems are solved if the sub-system consists of a large number of coarse-grained degrees of freedom which is natural as real measuring devices have both finite spatial and



temporal resolution. What results is an interpretation in which both decoherence and coarse graining play key roles and from which the rules of the Copenhagen Interpretation are seen to emerge in realistic situations. In this interpretation a measurement process is smooth but results in internal states that correspond to the distinct outcomes one expects. Previous work has suggested that the internal states of a device measuring the position of a particle would be spread out macroscopically. ■

■ **T. J. Hollowood,**

'The Copenhagen interpretation as an emergent phenomenon', *J. Phys. A: Math. Theor.* **46**, 325302 (2013)

APPLIED PHYSICS

Multilayer Memristive/Memcapacitive Devices

Memristive devices are reshaping computing paradigms as one of the leading candidates for the future of computer memory. In conventional memristors, metallic filaments form and extend stochastically under applied electrical bias, producing a highly non-uniform conduction front. This produces devices with large variations in electrical properties that are difficult to tune.

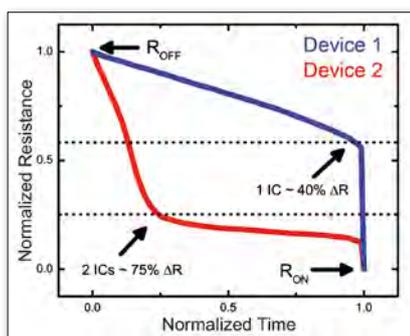
Here, we introduce and simulate a specialized multi-layered device structure with alternating ionic conductor layers that enables the development of a quasi-uniform conduction front. This

reduces catastrophic switching (Fig.) in which devices rapidly exit the linear-tuning region and switch state. In our simulations of a single layer memristor, the majority of the resistance change during a switching event occurs catastrophically, while in the multilayer device the majority of switching occurs in the linear tuning region. This ability to fine-tune switching events in devices is an important property for multi-bit memory and neuromorphic computing applications. ■

■ **P.R. Mickel and C.D. James,**

'Multilayer Memristive/Memcapacitive devices with engineered conduction fronts', *Eur. Phys. J. Appl. Phys.* **62**, 30102 (2013)

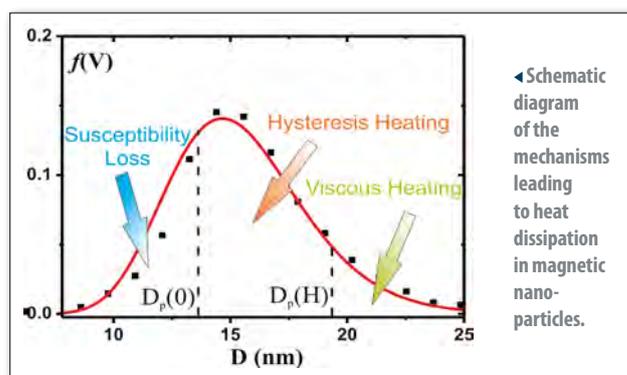
▼ Device 1 is the conventional memristor design: electrodes are separated by a single ionic conductor insulator. Device 2 utilizes the multi-layer design, which forms a quasi-uniform conduction front. The simulated resistive switching of the multilayer memristor occurs largely within the linear regions where tuning can occur.



BIOPHYSICS

Magnetic hyperthermia for tumour reduction

Magnetic hyperthermia is the process by which cycling magnetic nanoparticles in an alternating magnetic field leads to heat dissipation. It is a very attractive approach for the treatment of cancer because it generates no side effects unlike more conventional therapies such as radiotherapy or chemotherapy. The development of this therapy has been hampered by the lack of a clear understanding of the physical mechanisms leading to heat generation. At the present time it is not possible for clinicians to be given details of the dosage and field conditions required for a given therapeutic outcome.



There are three mechanisms by which exposing magnetic nanoparticles to a cycling field can generate heat: susceptibility loss, hysteresis loss and viscous heating. We have found that these mechanisms are highly particle size dependent as shown schematically in the figure and will also depend upon the degree of aggregation of the particles. In experiments of magnetic nanoparticles of different sizes dispersed in solvents of varying viscosities, hysteresis heating has been shown to be the dominant mechanism. Although the contribution arising from viscous heating is significant its effects are uncontrollable and will not occur in vivo due to the high viscosity of tumour tissue. ■

■ **G. Vallejo-Fernandez, O. Whear, A.G. Roca, S. Hussain, J. Timmis, V. Patel and K. O'Grady,**

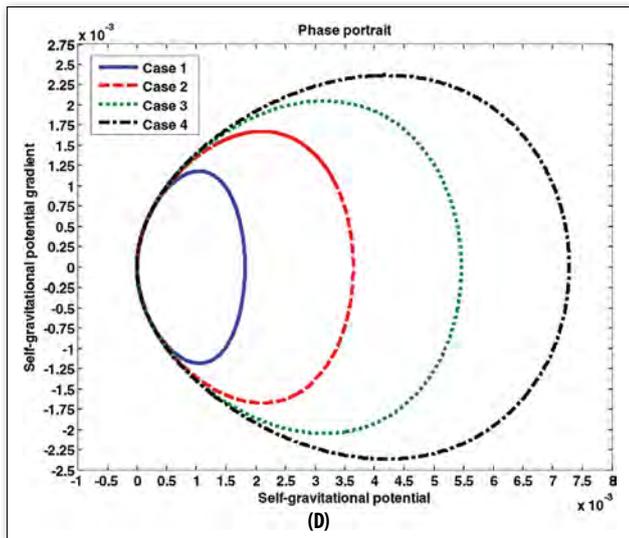
'Mechanisms of hyperthermia in magnetic nanoparticles', *J. Phys. D: Appl. Phys.* **46**, 312001 (2013)

PLASMA PHYSICS

Pulsating dust cloud dynamics modelled

New research outlines a new design of spatio-temporal models of astrophysical plasmas.

It is the collapse of dense molecular clouds under their own weight that offers the best sites of star formation. In the



▲ Different phases of a self-gravitational potential.

present work, the authors have proposed a new model for investigating molecular clouds fluctuations at sites of star formation and thus study their pulsational dynamics. They study the pulsating dynamics of inhomogeneous molecular clouds that periodically undergo both self-gravitational contraction due to the weight of the massive dust grains, and electrostatic expansion resulting from the interaction of dust grains of the same electric charge.

They designed a model for investigating the cloud fluctuations with charge-varying grains, as a function of weight and charge interaction (referred to as nonlinear gravito-electrostatic coupling). They then carried out a detailed shape analysis to characterize these clouds on the astrophysical scale. ■

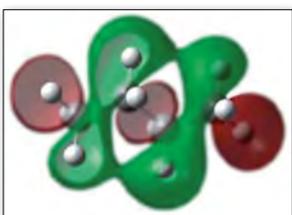
■ **P. K. Karmakar and B. Borah,**

'Nonlinear Pulsational Eigenmodes of a Planar Collisional Dust Molecular Cloud with Grain-charge Fluctuation', *Eur. Phys. J. D* **67**, 187 (2013)

ATOMIC AND MOLECULAR PHYSICS

Green photon beams more agile than optical tweezers

A new manipulation tool exploits the fact that when light interacts with matter, it creates a force that produces material



▲ Charge-density computation of butane molecules.

properties in macromolecules and biological cells.

Romanian scientists have discovered a novel approach for the optical manipulation of macromolecules. The authors had the idea to use green photon beams. With them, it is possible to perform optical

manipulation of macrostructures, such as biological proteins, with greater precision than with optical tweezers.

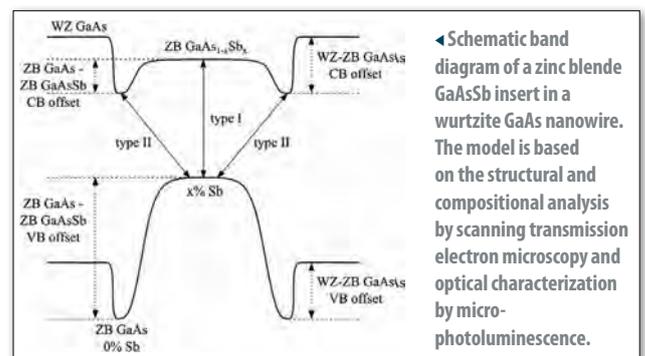
The authors used high-density green photon beams (HDGP) capable of inducing a polarisation effect within complex macrostructures. They found that the effect of the beam leads to 'biological optical matter'. This includes newly-organised material structures, such as molecular aggregates and micro-particles, and can feature new characteristics such as antioxidant properties. The authors realised that this approach covers a larger area than focused tweezers and is capable of organising mesoscopic matter into a new 3D molecular architecture. ■

■ **S. Comorosan, S. Polosan, I. Popescu, I. Stamatin, E. Ionescu, S. Avramescu, L. Cristian Cune and M. Apostol,** 'Optical manipulation of complex molecular systems by high density green photons: experimental and theoretical evidence', *Eur. Phys. J. B* **86**, 232 (2013)

APPLIED PHYSICS

Antimony variations in GaAs/GaAsSb nanowires

Semiconductor nanowires have attracted huge attention recently due to their unique and often superior properties compared to bulk or planar counterparts. Complex heterostructures can be made and several nanowire-based devices (e.g. solar cells) have been realized. GaAsSb is an interesting ternary compound semiconductor because of its tunable bandgap and the possibility for both type I and type II band alignment with GaAs. In the present study 20-80 nm long zinc blende GaAsSb segments in wurtzite GaAs bare-core and GaAs/AlGaAs core-shell nanowires were studied.



The work established the presence of both axial and radial compositional variations in the GaAsSb segments and their effect on the optical properties of these nanowires. The Sb concentration profiles within the inserts were determined using energy dispersive X-ray spectroscopy and quantitative scanning transmission electron microscopy and related directly to micro-photoluminescence measurements for the same single nanowires. The results of the article are relevant for further growth optimization and

tailoring of the optical properties of GaAs/GaAsSb heterostructured nanowires. ■

■ **J. Todorovic, H. Kauko, L. Ahtapodov, A.F. Moses, P. Olk, D.L. Dheeraj, B.O. Fimland, H. Weman and A.T.J. van Helvoort,**

'The effects of Sb concentration variation on the optical properties of GaAsSb/GaAs heterostructured nanowires', *Semicond. Sci. Technol.* **28**, 115004 (2013)

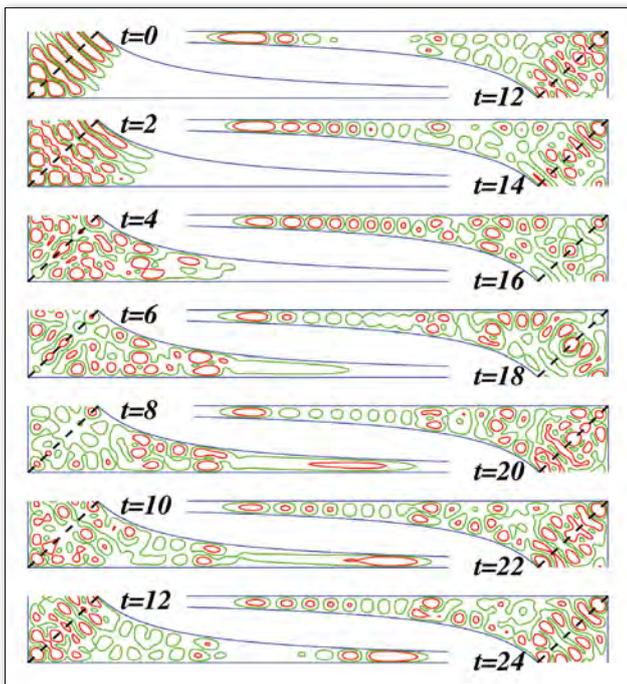
FIELD THEORY

Semiclassical propagation up to the Heisenberg time

Semiclassical propagation of waves is a fruitful approach to understand and evaluate a wide set of physical processes. This is performed by associating quantum states with Lagrangian manifolds in phase space, and the propagation is accomplished by the evolution of manifolds. However, long time propagation in Hamiltonian systems with chaotic dynamics is a longstanding unsolved problem; the reason being that Lagrangian manifolds evolve into very complex objects.

Recently, we have shown that by using the stable and unstable manifolds of periodic orbits, the propagation is simplified enormously. For this reason, in this paper we study in detail the manifolds of a periodic orbit of the hyperbola billiard, finding that they are organized by a simple tree structure. Then, we compute a complete set of homoclinic orbits (resulting from the intersection of the manifolds), which is required to evaluate

▼ Long time propagation of a resonance in the hyperbola billiard. The Ehrenfest time is 2.2, and the Heisenberg time is 35.3.



the autocorrelation function of a quantum state constructed in the neighborhood of the periodic orbit (resonance). Finally, we compare the quantum and semiclassical autocorrelation up to the Heisenberg time, finding a relative error of the order of the Planck constant. ■

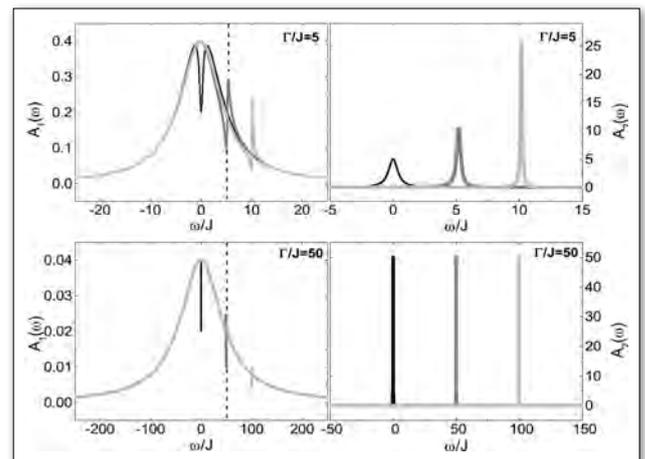
■ **E.G. Vergini,**

'Semiclassical propagation up to the Heisenberg time', *EPL* **103**, 20003 (2013)

ATOMIC AND MOLECULAR PHYSICS

Atom-based analogues to electronic devices

New research gives a theoretical explanation as to how transport of single atoms that may be applied to optical lattices is made possible through a chain of quantum dots.



▲ Spectral functions of the first (left panel) and the second (right panel) quantum dot.

The authors have pushed back the boundaries of atom-based transport, creating a current by characterising the many-body effects in the transport of the atoms along a periodic lattice. This work has adopted a new analytical approach before comparing it to approximate numerical simulations, and is reported in the present paper.

Ultra-cold atoms trapped in optical potentials offer solutions for the transport of particles capable of producing a current. In this study, the authors extended previous single-atoms transport approaches to a model reflecting the many-body setting of bosonic atoms transport. Their challenge was to develop an analytical approach that allows particles to jump in and out and therefore produce a controlled current through the sample under study. They used a chain of quantum dots coupled to two bosonic reservoirs that keep the system far from equilibrium. ■

■ **G. Ivanov, G. Kordas, A. Komnik and S. Wimberger,**

'Bosonic transport through a chain of quantum dots', *Eur. Phys. J. B* **86**, 345 (2013)



AN EYE-WITNESS REPORT ON HOW THE CD CAME ABOUT

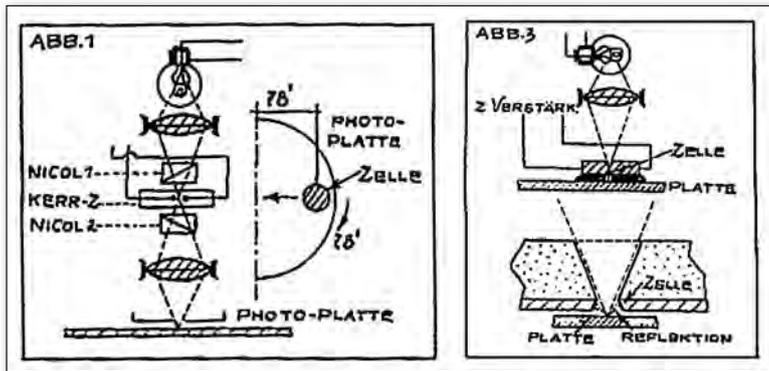
■ Jacques Heemskerk – former Philips employee – jpj@famheemskerk.nl – DOI: 10.1051/ejn/2013601

The Compact Disc was a smashing success. It pushed the traditional 45 and 33 RPM vinyl records off the market in an astonishingly short period of time. But the struggle to develop the CD and to get it on the market was just as fascinating.

The various technologies employed in the Compact Disc (CD) player, including laser optics, a-spherical lenses, digital signal processing, integrated circuitry, nano-scale injection molding are truly revolutionary by itself. Interestingly, the basic idea to write and read information to and from a disc by optical means was not new, as can be seen in Fig 1 taken from a 1931 article published in *Funkschau*. The pictures are not very clear, as would have been the signal produced for being limited by noise, preventing practical implementation of this reflective disc. Nevertheless, the transmission version of this scheme has been successfully employed in reading the sound track of the first ‘speaking pictures’.

The optical scheme of the Compact Disc player is very similar to the one published in *Funkschau*, see Figure 2. However, the devil is in the detail. In a CD player, the light source is a laser, *i.e.*, a real point source. So, in case of perfect optics, the read-out spot, which is the image of the point source on the disc, is of minimum, diffraction limited size. In formula, $D = \lambda/NA$, with D the spot diameter, λ the laser wave length, and NA the numerical aperture of the objective lens (NA equals the refractive index n times the sine of the convergence angle α). The Compact Disc itself looks quite different from the 1931 example. The audio signal is digitally coded instead of stored as the audio wave itself. The signal is not derived from reflectivity variations in a photographic material

▲ © iStockPhoto



▲ FIG. 1: Original 1931 figures, showing the idea behind the reflective audio disc recorder. **Left:** Recording method. Lamp light is focused onto a small spot on the disc where the spot size is determined by the pinhole just above the information plane. A Kerr cell is placed in the optical path between two crossed polarizers. By applying a voltage across the Kerr cell generated by the audio signal, the intensity of the light spot on the disc is modulated and the audio signal is recorded onto the photographic material. **Right:** Reading set up. The lower part of the panel shows the details of the detector geometry. The spot size is limited by a pinhole. Variations in local reflectivity are measured by a ring-shaped detector, in this case a photoelectric Selenium detector.

but from a relief pattern, a succession of ‘pits’ and ‘lands’. Digital coding means that the audio signal has undergone a series of processing steps: first, the audio signal is transformed into 16-bit samples; second, parity bits are added (for error detection and correction); and third, the bit train is transformed into an information track on the disc, consisting of pits and lands of discrete lengths of 3, 4, ... ,11 units, where one unit corresponds to 0.3 μm on the disc. The bit rate and bit density are constant. This means that the scanning speed is constant (1.3 m/s), and that the angular frequency of the disc gradually decreases during play-back (the reading head is moving from inside to outside of the disc).

Two companies, two cultures

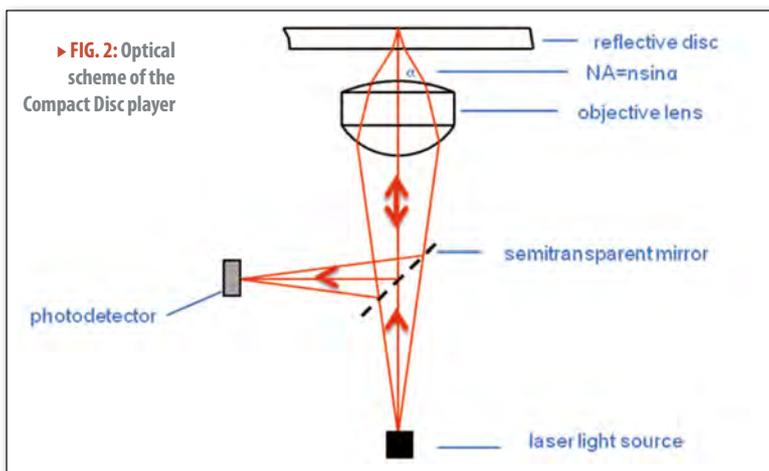
In this brief history, I should like to share my personal experience of CD development. Such experience often makes innovation real fun. I myself became involved in CD development in 1979, directly after Philips gave its first public demonstration of a CD prototype player and after Philips had toured Japan in search of allies to join

into the development of the CD as a successor of the LP record. Sony was the company that responded most eagerly to this invitation, and Philips and Sony agreed on a joint development of a miniature-sized digital audio disc. The two companies realized that a common format would be necessary to convince the other Consumer Electronics companies to join at a later stage. As an optical engineer, I was present at all meetings between Sony and Philips to forge a common format.

I remember our first technical meeting very well. Management had instructed us to be completely open: “one cannot blow with one’s mouth shut”. However, we as scientists and engineers, knew very well how much effort it had cost us to achieve a reliable prototype and – as is often the case amongst engineers – we doubted whether our management really knew what they were doing. The more so, because Japan at that time was in a similar position as China is today: its industry was growing fast and it was changing from a low-cost producer into a high-tech competitor. So, at that first meeting, mistrust was the overriding emotion at our side. Later, I heard from my Japanese counterparts that they had similar reservations about the wisdom of their own management.

Looking back, I think our first meeting actually went pretty well, although we did not achieve very much in technical terms: we made a good start in team building with engineers that belonged not only to a different company, but also to a different culture. We succeeded in doing so at a time (1979) when the world was certainly not ‘globalized’. Initially, I felt as if those guys came from another planet. Indeed, they came from ‘the Far East’. Soon however, we discovered that engineers are pretty much the same all over the world, with similar emotions: proud of their expertise, sincere about their problems, eager to explain their own solutions, and willing to learn and to appreciate the solutions of others. Soon, we found a way of working together that turned out to be very effective: we challenged each other’s assumptions, and we agreed that we should not accept technical proposals out of politeness or kindness: we accepted only the best solutions, based on data, not on theories.

We quickly established a pattern of regular 2- or 3-monthly meetings, either in Japan or in Holland, and within 2 years we reached a complete agreement on the format that is now called the CD. The problem we had to solve was rather straightforward: find the best solution in reliability and information density for a small digital, read-only disc. The technical solution was less straightforward: while we both had developed our prototypes step-by-step, when reconsidering our solutions we realized that every new choice was leading to another new issue. Obviously, the most direct solution to increase information density is to increase the NA, and to reduce the wave length of the optics. However, as Fig 3 shows, the disc substrate is part of the objective lens, so any variation in thickness d will

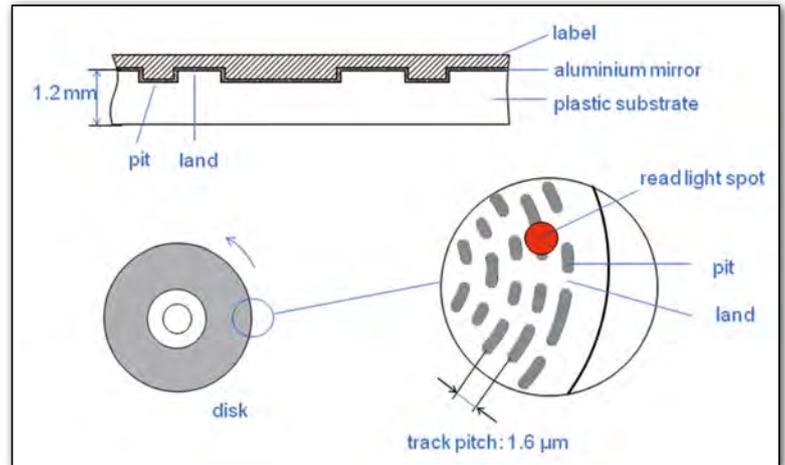


cause spherical aberration ($\Delta d \times NA^4 / \lambda$), and any tilt angle will cause coma ($\epsilon \times d \times NA^3 / \lambda$) with Δd the thickness deviation, and with ϵ the tilt angle of the disc substrate. Because of the strong dependence on NA, a small increase in NA directly results in more stringent disc tolerances. As a result, we had very tough discussions about realistic disc tolerances, because we had only a few preliminary disc samples available of rather uncertain quality. In the end, we agreed on $NA = 0.45$, but with strong reservations on both sides, especially from our media engineers.

On the selection of wave length a similar problem ensued. The only diode lasers available at the time were prototype samples designed for fiber communication, operating at a wave length of 820 nm. Pressed by the need for the highest data capacity, we decided to agree on 780 nm as the wave length for CD, a decision that was based on a very limited number of 780 nm laser prototypes. During our joint experiments on the bits/mm² attainable, lots of test discs with different land/pit sequences were exchanged. In a quick succession of meetings between the Philips and Sony engineers, we improved each time on our previous results in information density and detection robustness. In the end, we concluded that for maximum information density, pits and lands had to have a minimum length of 3 units with one unit as quantization size. We also found that it was absolutely necessary to choose a 'channel code' where pits and lands were evenly distributed over the disc. Only in that case, we would be able to filter away the effects of severe scratches and fingerprints on the disc. In a similar way we confronted each other with different Error Correction schemes. Error correction is an integral part of any digital storage of communication system. Usually, a trade-off must be made between three parameters: correction performance, the relative number of parity bits, and cost. In line with our different initial target markets, also here Sony and Philips had different priorities. Sony was pushing for the most powerful scheme, while Philips was very critical on cost. Depending on the algorithm, a balance had to be struck between correction capability for large defects – like scratches and fingerprints – and small ones, such as random errors like noise. Because the two companies used discs and players that were still very much under development, we had to assess what level of quality could be achieved later in mass production. A lot of guess work! In the end we agreed on a scheme that combined good correction of large disc errors with a limited RAM size, using a structure with continuous data input and output, instead of the conventional block structure. This is a solution that works well for a continuous data stream like Audio, practical at a time when memory space was scarce.

Fixing sizes

I remember tough discussions taking place between our two companies on the parameters for the quantization



▲ FIG. 3: Details of the CD surface structure

level of the audio samples. Philips' priority was a small disc, fitting not only in Hifi decks, but also in mobile applications like the automobile and the so-called ghetto blasters. These markets were much larger than the stationary Hifi market. With a small disc of about half an hour playing time in mind, Philips wanted to limit the number of bits per sample to 14 bits. Sony was adamant in achieving perfect Audio Quality. I remember that in one of our meetings Toshi Doi tried to convince us of the necessity to choose 16 bit quantization. He did so by recording soft triangle music at both 14 bit and at 16 bit resolution: we were supposed to hear the difference. Frankly speaking, none of us heard any difference at all, but Sony's message was loud and clear: the new format must not compromise on sound quality!

We had settled on a 11.5 cm diameter disc, until Sony's president, Mr Ohga, — a former opera singer — put a new requirement on the table: the playing time had to be 74 minutes. This new requirement came out of the blue for all of us. In earlier meetings, we had worked on the basis of a maximum playing time requirement of one hour. What we did not know was that Ohga had promised his conductor friend Herbert van Karajan that his version of Beethoven's Ninth Symphony would fit on one CD only. No discussion was possible: at the highest level, a



▲ FIG. 4: The center hole in the CD: a Dutch 10 cents coin



▲ FIG. 5: The Philips and Sony teams at the final, decisive meeting (June 1980). The author is at the far left

promise is a promise. One also has to bear in mind that, after Hiroshima and Nagasaki, the 9th Symphony choral ‘Alle Menschen werden Brüder’ had become an important musical symbol in Japan.

Polygram, the music company of Philips, was shocked by this new requirement. Contrary to Ohga, Polygram wanted a rather limited playing time. The argument was that no music group would be able to regularly produce albums with playing time much in excess of existing LP’s 40 minute playing time. Eventually, a political compromise was reached at an actual playing time of 74 minutes on the disc, while the Red Book Standard defined a playing time of 60 minutes only. Not often a new format formally denied its higher storage performance!

An unfortunate consequence of the playing time requirement was the disc size: it grew from 11.5 cm to 12 cm diameter. This last-minute change caused real problems. With great difficulty, I had convinced our media engineers to accept the critical specification on disc flatness based on an 11.5 cm disc size. I had no choice, so I told them they had no choice. In hindsight, I think we were too conservative, we could have maintained the 11.5 cm disc size, whilst squeezing the data density on the disc a bit more. However, at the time, only one trial run of one thousand discs from one ‘stamper’ was available, so we had no real information on mass production quality of discs.

▼ FIG. 6: The first commercial Philips CD player



This history may sound as work only; in actual fact, we enjoyed the drinking parties in the evenings just as well. Yet, we worked very hard indeed: many times the target for next round of testing was felt as impossible to meet. And often, when proudly showing our hottest Philips data, it turned out that also Sony had met the impossible dead line, sometimes during the night before: it was a neck-and-neck race.

One of the last discussion points was the center-hole diameter. This time, we agreed within a few minutes. Our project leader, Joop Sinjou, put a tiny Dutch 10 cents coin on the table and said: why not? Indeed: why not, so we agreed on a center hole of a Dutch 10 cents coin, i.e., 15 mm diameter (Fig 4).

In June 1980, the two development teams agreed on the specification of Compact Disc. Fig 5 shows the two teams at that decisive meeting.

The history of CD did not end by finalizing the format: actually that is where its history started. Therefore, I want to share also some of my memories on the product introduction of the CD.

A highlight for me was the Tokyo Audio Fair of 1982. Suddenly all Consumer Electronics companies presented their first CD players. During that Fair, I met many product engineers. They were all very proud to show the first CD player of their company. Their enthusiasm created a great feeling in all of us being part of a major innovation. And certainly, as a Philips engineer, I could be proud of our first CD player: the smallest one at the show! And with very simple and logical control and display. In one word: a beauty (Fig 6).

When I saw the first CD player in the shop at my own little home town I felt proud. I remember what I said, with some exaggeration, to my 11-year-old daughter: Look, this is what daddy invented! But she was not impressed, which taught me another lesson: There is more to life than the CD. ■

About the author



After earning his PhD in Physics from Leiden University in 1973, Jacques Heemskerk joined Philips Research in Eindhoven, where he worked on various optical problems. When, in 1979, a development laboratory was established for the Compact Disc, he joined as optical group leader. Later he became head of the laboratory, head of the optical predevelopment of Philips Consumer Electronics, and responsible for the physical part of the standardization of DVD and Blu-ray. He received the Japan Audio Society award for his contribution to CD development, the Nakajima award for CD-R, and he has been honored with a Knighthood in the ‘Orde van de Nederlandse Leeuw’ for his contributions to industry and optical disc technology. He holds more than 180 patents for over 50 inventions.

COMBATING A TWO-DECADE CAMPAIGN ATTACKING THE SCIENTIFIC CONSENSUS ON CLIMATE CHANGE

John Cook

Global Change Institute,
University of Queensland,
Australia

DOI: 10.1051/
epn/2013602



New research published this year found that among peer-reviewed climate papers stating a position on anthropogenic global warming, over 97% endorsed the scientific consensus that humans were causing climate change. Meanwhile, the public think there is a 50:50 debate among climate scientists. How did this “consensus gap” arise and can it be closed?

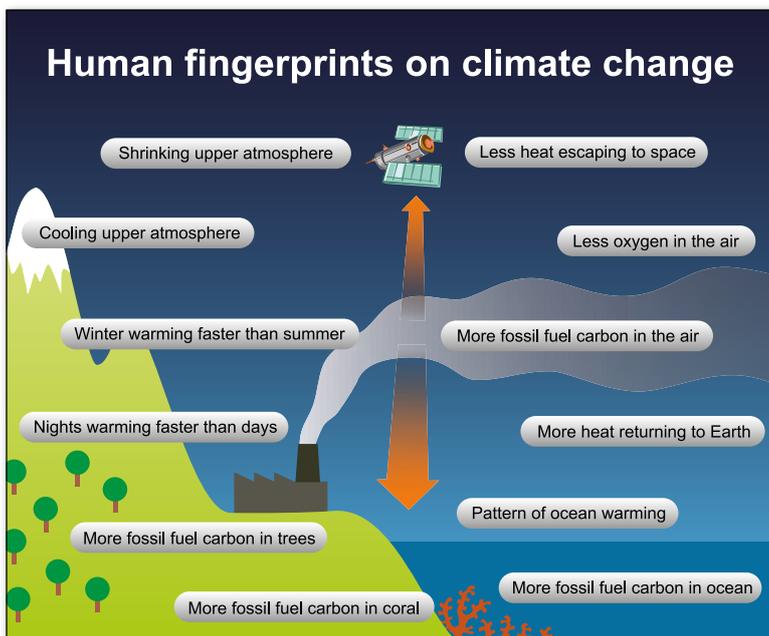
Climate science is a sprawling, multi-disciplinary field incorporating radiative physics, atmospheric chemistry, meteorology, geology and many other fields. As with any area of science, different aspects are understood to varying degrees. Cutting-edge areas of climate research include the role of aerosols in cloud formation, or the role of ocean mixing in exchanging heat between the atmosphere and the deep ocean.

One area of climate change well understood for decades is the fundamental fact that humans are causing global warming. The mechanism driving the greenhouse effect was first identified in the 1850s, when John Tyndall ran laboratory experiments measuring the absorption of infrared radiation by certain gases. These included carbon dioxide, water vapour and methane, now known as greenhouse gases for their ability to trap heat.

Tyndall also described distinctive patterns associated with greenhouse warming. If increased greenhouse gases were causing global warming, Tyndall expected that nights would warm faster than days and winters warm faster than summers. 160 years ago later, Tyndall's predictions have been fulfilled. The greenhouse signatures anticipated in the daily and annual cycle have been observed.

In fact, a number of "human fingerprints" associated with greenhouse warming have been observed (see Figure 1). As increased greenhouse gases absorb more infrared radiation, satellites have observed less heat escaping to space. This should cause more infrared radiation to return to the Earth's surface, which surface measurements of downward radiation have confirmed. Another tell-tale human fingerprint is a cooling stratosphere (upper atmosphere) while the troposphere (lower atmosphere) warms.

▼ FIG 1: Observed indicators of anthropogenic global warming. Feature image credit: John Garrett



The strengthening consensus on human-caused global warming

As empirical evidence for human-caused global warming accumulated, agreement among the scientific community strengthened. The seminal work measuring the scientific consensus on climate change was Naomi Oreskes' 2004 analysis of peer-reviewed papers, published from 1993 to 2003, on the topic of 'global climate change' [1]. Among 928 climate papers, the number rejecting human-caused global warming totalled zero.

A 2009 survey of Earth scientists found that the higher a scientist's expertise in climate science, the more likely they were to endorse the consensus [2]. Among actively publishing climate scientists, they found 97% agreement. Interestingly, the group of scientists showing highest scepticism about climate change were economic geologists. Nearly every reputable, relevant scientific organisation in the world, including the National Academies of Science from 33 different countries, has issued statements endorsing human-caused global warming. This isn't to say the consensus is unanimous. One dissenting organisation is the American Association of Petroleum Geologists.

The Intergovernmental Panel on Climate Change (IPCC) is widely regarded as the most authoritative source of information on climate change. The IPCC has issued a series of increasingly definitive statements on the human role in recent climate change. Their language has evolved from the tenuous "the balance of evidence suggests that there is a discernible human influence on global climate change" in 1996 to recent global warming being "...very likely due to the observed increase in anthropogenic greenhouse gas concentrations" in 2007. The latest IPCC report released in 2013 upgraded "very likely" (more than 90% probability) to "extremely likely" (more than 95% probability).

The two-decade attack on scientific consensus

As scientific consensus strengthened, efforts to confuse the public about the level of agreement in the scientific community intensified as documented in Figure 2). The misinformation campaign originated from opponents of climate action who rather than propose alternative policy solutions to climate change instead opted to attack the science.

A key strategy was (and still is) creating the illusion of ongoing debate by magnifying the voices of a few dissenting scientists. This strategy dates back to 1991, when Western Fuels Association spent over half a million dollars on a campaign designed to "reposition global warming as theory (not fact)." Their approach was to promote the views of a handful of scientific spokesmen, giving the impression of a 50:50 debate among the climate science community. Another common technique is the promotion of "fake experts", using spokespeople unqualified in climate research. The most prominent example of the fake expert strategy

is the Petition Project, launched by the Oregon Institute of Science and Medicine (OISM) in 1998. This petition features over 31,000 scientists signing a statement that humans aren't disrupting our climate. The Petition Project is widely cited by many, including public figures such as Congressman Dana Rohrabacher. What the petition neglects to highlight is that 99.9% of the signatories on the survey aren't climate scientists.

In 2002, a memo by Republican political strategist Frank Luntz was leaked, disclosing the conservative strategy to delay climate action. Luntz argued that "should the public come to believe that the scientific issues are settled, their views about global warming will change accordingly". Consequently, he advised Republicans to cast doubt on the scientific consensus.

Luntz was ahead of the curve. In 2011, social scientists measured an important link between public perception of consensus and support for climate policy [3]. When people perceive that scientists agree on climate change, they're more likely to support for climate policy. Based on this insight, Luntz' was strategizing over a decade before social scientists joined the dots.

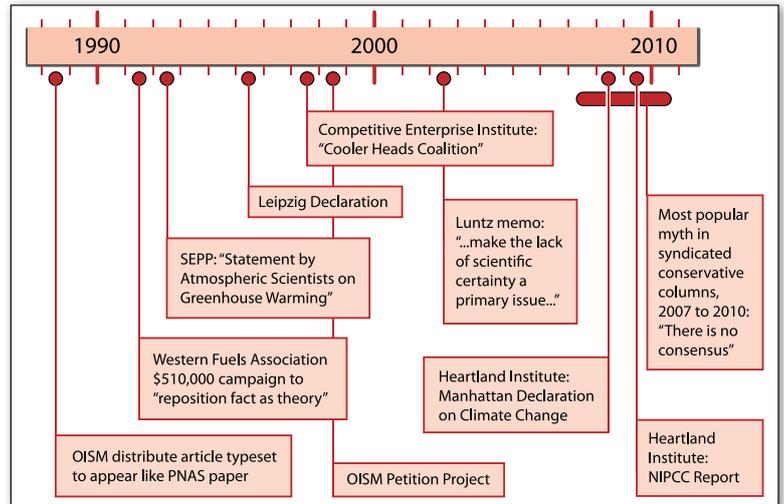
Opponents of climate action recognise a winning formula and persist with this approach to this day. A recent study tallied up the different climate myths presented in opinion pieces from 2007 to 2010 by syndicated conservative columnists [4]. The most common myth was "there is no consensus". Why is this rather transparent form of misinformation so effective? When presented with two opposing voices debating about climate science in the news media, people become more confused about global warming and less likely to support climate action [5]. Consequently, opponents of climate action have endeavoured to position their spokespeople in the media, arguing against climate science.

The result is a significant "consensus gap" between public perception and the actual 97% scientific consensus (see Figure 3). Public polls have found that nearly half of the American public think climate scientists are still in disagreement [6]. In my own research, when I asked Americans what percentage of climate scientists agree on human-caused global warming, the average answer was 55%.

Closing the "Consensus Gap"

I recently led a citizen science effort to conduct the most comprehensive analysis of climate research yet done [7]. We analysed 21 years of peer-reviewed papers from 1991 to 2011, identifying over 4000 abstracts that stated a position on whether humans were causing global warming. Among those papers, 97.1% endorsed the consensus. We also found that the consensus was already present in the peer-reviewed literature in the early 1990s, with agreement strengthening over two decades.

In 2007, Naomi Oreskes predicted that as a scientific consensus formed, you should expect to see less explicit



endorsements of the consensus position [8]. For example, you don't often see new physics papers reaffirming the validity of Einstein's theory of relativity. We found that over the 21 year period, the percentage of abstracts stating a position on human-caused global warming decreased. Fewer papers bothered to endorse the consensus position in their abstract. At the same time, among abstracts stating a position, the percentage endorsing the consensus increased. This pattern fulfilled Oreskes' prediction.

An important aspect of scientific research is replication. To independently check our abstract ratings, we emailed the scientists who authored the papers, asking them to rate the level of endorsement of their own research. Exactly 1,200 scientists responded, resulting in over 2,000 papers receiving a rating from the papers' authors. Among the papers that were self-rated as expressing a position on human-caused global warming, there was a 97.2% consensus. According to the actual scientists conducting the research, there is an overwhelming and strengthening consensus (see Figure 4).

Closing the consensus gap was never going to be easy. To further complicate matters, public perception of consensus is strongly associated with political ideology. The more conservative one's political views, the lower the perceived consensus. However, even liberals think the consensus is only around 70%, indicating that the consensus gap is a mix of information deficit, the injection of misinformation and influence of cultural values. On the plus side, presenting quantitative information about the consensus has been shown to significantly increase acceptance of anthropogenic global warming [9].

How does one address a public misconception that has persisted for two decades? The golden rule to refuting myths is to "fight sticky myths with stickier ideas" [10]. We decided to focus our public messaging on a single number, the 97% consensus. The message couldn't be simpler and considering public perception of consensus languishes at 55%, it was sure to take many by surprise (a trait of sticky ideas).

▲ FIG 2: Two decade campaign manufacturing doubt on scientific consensus. OISM is the Oregon Institute for Science & Medicine, SEPP is the Science & Environmental Policy Project (founded by Fred Singer) and NIPCC is the Nongovernmental International Panel on Climate Change. Image credit: John Garrett

Our paper was published in the peer-reviewed journal *Environmental Research Letters* in May this year. To raise awareness of the 97% consensus, we launched a website [11], explaining the paper's results using simple language and strong visuals. We also encouraged readers to rate the abstracts themselves via an online, interactive system [12]. The idea was for readers to engage with our content, replicate our methodology and compare their ratings with our own.

The group of scientists showing highest scepticism about climate change were economic geologists

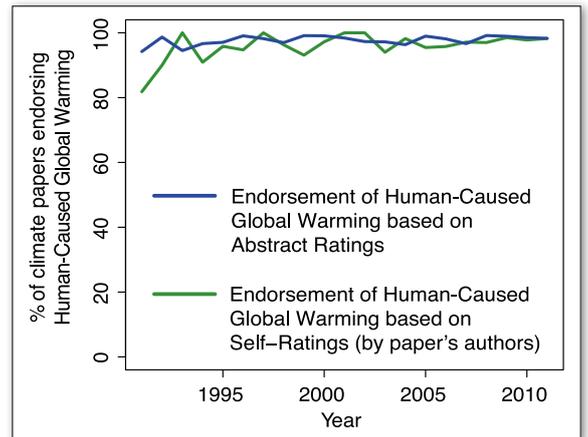
Our goal of raising awareness of the 97% consensus was given a significant boost when President Obama tweeted our research to over 31 million followers. Shortly afterwards, Obama delivered a landmark speech calling for climate action where he again invoked the 97% consensus. Representative Henry Waxman, former Vice-President Al Gore and the UK Minister for Energy and Climate Change also highlighted our research.

It remains to be seen whether public perception of consensus will shift due to these efforts. It also bears mentioning that raising awareness of scientific consensus is not a magic bullet that will singlehandedly solve the climate problem. Climate change is described as a “wicked problem”, with a range of strategies required to overcome the many barriers to climate action. Nevertheless, closing the “consensus gap”, the chasm between public perception and the 97% reality, will remove a roadblock that has delayed public support for climate action. ■

▼ FIG 3: The gap between the public perception of scientific agreement and the actual 97% consensus (public opinion data collected by John Cook) Image credit: SJI Associates

About the Author

John Cook is the Climate Communication Fellow for the Global Change Institute at the University of Queensland. He created *SkepticalScience.com*, a website that refutes climate misinformation with peer-reviewed science. In 2011, *Skeptical Science* won the Australian



▲ FIG 4: Percentage of climate papers endorsing human-caused warming. Blue line represents consensus based on abstract ratings. Green line represents consensus based on ratings provided by the papers' authors.

Museum Eureka Prize for the Advancement of Climate Change Knowledge. John co-authored the college textbook *Climate Change Science: A Modern Synthesis*, the book *Climate Change Denial: Heads in the Sand* and several papers on climate change and the psychology of misinformation.

References

- [1] N. Oreskes, *Science* **306**(5702), 1686 (2004).
- [2] P.T. Doran and M.K. Zimmerman, *Eos, Transactions, American Geophysical Union* **90**(3), 22 (2009).
- [3] D. Ding, E.W. Maibach, X. Zhao, C. Roser-Renouf and A. Leiserowitz, *Nature Climate Change* **1**(9), 462-466 (2011).
- [4] S.W. Elsasser and R.E. Dunlap, *American Behavioral Scientist* (2012).
- [5] A. Malka, J.A. Krosnick, M. Debell, J. Pasek, and D. Schneider, 'Featuring skeptics in news media stories about global warming reduces public beliefs in the seriousness of global warming'. Woods Institute for the Environment, Stanford University, Technical Paper), Available at <http://woods.stanford.edu/research/global-warming-skeptics.html> (2009).
- [6] A. Leiserowitz, E. Maibach, C. Roser-Renouf, G. Feinberg and P. Howe, 'Climate change in the American mind: Americans' global warming beliefs and attitudes in September, 2012'. Yale University and George Mason University. New Haven, CT: Yale Project on Climate Change Communication. <http://environment.yale.edu/climate/files/Climate-Beliefs-September-2012.pdf> (2012)
- [7] J. Cook, D. Nuccitelli, S.A. Green, M. Richardson, B. Winkler, R. Painting, R. Way, P. Jacobs and A. Skuce, *Environmental Research Letters* **8**(2), 024024+ (2013).
- [8] N. Oreskes, 'The Scientific Consensus on Climate Change: How Do We Know We're Not Wrong?' *Climate Change: What It Means for Us, Our Children, and Our Grandchildren*, MIT Press (2007).
- [9] S. Lewandowsky, G. Gilles and S. Vaughan, *Nature Climate Change* **10**.1038/10.1038/NCLIMATE1720 (2012).
- [10] C. Heath and D. Heath, Random House (2008).
- [11] www.theconsensusproject.com/
- [12] www.skepticalscience.com/tcp.php?t=rate_papers

THE "CONSENSUS GAP"

THE PUBLIC THINK...

55%

OF CLIMATE SCIENTISTS AGREE ON GLOBAL WARMING

IN REALITY...

97%

OF CLIMATE SCIENTISTS AGREE ON GLOBAL WARMING

When people don't realize there's a scientific consensus, they're less likely to support climate action. This underscores the importance of closing the consensus gap.



PHYSICS FUNDING AT THE GERMAN RESEARCH FOUNDATION

■ Karin Zach – Deutsche Forschungsgemeinschaft (DFG), Bonn – DOI: 10.1051/epn/2013603

The German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) is the central German organization to support basic research primarily at German universities. An important difference to other national funding organizations is that DFG works as a self-governing organization of German Science in a “response mode” by funding proposals made by scientists, but also contributing strategically to the development of priority areas. In both cases the research objectives are defined from science and within the research system itself. There is no political guidance to fund or to favour special fields of political relevance.

DFG promotes projects in all fields of science and humanities. This includes support for individual projects and research collaboration, awards for outstanding research achievements, and funding for scientific infrastructure and scientific cooperation.

In organizational terms, the DFG is an association under private law. Its membership consists of German research

universities, non-university research institutions, scientific associations and the Academies of Science and the Humanities.

The DFG receives the large majority of its funds from the Federal Government and the 16 German states, which are represented in all Grants Committees. At the same time the voting and the procedural regulations guarantee that all decisions made are science driven.

▲ Building of the German Research Foundation in Bonn (copyright DFG)

The funding opportunities

The German Research Foundation offers a broad variety of funding opportunities. Figure 1 shows the different programmes and the amount of research funding awarded by programme in 2012. The total sum is about 2 677 Million €.

The most traditional and at the same time – given its possibilities – broadest programme is the **individual grants programme**. This enables individuals who have completed their academic training to conduct research projects with clearly defined topics, regardless of the subject. The typical duration of such a project is 3 years with the possibility of prolongation. Every scientist having a PhD and working at a German university at any time can apply for support for a research project on any topic. There are no deadlines. DFG supports direct project costs, project specific staff, and instrumentation necessary to carry out the project.

As a special possibility the application for an individual research grant can include the position for the applicant as a project leader to be funded with a temporary position. This enables the project leader to realize his/her own ideas more independently than as a staff member in a project of another person.

Research Fellowships are another form of an individual grant. These stipends intend to help early-career researchers to conduct a defined project at a location of their choice outside Germany to familiarize with new research methods and at the same time with another scientific system.

The **Emmy Noether Programme** provides outstanding researchers at an early stage of their career with the opportunity to rapidly qualify for a leading position in science, preferably for a university teaching career, by leading an independent junior research group. It is our high-end excellence programme to recruit young

outstanding postdocs having international experience (back) to Germany. Foreign applicants are expected to continue their scientific career in Germany following the funding period. The funding possibilities in this programme include, for a period of five years, the position for the project leader, positions for staff, consumables, money for travel, project specific equipment; in brief - all that is necessary to run the group. The programme is highly competitive, as holding such a grant is a major step in a scientific career.

As seen from Figure 1 there also is a big amount of funding to different programmes for collaborative work.

A **Research Unit** is made of a team of researchers working together on a research project which, in terms of thematic focus, duration and finances, extends beyond the funding options available under the individual Grants Program. Research Units provide the staff and material resources required for carrying out intensive, medium-term cooperative projects.

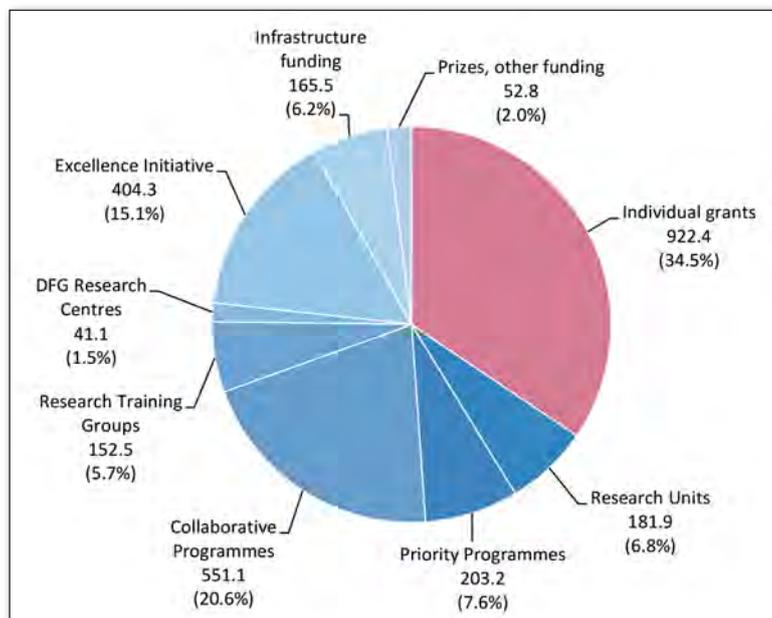
Priority Programmes serve for nationwide cooperation between its participating researchers. The Senate of the DFG (for organizational structures look at www.dfg.de/en/dfg_profile/index.jsp) establishes Priority Programmes when coordinated support given to the area in question promises to produce particular scientific gain. This is the only programme for which the DFG announces a call for proposals.

Collaborative Research Centres (CRC) are institutions established at universities for a period of up to 12 years that enable researchers to pursue outstanding research programmes, crossing the boundaries of disciplines, institutes, departments and faculties. They facilitate scientifically ambitious, complex, long-term research by concentrating and coordinating the resources available at a university.

Research Training Groups (RTG) are established by universities to promote young researchers. Their emphasis is on the qualification of doctoral researchers within the framework of a focused research programme and a structural training strategy. RTGs with an interdisciplinary approach are welcome. There are also very successful examples of international Research Training Groups.

Writing about the actual funding landscape in Germany must include the **German Excellence Initiative**. This initiative aims to promote top-level research and to improve the quality of German universities and research institutions in general, thus making Germany a more attractive research location, making it more internationally competitive and focusing attention on the outstanding achievements of German universities and the German scientific community. The DFG runs this initiative together with the German Science Council. The Excellence Initiative started in 2005. In 2009 the federal and state governments approved continuing the Excellence Initiative for another five years (2012

▼ FIG. 1: Amount of DFG funding awarded by programme in 2012 to all fields of science, in Million Euros



through 2017), allocating 2.7 billion € in funding for this period.

The DFG is responsible for two of the three funding lines – the Graduate Schools and the Clusters of Excellence. A third line dealing with institutional strategies is under responsibility of the German Science Council. The **Graduate Schools** serve as an instrument of quality assurance in promoting young researchers and are based on the principle of training outstanding doctoral students within an excellent research environment. They offer ideal conditions for doctoral students within a broad scientific area and, as integrative institutions with international visibility, they encourage students to be active members of their academic and social communities. As a result, graduate schools will extend far beyond DFG Research Training Groups and differ from them substantially.

Clusters of Excellence will enable German university locations to establish internationally visible, competitive research and training facilities, thereby enhancing scientific networking and cooperation among the participating institutions. They should form an important part of a university's strategic and thematic planning, significantly raise its profile and reflect its considered long-term priorities.

With its enormous possibilities the German Excellence Initiative was a starting point for a new kind of thinking at German universities and brought together a lot of people, who otherwise would have never talked to each other and who now collaborate to realize new ideas.

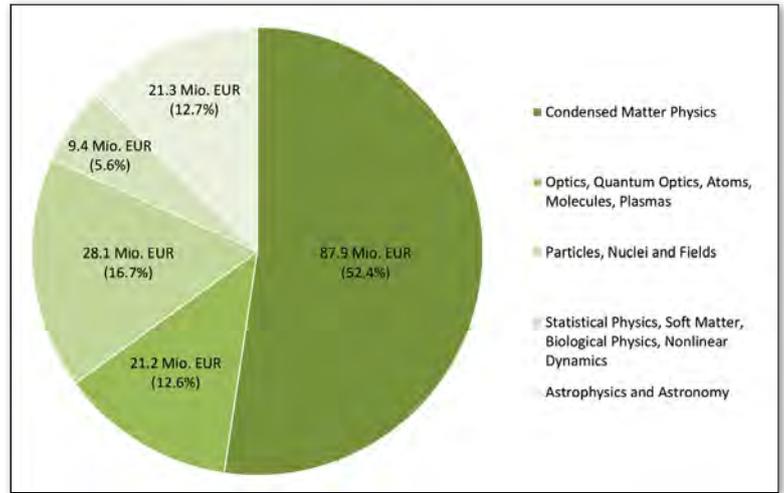
A much more detailed overview on funding possibilities and funded projects is given on the DFGs websites www.dfg.de/en/index.jsp.

The decision making process

Similar to other funding organizations the German Research Foundation makes its decisions on the basis of a peer review process. For all individual proposals we ask at least two national or international peers familiar with the field of the application to write an assessment on the quality of the project, the qualification of the applicant, the aims and work programme of the project and the planned allocation of funding. To prioritize the proposals on the basis of the statements of the reviewers (usually we have positive opinions for many more proposals than could be financed) we work with **elected review boards**. This is a big difference to other organizations as by the election process the members of these review boards have the mandate and at the same time the confidence of the scientific community to do this work. Actually 48 such boards from all fields of science with 606 members elected from the scientific community for the duration of 4 years work for the DFG on a voluntary basis.

In Physics we have five such boards:

- Condensed Matter Physics

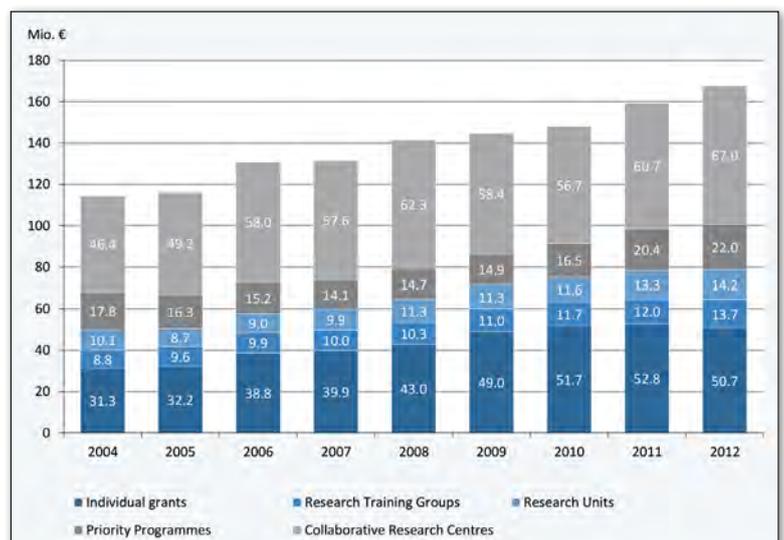


- Optics, Quantum Optics, Atoms, Molecules and Plasmas
- Particles, Nuclei and Fields
- Statistical Physics, Soft Matter, Biological Physics, Non-linear Dynamics
- Astrophysics and Astronomy

▲ FIG. 2: DFG funding to the different fields in physics in 2012

These boards meet four to six times per year to discuss all individual proposals from the respective subject area and to prepare the final decision on the proposals considering the financial possibilities. This way we ensure that all proposals within the subject area are assessed using a common standard. At the same time an important task of the boards is quality assurance. For example, they check if the selection of peer reviewers made by the DFG head office was the right one. In the DFG's coordinated programmes, which involve reviews by panels, review board members participate at the on-site evaluation to ensure the same quality standards in all funding programmes. Figure 2 shows the amount of funding to the different fields in physics in 2012. The whole sum was 167.6 Million €. This number includes the Individual grants programme, Research Units, Priority Programmes, Collaborative Research Centers and Research Training groups. It does not include the Excellence Initiative (difficult to count

▼ FIG. 3: Development of funding in physics over the last years for the different programmes (for better comparability all sums are divided into yearly amounts even if the project duration is much longer, this means that a 3 years grant is calculated as 3 parts for 3 years)



because of interdisciplinary approaches) nor the overhead of 20% which comes on top. The major part of the money goes to Condensed Matter Physics with more than half of the proposals and initiatives, whereas the amount for the other fields is smaller. We have to consider that there are fields in physics requiring large infrastructures, for example experimental particle physics, for which the funding responsibility in Germany is at the Ministry for Science and Education. There DFG money is only a small part of funding for these fields.

Development of DFG Funding in Physics

Figure 3 shows the development of funding in physics over the last years. For comparability all numbers given are counted as funding sums for the respective year. Physics is the strongest among the Natural Sciences (physics, chemistry, mathematics, geosciences). It receives approximately 10% of the whole DFG funding. The figure clearly shows the growth of the funding sums with time. We have the very favourable situation that the Federal Government and the 16 German states agreed to increase the DFG funds until 2015 by 5% per year. This is the basis for a substantial increase of funding in all programmes. Nevertheless the need for science funds grows faster than the financial possibilities, also in Germany. So, the elected review boards at every meeting have to reject very interesting proposals for financial reasons.

The individual funding programmes are the core of DFG funding as they give the scientists very flexible possibilities to realize innovative ideas. During the time shown the amount for individual grants in physics rose from 31.3

Million € to 50.7 Million € per year. Even if the rejection rate is actually quite high, very good proposals have a good chance to be funded.

Another point should be made on the part of money physics raises in programmes for collaborative work. For Collaborative Research Centres and Research Training Groups there is a common budget for all fields of science, "from archeology to zoology", and all proposals are decided in competition to each other. Physicists are very successful in these programmes. With attractive concepts they gain approximately 48% of their funds from these programmes whereas the average over all scientific fields adds up to approximately 35%.

We are convinced that the positive development of physics funding will continue at a national as well as at an international level. Most of our programmes enable common work with scientists from other countries. On the basis of what we have reached up to now one task for the future will be to further strengthen collaboration between physicists in Europe. ■

About the author



Karin Zach studied physics at Kharkov University in the former Soviet Union. She received her PhD in 1984 at Jena University (Germany). Her field of interest was experimental condensed matter physics. In 1994 she started working at the German Research Foundation, since 2005 as the Head of Division of Physics, Mathematics and Geosciences.

[Letter to the Editor]

by **Giorgio Benedek**

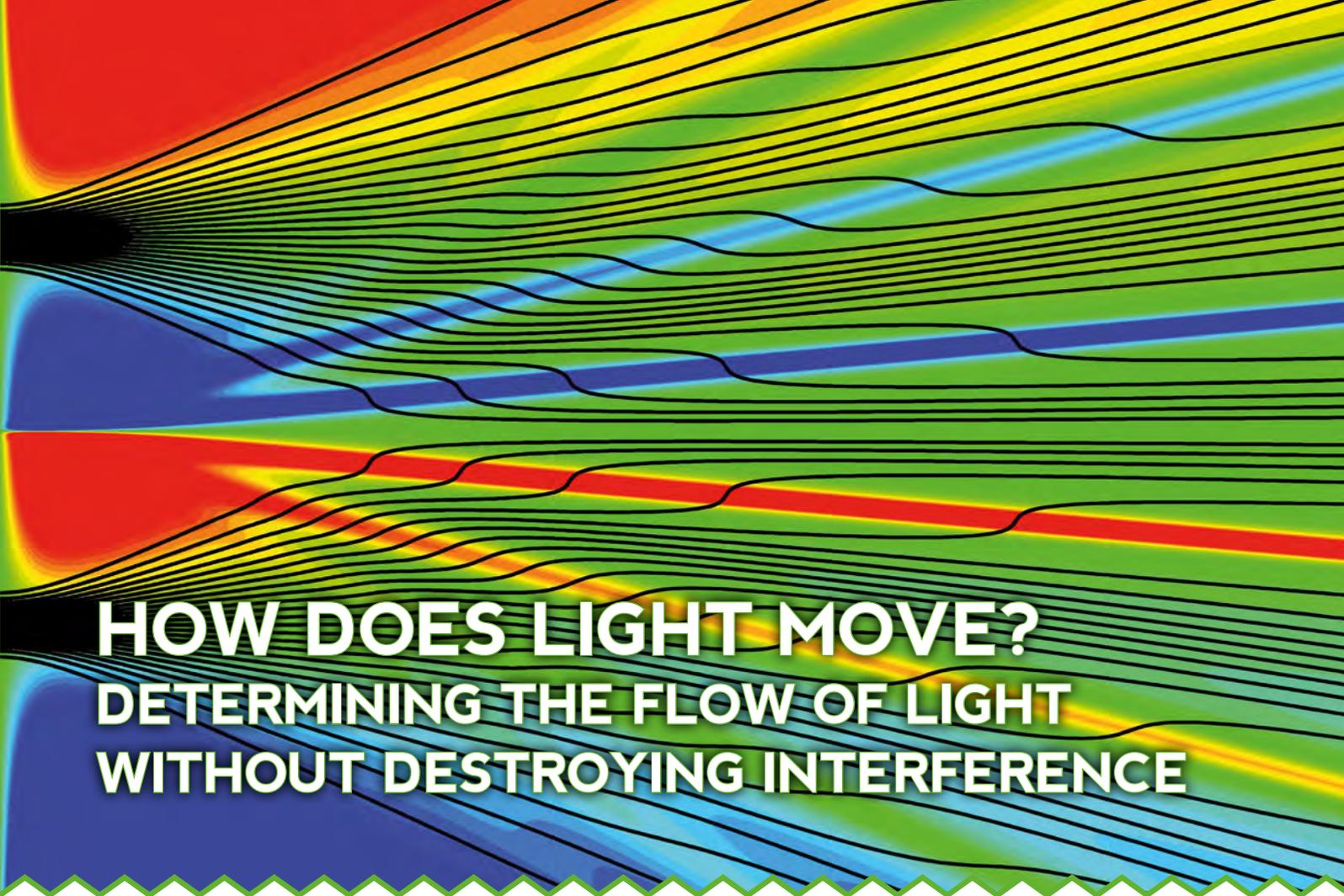
University of Milan-Bicocca

About 'Crossing borders'

I enjoyed reading 'Crossing Borders' by Herman Beijerinck in EPN 44/4, page 21. I agree on everything, and wish to answer the question about the play on the Heisenberg/Bohr discussion: see the article Revisiting Farm Hall by Amand Lucas in *Europhysics News* 38 n. 4, p. 25 (2007), directly accessible

through www.europhysicsnews.org. Amand Lucas also wrote a play on the same subject, published by Amazon 2011: "The Bomb and the Swastika" (Moral dilemma faced by history's greatest scientists, who tickled the tail of the sleeping nuclear dragon) Paperback – December 22, 2011, in the excellent English translation by Milton

W. Cole and Stephane Coutu from the original French. It is quite informative and enjoyable. Amand (amand.lucas@fundp.ac.be), will be happy to let readers have further information. Incidentally, I wrote a comment on this play: "Science Ethics in Four Acts", in *Revue des Questions Scientifiques* 184, n. 3 (Université de Namur, 2013). ■



HOW DOES LIGHT MOVE? DETERMINING THE FLOW OF LIGHT WITHOUT DESTROYING INTERFERENCE

■ M.D. Davidović¹ and A.S. Sanz² – DOI: 10.1051/e3n/2013604

■ ¹ Faculty of Civil Engineering, University of Belgrade – Belgrade, Serbia

■ ² Instituto de Física Fundamental, Consejo Superior de Investigaciones Científicas – Madrid, Spain

Young's two-slit experiment constitutes the paradigm of quantum complementarity. According to the complementarity principle, complementary aspects of quantum systems cannot be measured at the same time by the same experiment. This has been a long debate in quantum mechanics since its inception. But is this a true constraint? In 2011, an astounding realization of this experiment showed that perhaps this is not the case, and the boundaries to our understanding of the quantum world are still far away.

It is now 210 years ago that Thomas Young presented the outcomes of his nowadays world-renowned two-slit experiment to the Royal Society [1]. This experiment confirmed Huygens' wave theory of light and refuted Newton's corpuscular one. About 100 years later, though, Albert Einstein again suggested that light was composed of quanta of electromagnetic radiation or photons. Ever since, Young's experiment has constituted the simplest and most elegant proof of the fuzzy dual behaviour displayed by quantum systems, both light (photons) and material particles (electrons, atoms, molecules, *etc.*). Depending on how the experiment is performed, a different complementary aspect of the system is revealed: wave or corpuscle.

In 2011, Aephraim Steinberg and colleagues from the University of Toronto caused a stir in the physics community [2,3] with their challenging realization of Young's experiment with single photons [4]. As they showed, in a certain sense, going beyond the restrictions imposed by both Bohr's complementarity principle and Heisenberg's uncertainty principle is actually feasible. From measurements of the photons' transversal momentum, this group was able to determine the energy streamlines associated with the photon electromagnetic field and, therefore, to infer "which"-slit information (corpuscle behavior) without destroying the interference pattern (wave behavior). In other words, these measurements imply that the field contributing to each half of the interference

▲ Bohmian reinterpretation of Young's diagram. The trajectories (solid lines) describing the flow of light in space are in compliance with the velocity field defined by the transport relation between the Poynting vector and the electromagnetic energy density.

pattern comes uniquely from the slit that is placed just in front of it, thus indirectly revealing *which* slit the field (photons) passed through. But, how is this possible? Is it not in contradiction with our standard perception and understanding of the quantum world?

What are Bohmian trajectories?

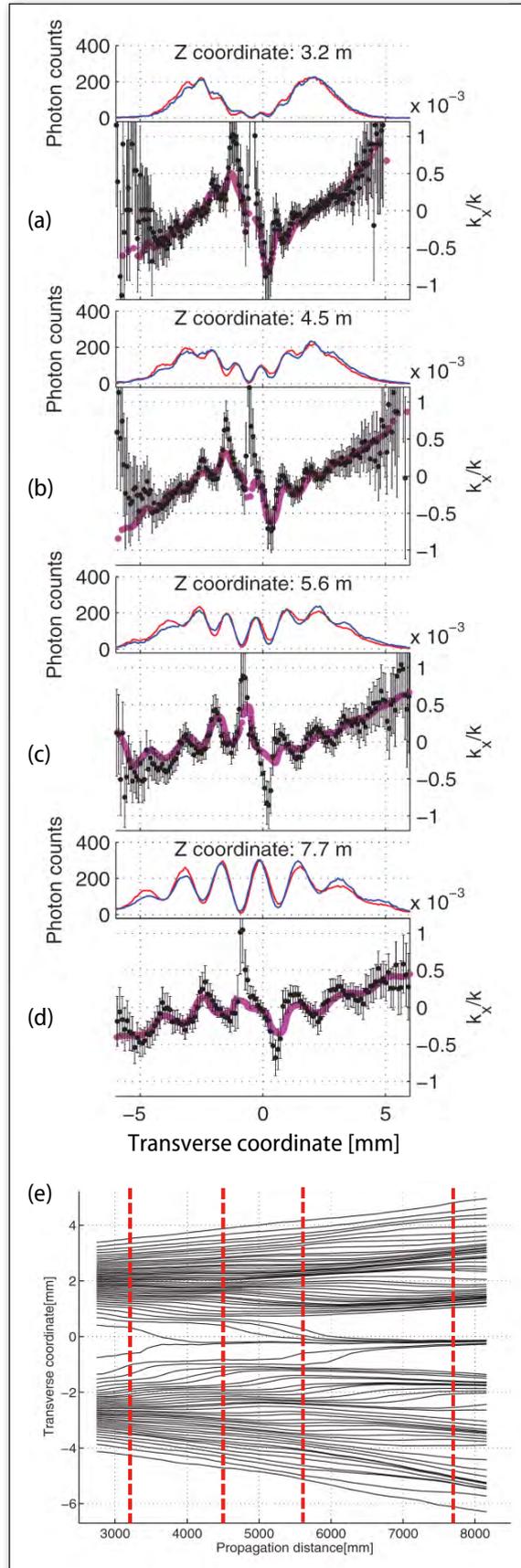
Leaving aside conceptual issues connected to the complementarity and uncertainty principles, there is no reason that impedes us to formulate models aimed at locally tracking the evolution of quantum systems. Actually, from a practical viewpoint, such models are very convenient: they provide us with a feeling of how the probability flows in (configuration) space and time. This is the case of Bohmian mechanics [5], a hydrodynamic formulation of quantum mechanics, where the evolution of quantum systems is described in terms of streamlines or trajectories. This is possible, because this approach focuses on the phase information encoded in the wave function. Thus, for example, in interference phenomena, bundles of trajectories gather along certain directions (maxima), while avoiding others (minima).

Bohmian mechanics is applicable whenever the quantum system is described by Schrödinger's equation. But, what happens if we are dealing with light instead? The answer is simple. Given that light interference patterns arise from the accumulation of a large number of photons [6], they can be well described by standard (classical) electromagnetism. Following the Bohmian prescription, an analogous model can then be formulated, where the trajectories (electromagnetic energy flow lines) are obtained from the Poynting vector [7,8] and describe the spatial distribution of the electromagnetic energy density.

Weak measurements vs. strong or von Neumann measurements

Now, is it possible to experimentally test the feasibility of the above model? Appealing to the complementarity and uncertainty principles, the immediate answer is "no". Standard (strong) measurements do not follow a unitary evolution transformation, inducing an irreversible change in the system evolution. This problem can be overcome, though, by performing "weak measurements" [9]. These are tiny perturbations performed on the system, which do not alter much its evolution, but which, when averaged over a large number, render complementary information about it. In practice, these data are equivalent to transition probabilities between two different states, the transition being described by a certain operator. If this operator corresponds to the momentum operator, the average coincides with the Bohmian momentum [10]. In other words, a weak measurement is just a measure of the local flow of the probability density or, equivalently, the local value of the quantum probability current density, often regarded as a non-observable. In the case of light, this translates into a local measure of the photon transversal momentum. This momentum, when averaged over many photons, happens to be proportional to the transversal component of the Poynting vector.

►FIG. 1: From (a) to (d), experimental intensities (red and blue curves) for the two circular components obtained from photon counts on a CCD camera, and weak momentum values obtained from these intensities at different imaging planes [2]. (e) Reconstruction of average photon (Bohmian) trajectories from weak momentum values taken on 41 imaging planes covering a range of 2.75 to 8.2 meters (the vertical red dashed lines denote the position of the imaging planes of the data shown in the above panels). Results obtained from Ref. [2]. Reprinted with permission from AAAS.



Measuring average photon paths experimentally

In the experiment [4] (see box), single photons produced by a quantum dot pass through a 50:50 beam splitter, which plays the role of Young's two slits. These photons are prepared in a diagonal polarization state, after which they pass through a thin chip of calcite, where the weak measurement is performed: the inclination of the calcite optical axis rotates the photon state, which becomes slightly elliptically polarized. By means of a quarter-wave plate (QWP) and a polarization beam displacer, the two polarization components are eventually separated (according to a circular polarization basis set), each one giving rise to an interference pattern. The shift between these two patterns is proportional to the photon transversal momentum at a particular position – in other words, from the intensities of the left-hand and right-hand circular components, the weak value of the photon transversal momentum is extracted. Averaging over a large number of photons on that position, not only the typical fringe interference pattern is reconstructed, but also the photon transversal momentum distribution. In order to obtain information at different distances from the “two slits”, a set of three lenses is used. By displacing one of them (the middle one), one achieves the effect of detecting the photons at imaging planes closer to or further away from two slits. Experimental results at four different imaging planes are shown in Figs 1a-d.

The information provided by a sequence of transversal momentum distributions recorded for many consecutive and closely spaced imaging planes is then used to determine the average flow of photons. It is here that Bohmian mechanics comes into play. To be more precise, Bohmian mechanics provides the idea and classical electromagnetism the theoretical framework, as mentioned above. The corresponding trajectories are reconstructed

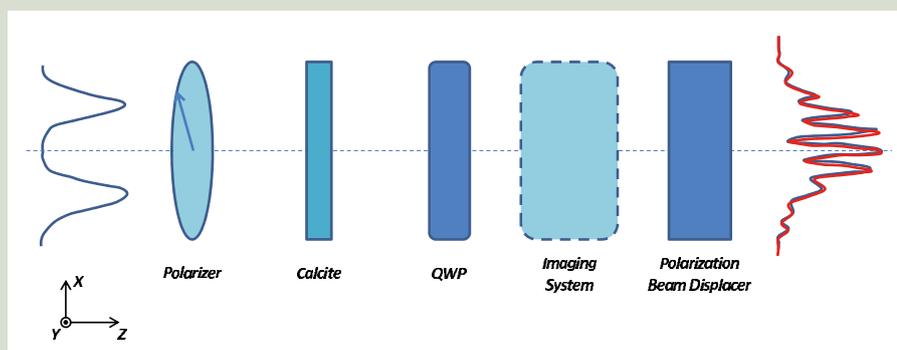
by propagating a set of initial conditions with the aid of the momenta along the transversal direction (see bottom panel of Fig. 1).

In spite of the complexity involved in the experimental setup, the trajectories themselves are a result that can be easily explained in terms of classical electromagnetism. To understand this basic idea, consider two slits such that, when illuminated by monochromatic light, they produce two diffracted Gaussian beams [11]. The energy density of the electromagnetic field behind the slits distributes as shown in Fig. 2a, while its phase is as displayed in Fig. 2b. The relation between the corresponding Poynting vector and the electromagnetic energy density gives a velocity field, which accounts for the local transport of energy. The photon transversal momenta (weak values) of Fig. 1 correspond to the transversal components of this field. This correspondence can be seen in Fig. 2c together with some trajectories. This quantity is compared with the experimental data at different distances from the two slits and using different initial electromagnetic energy density distributions [11] (Gaussian and non-Gaussian).

Plato and photon paths

In Plato's Allegory of the Cave, a series of people are enforced to face a wall where they observe the projected shadows of some objects passing by behind them. For those people, these shadows constitute their closer notion to the idea of reality, without ever knowing what the true nature is of the objects that cause such shadows. To some extent, the quantum world operates in a similar fashion: we can only understand quantum systems in a rather limited way. Under these circumstances, the Bohmian formulation offers the possibility to locally describe the evolution of quantum systems in terms of well-defined trajectories in the configuration space and time. These trajectories, in compliance with the (global) evolution

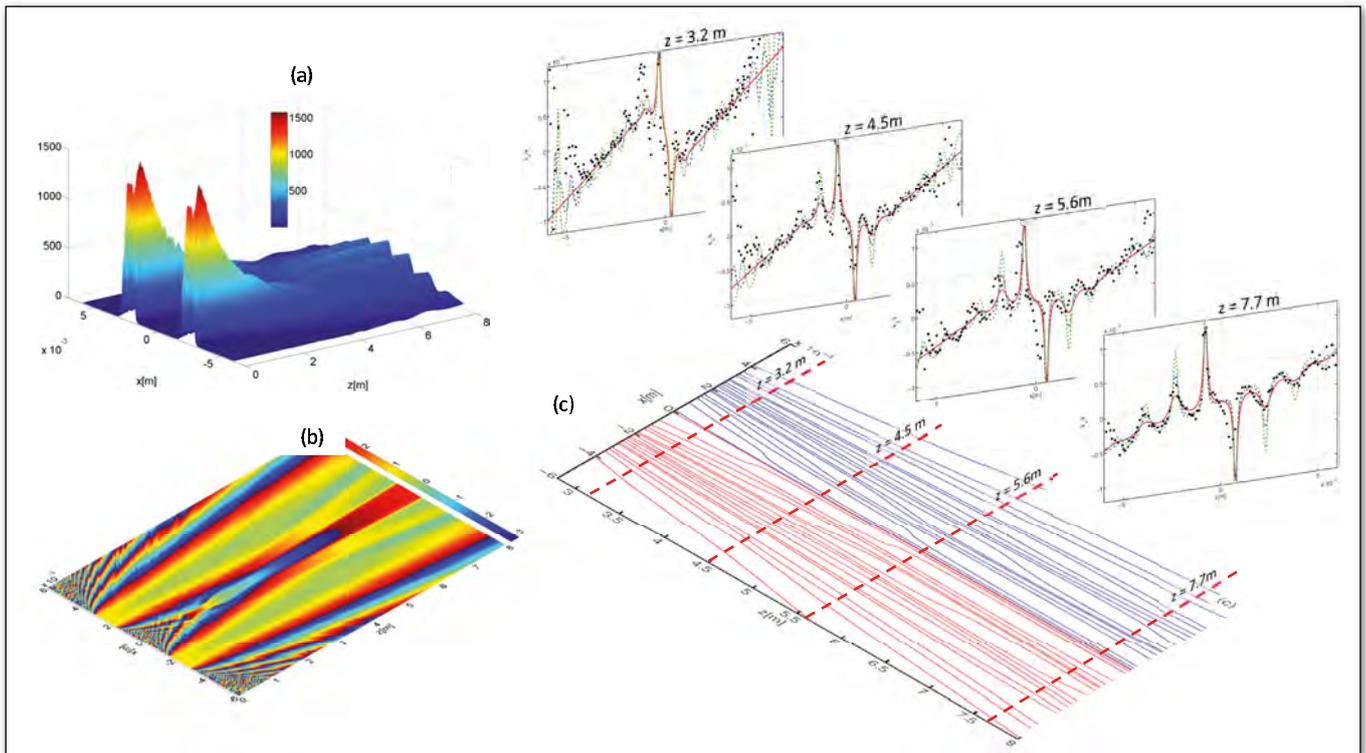
BOX: WEAK MEASUREMENTS IN YOUNG'S TWO SLITS



Simplified scheme of the version of Young's experiment performed by Kocsis *et al.* [4]. Photons are prepared with diagonal polarization $|D\rangle \propto |H\rangle + |V\rangle$ when they cross the first

polarizer. A thin calcite chip with optical axis at 42° induces a small phase-shift between the two photon polarization components (weak measurement), which is a linear

function of the photon transverse momentum, $\varphi(k_x) = \zeta(k_x/k) + \varphi_0$ (in the experiment the calcite is tilted in such a way that $\varphi_0 = 0$). The photon polarization state then becomes $|\Psi\rangle \propto e^{-i\varphi(k_x)/2}|H\rangle + |\Psi\rangle \propto e^{i\varphi(k_x)/2}|V\rangle$, which can also be recast as $|\Psi\rangle \propto (e^{-i\varphi(k_x)/2} + ie^{-i\varphi(k_x)/2})|R\rangle + (e^{-i\varphi(k_x)/2} - ie^{-i\varphi(k_x)/2})|L\rangle$, in the circularly polarized basis set $|H\rangle = (|R\rangle + |L\rangle)/\sqrt{2}$ and $|V\rangle = (|R\rangle - |L\rangle)/\sqrt{2}$. These two polarization components give rise to two separate and independently detected interference patterns (strong measurement), with intensities $I_R \propto 1 - \sin\varphi(k_x)$ and $I_L \propto 1 + \sin\varphi(k_x)$. The phase-shift is obtained from the relation $\sin\varphi(k_x) = (I_L - I_R)/(I_L + I_R)$, which relates to the transversal momentum as $k_x = (k/\zeta) \arcsin(I_L - I_R)/(I_L + I_R)$.



▲ FIG. 2: Young's two slit experiment with light. Energy density distribution (a) and phase field (b) of the electromagnetic field generated by two identical, Gaussian slits [11]. The corresponding electromagnetic energy flow lines or average (Bohmian) photon trajectories are displayed in (c), together with a comparison between transversal momenta obtained from numerical simulations with different models of slits (colored curves) and the corresponding sets of experimental data [2] (full circles).

accounted for by the wave function, are not in contradiction, though, with the complementarity and uncertainty principles (understood in a broader sense than is commonly done). This is an appealing idea from which a richer picture of the physical nature of quantum systems can be extracted, as the above experiment or some other that are currently being proposed [12,13] show.

In that sense, even though the trajectories reconstructed from the experiment cannot be associated with the paths followed by individual photons, but with electromagnetic energy streamlines, the experiment constitutes an important milestone in modern physics. The fact that the trajectories do not cross means that, at the level of the average electromagnetic field (or the wave function, in the case of material particles, in general), full which-way information can still be inferred without destroying the interference pattern. That is, rather than complementarity, the experiment seems to suggest that superposition has a tangible (measurable) physical reality [14], in agreement with a recent theorem on the realistic nature of the wave function [15]. ■

About the authors

Milena Davidović received her PhD at the Faculty of Electrical Engineering, University of Belgrade. After graduation she joined the Faculty of Civil Engineering in Belgrade, as a teaching assistant at the Department of Mathematics and Technical Physics. Fields of interest include foundational problems of quantum mechanics, laser physics, and civil engineering physics.

Angel S. Sanz received his PhD at the Universidad Autónoma de Madrid. Currently, he is "Ramón y Cajal"

Research Fellow at the Instituto de Física Fundamental (CSIC), in Madrid, where his research is mainly focused on applications of Bohmian mechanics to atomic, molecular, and optical physics, chemical physics, and surface science.

References

- [1] T. Young, *Phil. Trans. R. Soc. Lond.* **94**, 1 (1804)
- [2] www.quantumpie.com/media-coverage-over-our-double-slit-experiment/
- [3] <http://physicsworld.com/cws/article/news/2011/dec/16/physics-world-reveals-its-top-10-breakthroughs-for-2011>
- [4] S. Kocsis, B. Braverman, S. Ravets, M.J. Stevens, R.P. Mirin, L.K. Shalm, and A.M. Steinberg, *Science* **332**, 1170 (2011)
- [5] D. Bohm, *Phys. Rev.* **85**, 166 (1952)
- [6] T. L. Dimitrova and A. Weis, *Am. J. Phys.* **76**, 137 (2008)
- [7] M. Davidović, A. S. Sanz, D. Arsenović, M. Božić, and S. Miret-Artés, *Phys. Scr. T* **135**, 14009 (2009)
- [8] A.S. Sanz, M. Davidović, M. Božić, and S. Miret-Artés, *Ann. Phys.* **325**, 763 (2010)
- [9] Y. Aharonov, D.Z. Albert, and L. Vaidman, *Phys. Rev. Lett.* **60**, 1351 (1988)
- [10] H. Weisman, *New J. Phys.* **9**, 165 (2007)
- [11] M. Davidović, A. S. Sanz, M. Božić, D. Arsenović, and D. Dimić, *Phys. Scr. T* **153**, 014015 (2013)
- [12] W.P. Schleich, M. Freyberger, and M.S. Zubairy, *Phys. Rev. A* **87**, 014102 (2013)
- [13] B. Braverman and C. Simon, *Phys. Rev. Lett.* **110**, 060406 (2013)
- [14] A.S. Sanz and S. Miret-Artés, *J. Phys. A: Math. Theor.* **41**, 435303 (2008)
- [15] M. F. Pusey, J. Barrett, and T. Rudolph, *Nature Phys.* **8**, 475 (2012)



Opinion: Where are the women in physics?

Elisabeth Rachlew is emeritus professor of Applied Atomic and Molecular Physics at the KTH Royal Institute of Technology in Stockholm

In my country only about 10% of the Physics professors are women. So the question above is appropriate. There are frequent discussions about the issue of women in science, and not very seldom the question 'Where are they?' is replaced by 'Do we need them?'. When the physics class of the Royal Swedish Academy visited Brussels a few years ago, one of the leading politicians welcomed us by saying "...we are proud to welcome the physics class of the Royal Academy and also the wives...". Needless to say the women in the group were members of the physics class (including myself).

When we discuss the issue of women in physics usually one answer is sought, like 'it depends on the lack of self confidence of the women', or 'it is because women want to care for the children', or 'women are not interested in science...'. But I can tell you, the answer is not one single issue, but rather the structures which are built around natural sciences, around the technical sciences, around the power structure in the universities. I dare to say that the situation has not changed much since 1933, when the famous Solvay Conference picture was taken. Only 3 out of 41 are women – close to the percentage of faculty we have today in the physics department!

It would be unfair to say that nothing is being tried today in the universities, but it goes too slowly. The APS committee on Women in Science started a very impressive programme, with visits to the faculties and the physics departments, to find out why women disappear more quickly than the men from the faculty (the 'scissors'). The group performing

these visits includes the leadership of the university, from both the president's office and the personnel office. Many effects were found which caused women to leave, such as lack of university support in funding, in office area, in laboratory area, in participation in important committees. And these findings have resulted in changes at the physics departments. But more needs to be done. At the Swedish universities the defence of PhD theses is an important occasion. So an external expert is called in as the "opponent". Why not invite more women to be opponents? At scientific conferences it is not enough to have women as "chairmen". Ask them as invited speakers!

These are only examples where decision makers (usually men) should realize which assignments give scientific esteem. Many more actions are possible. Look at the statistics of Physics Department Heads and other university decision makers. An

Very recently the percentage of female presidents at the Swedish universities rose to over 60%, and most of these women have been in contact through mentorship programmes earlier in their careers.

interesting fact is that very recently the percentage of female presidents at the Swedish universities rose to over 60%, and most of these women have been in contact through mentorship programmes earlier in their careers. More general than *Women in Science* is the issue *Women in key positions* (Sweden never had a female prime minister, and women have the right to vote only since 1921). I think, though, that these two issues are strongly linked: who wants to pursue a science career if there is very little chance to arrive at a professorship? I frequently hear the argument 'the situation is changing, now we have many more undergraduate girls in physics', but the scissors show that this is not true. At every step in the university career women are disappearing faster than men. A man holding a PhD in physics has five times more chance to become a professor than a woman. And knowing this, why enter such a subject, even if physics is very much fun! ■

EPS CONSTITUTIONAL CHANGES?

The Executive Committee of the European Physical Society will propose modifications to the EPS Constitution and By-laws to the EPS Council during its meeting of 4-5 April 2014. A list of all the modifications can be found here: www.eps.org/?page=about_us_modif_prop.

An increase in Membership Fees for Individual Members only will also be presented to Council, modifying section 6 of Annexe 1 to the Constitution and By-laws.

The proposal would increase EPS Individual Membership fees as follows:

- Individual Member Category 3a euro 22 would be increased to euro 25,
- Individual Member Category 3b euro 44 would be increased to euro 50,
- Individual Member Category 3c euro 66 would be increased to euro 70,
- Individual Member Category 3d euro 16,50 would be increased to euro 18,
- Individual Member Category 3e euro 16,50 would be increased to euro 18.

Any increase decided by Council 2014 will not take effect until 2015. ■

ANNUAL INDEX VOLUME 44 - 2013

AUTHOR INDEX

- » **A**
- Arnaud N.** The LAL-LURE accelerator complex • 44/6 • p.04
- » **B**
- Beijerinck H.C.W.** Crossing borders • 44/4 • p.21
- Benedek G.** Letter to the editor: About 'Crossing borders' • 44/6 • p.32
- Benvenuti C.** The SRB solar thermal panel • 44/3 • p.16
- Bergé L.** see Bloch I.
- Bloch I.** The 2013 QEOD Major Prizes • 44/3 • p.09
- Blocken B.** Surprises in cycling aerodynamics • 44/1 • p.04
- Bobbert P.** A look inside white OLEDs • 44/5 • p.21
- Bobin J.-L.** 2010 to 2050: Which Energy Policy for France? • 44/1 • p.04
- Boldiš Z.** Czech electricity grid challenged by German wind • 44/4 • p.16
- Božić M.** Inspiring learning environment, the school as a three-dimensional text book • 44/2 • p.22
- Bradshaw A.** Open access: accept the challenge! • 44/4 • p.29
- » **C**
- Cammelli A.** Forum Physics and Society (AlmaLaurea in Italy) • 44/1 • p.09
- Carmeliet J.** see Blocken B.
- Cifarelli L.** The European Physical Society is 45 years old • 44/1 • p.03 // The impact of physics in the European economy • 44/2 • p.03 // The EPS Edison Volta Prize • 44/4 • p.09
- Coehoorn R.** see Bobbert P.
- Cook J.** The scientific consensus on climate change • 44/6 • p.25
- Courvoisier T.J.-L.** Surprises in the Hard X-ray Sky • 44/4 • p.25
- Cueno P.** Museo L. da Vinci • 44/1 • p.30
- » **D**
- Davidović M.D.** How does light move? • 44/6 • p.33
- Defraeye T.** see Blocken B.
- Dellago C.** see Telo da Gama M.M.
- Dominici D.** The Hill of Arcetri • 44/4 • p.04
- Dudley J.** The challenge of communication • 44/3 • p.03 // Surviving in Science • 44/4 • p.03 // Future focus • 44/5 • p.03 // see Hidalgo C.
- Duvez A.-S.** see Svaldo-Lanero T.
- » **F**
- Ferrante F.** see Cammelli A.
- » **G**
- Grzadkowski B.** Physics Faculty of the University of Warsaw • 44/2 • p.04
- » **H**
- Haïssinski J.** see Arnaud N.
- Hellborg R.** The Hven Island in Øresund • 44/6 • p.10
- Heemskerck J.** An eye-witness report on how the CD came about • 44/6 • p.21
- Henri A.** The challenge of Open Access • 44/5 • p.30
- Hermans L.J.F. (Jo)** Heavy ice • 44/1 • p.19 // Water lenses • 44/5 • p.15
- Hespel P.** see Blocken B.
- Hidalgo C.** European Programme for Research and Innovation Horizon 2020 • 44/6 • p.06
- Huchet B.** The Odysseus contest reveals the next generation of scientists • 44/4 • p.08
- » **J**
- Jarlskog C.** Emmy Noether's Legacy in Physics • 44/2 • p.07
- Jobert G.** On inverse problems in physics • 44/5 • p.26
- » **K**
- Kahana O.** My amazing experience • 44/2 • p.21
- Koninckx E.** see Blocken B.
- Kubbinga H.** A tribute to Jean Perrin • 44/5 • p.16
- » **L**
- Langanke K.** Making the Elements in the Universe • 44/3 • p.23
- Lee D.** EPS Council 5-6 April 2013 Strasbourg, France • 44/3 • p.06 // About the June Executive Committee meeting of the EPS • 44/4 • p.07 // see Hidalgo C.
- Lister J.** Laboratory 'Les Cosmiques' • 44/1 • p.11 // Interview of Alessandra Gatti • 44/5 • p.07
- Lugiato L.** A. Gatti, the first EPS Emmy Noether Distinction laureate • 44/2 • p.08
- » **M**
- Maiani L.** Comment on the 2013 Nobel Prize in Physics • 44/6 • p.12
- » **O**
- Ohler C.** Beauty in disguise – the physics behind the power grid • 44/2 • p.27
- Olsheskiy A.** The study of Bruno Pontecorvo • 44/3 • p.04
- Osland P.** see Jarlskog C.
- » **P**
- Palmonari F.** The Villa Griffone in Pontecchio Marconi • 44/5 • p.04
- Pascual R.** Royal Academy of Sciences and Arts of Barcelona • 44/3 • p.27
- Proykova A.** EPS Emmy Noether Distinction for Women in Physics • 44/2 • p.06
- Punturo M.** Opening a new window on the Universe: the future Gravitational Wave detectors • 44/2 • p.17
- » **R**
- Rachlew E.** Where are the women in physics? • 44/6 • p.37
- Roturier J.** Unlearned lessons from a forgotten crisis • 44/3 • p.19
- Rummel R.** Earth gravity from space or how attractive is our planet? • 44/1 • p.24
- » **S**
- van Saarloos W.** Rethinking our relation with society and industry • 44/1 • p.32
- Sanz A.S.** see Davidović M.D.
- Sanz-Solé M.** The European Mathematical Society: the home for Mathematics in Europe • 44/4 • p.19
- Schreiber M.** Can comments cause citations? Yes, they can! • 44/5 • p.19
- Schwoerer M.** EPL: Giorgio Benedek succeeds Michael Schreiber • 44/3 • p.10
- Sébenne C.** Goodbye and good luck EPN! • 44/6 • p.03
- Svaldo-Lanero T.** The pulling force of a tiny synthetic molecular machine • 44/3 • p.10
- » **T**
- Telo da Gama M.M.** EPS Liquid Matter Prize 2014 • 44/6 • p.14
- Thielemann F.-K.** see Langanke K.
- » **W**
- Wagner F.** The pitfalls of time derivatives • 44/3 • p.30
- Weaire D.** Bibliomeritocracy, the merciless march of metrics • 44/2 • p.32
- Wenninger H.** An eye-witness report on how the WWW came about • 44/4 • p.22
- » **Z**
- Zach K.** Physics funding at the German Research Foundation • 44/6 • p.29

MATTER INDEX

» **Annual index**

Volume 44 - 2013 • 44/6 • p.38

» **Editorials**

The European Physical Society is 45 years old **Cifarelli L.**

The impact of physics in the European economy **Cifarelli L.**

The challenge of communication **Dudley J.**

Surviving in Science **Dudley J.**

Future focus **Dudley J.**

Goodbye and good luck EPN! **Sébenne C.**

» **Education**

Inspiring science education: eLearning tools to promote IBSE • 44/5 • p.08

The Energy Network, Norway 2005-2013 • 44/6 • p.08

» **Energy**

2010 to 2050: Which Energy Policy for France? **Bobin J.-L.**

» **Features (Science)**

A look inside white OLEDs **Bobbert P. and Coehoorn R.**

A tribute to Jean Perrin **Kubbinga H.**

An eye-witness report on how the CD came about **Heemskerk J.**

An eye-witness report on how the WWW came about **Wenninger H.**

Beauty in disguise – the physics behind the power grid **Ohler C.**

Czech electricity grid challenged by German wind **Boldiš Z.**

Earth gravity from space or how attractive is our planet? **Rummel R.**

How does light move? **Davidović M.D. and Sanz A.S.**

Inspiring learning environment, the school as a three-dimensional text book **Božić M.**

Making the Elements in the Universe **Langanke K. and Thielemann F.-K.**

On inverse problems in physics **Jobert G.**

Surprises in cycling aerodynamics **Blocken B., Defraeye T., Koninckx E., Carmeliet J. and Hespel P.**

Surprises in the Hard X-ray Sky **Courvoisier T.J.-L.**

The pulling force of a tiny synthetic molecular machine **Svaldo-Lanero T. and Duwez A.-S.**

The SRB solar thermal panel **Benvenuti C.**

Opening a new window on the Universe: the future Gravitational Wave detectors **Punturo M.**

Physics funding at the German Research Foundation **Zach K.**

Royal Academy of Sciences and Arts of Barcelona **Pascual R.**

The European Mathematical Society: the home for Mathematics in Europe **Sanz-Solé M.**

The scientific consensus on climate change **Cook J.**

» **Highlights**

44/1 • 12 summaries • p.13-18

44/2 • 12 summaries • p.10-15

44/3 • 08 summaries • p.12-15

44/4 • 07 summaries • p.13-15

44/5 • 14 summaries • p.09-14

44/6 • 13 summaries • p.16-20

» **Historic sites**

Laboratory 'Les Cosmiques' **Lister J.**

Physics Faculty of the University of Warsaw **Grzadkowski B.**

The Hill of Arcetri **Dominici D.**

The Hven Island in Øresund **Hellborg R.**

The LAL-LURE accelerator complex **Arnaud N. and Haïssinski J.**

The study of B. Pontecorvo **Olshevskiy A.**

The Villa Griffone in Pontecchione Marconi **Palmonari F.**

» **Inside EPS**

About the June Executive Committee meeting of the EPS **Lee D.**

EPL: Giorgio Benedek succeeds Michael Schreiber **Schwoerer M.**

EPS constitutional changes? • 44/6 • p.37

EPS directory • 44/4 • p.30

Letters to the Editor - an invitation to EPN readers • 44/1 • p.05

» **Interview**

Interview of A. Gatti **Lister J.B.**

» **Letters**

About 'Crossing borders' **Benedek G.**

Can comments cause citations? Yes, they can! **Schreiber M.**

Crossing borders **Beijerinck H.C.W.**

Unlearned lessons from a forgotten crisis **Roturier J.**

My amazing experience **Kahana O.**

» **Museum review**

Museo Leonardo da Vinci **Cueno P.**

» **Obituary**

Øystein Håkon Fischer • 44/6 • p.09

» **Opinion**

Bibliomeritocracy, the merciless march of metrics **Weaire D.**

Open access: accept the challenge! **Bradshaw A.**

Rethinking our relation with society and industry **van Saarloos W.**

The challenge of Open Access **Henri A.**

The pitfalls of time derivatives **Wagner F.**

Where are the women in physics? **Rachlew E.**

» **Physics in daily life**

Heavy ice **Hermans L.J.F. (Jo)**

Water lenses **Hermans L.J.F. (Jo)**

» **Prizes - Awards - Medals**

2013 Prize winners of the High Energy Physics Division of the EPS • 44/4 • p.06

Alessandra Gatti, the first EPS Emmy Noether Distinction laureate **Lugiato L.**

Comment on the 2013 Nobel Prize in Physics **Maiani L.**

Emmy Noether's Legacy in Physics **Jarlskog C. and Osland P.**

EPS Emmy Noether Distinction for Women in Physics **Proykova A.**

EPS Liquid Matter Prize 2014 **Telo da Gama M.M. and Dellago C.**

EPS-NPD Lize Meitner Prize 2012 • 44/1 • p.06

The 2013 QEOD Major Prizes **Bloch I. and Bergé L.**

The EPS Edison Volta Prize **Cifarelli L.**

» **Report**

EPS Council 5-6 April 2013 Strasbourg, France **Lee D.**

» **Science and Society**

European Programme for Research and Innovation Horizon 2020 **Hidalgo C., Lee D. and Dudley J.,**

Forum Physics and Society (general report) • 44/1 • p.07

Forum Physics and Society (AlmaLaurea in Italy) **Cammelli A. and Ferrante F.**

The Odysseus contest reveals the next generation of scientists **Huchet B.**

KIAS

Postdoctoral Research Fellow and KIAS Assistant Professor in Theoretical Physics

The School of Physics at Korea Institute for Advanced Study (KIAS) invites applicants for the positions of Postdoctoral Research Fellow and KIAS Assistant Professor in theoretical physics.

Applicants are expected to have demonstrated remarkable research potential, including major contributions beyond or through the doctoral dissertation. For research fellows, annual salary starts from 42,000,000 Korean Won (approximately US\$39,000 at current exchange rate) and additional research funds of 10,000,000 Korean Won (US\$9,300) will be provided each year. The initial appointment for the position is for two years and is renewable for up to two years, depending on your research performance and the needs of the research program at KIAS.

Exceptional candidates may be asked to join KIAS as KIAS Assistant Professors. Annual salary for the position starts from 50,000,000 Korean Won (US\$46,000) and research funds of 15,000,000 Korean Won (US\$14,000) will be provided per year. The initial appointment is for two years and is renewable for up to three additional years.

The deadline is December 29 for positions beginning in Spring 2014 or earlier. Applications must include a complete vitae with a cover letter, a list of publications, and a research plan. Three letters of recommendation should be mailed to:

Ms. Sunmi Wee

Korea Institute for Advanced Study (KIAS)

85 Hoegiro (Cheongnyangni-dong 207-43), Dongdaemun-gu, Seoul 130-722, Republic of Korea

Those interested are encouraged to contact individual faculty members. Visit our website at <http://www.kias.re.kr> to learn about our faculty members and their research interests.

You can also submit your application materials at AcademicJobsOnline.





Open Access publishing from EDP Sciences

A large graphic featuring a man in a light blue shirt sitting at a laptop, looking thoughtful with his hand to his chin. The background is a warm orange color with a hexagonal pattern and a glowing globe on the right side.

**A world of opportunity
with EDP Open**

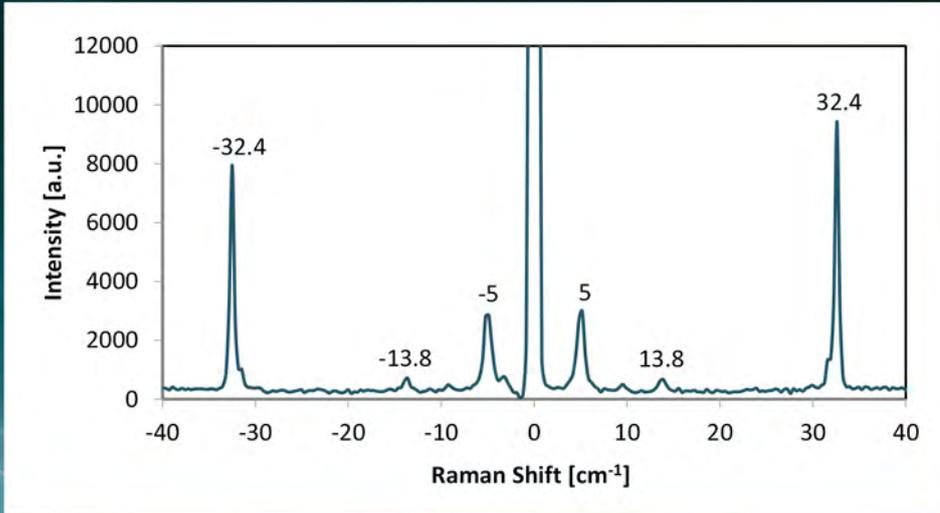
At EDP Open we publish a growing suite of international high quality Open Access journals and partner with learned societies, publishers and academics to create opportunities from Open Access.

www.edp-open.org

Your Open Access partner

Ultra-Low Frequency Raman Spectroscopy

“Extend your Raman system into THz frequency range ($5\text{-}200\text{ cm}^{-1}$)”



Raman spectrum of MoS₂ flakes measured at 633 nm with BragGrate™ Notch filters and single stage spectrometer

(data courtesy of: P. H. Tan, State Key Laboratory of SL and Microstr., Institute of Semiconductors, CAS, Beijing, P. R. China)

BragGrate™ Bandpass and Notch Filters

Spectral and spatial laser line cleaning filters and ultra-narrow line notch filters for low frequency Raman Spectroscopy



488 nm 633 nm
514 nm 785 nm
532 nm 1064 nm

- Frequencies below 10 cm^{-1} with single stage spectrometer
- Stokes and anti-Stokes Raman bands
- Unlimited optical life-time
- Custom wavelengths in range 400–2000 nm

OptiGRATE
HIGH EFFICIENCY FOR HIGH POWER

+1 (407) 542-7704
info@optigrate.com
www.optigrate.com