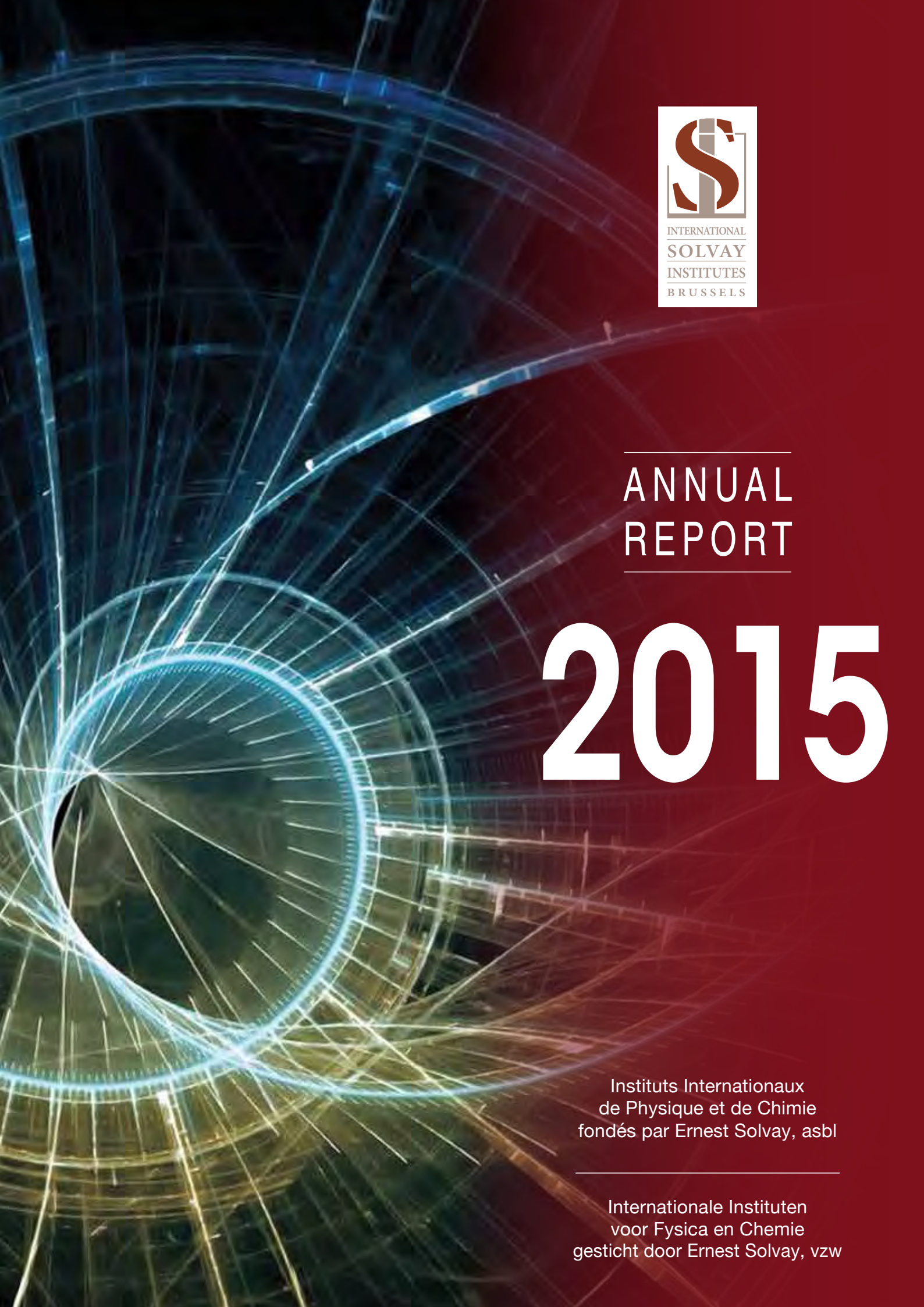

INTERNATIONAL SOLVAY INSTITUTES BRUSSELS

ANNUAL REPORT

2015

Instituts Internationaux
de Physique et de Chimie
fondés par Ernest Solvay, asbl

Internationale Instituten
voor Fysica en Chemie
gesticht door Ernest Solvay, vzw

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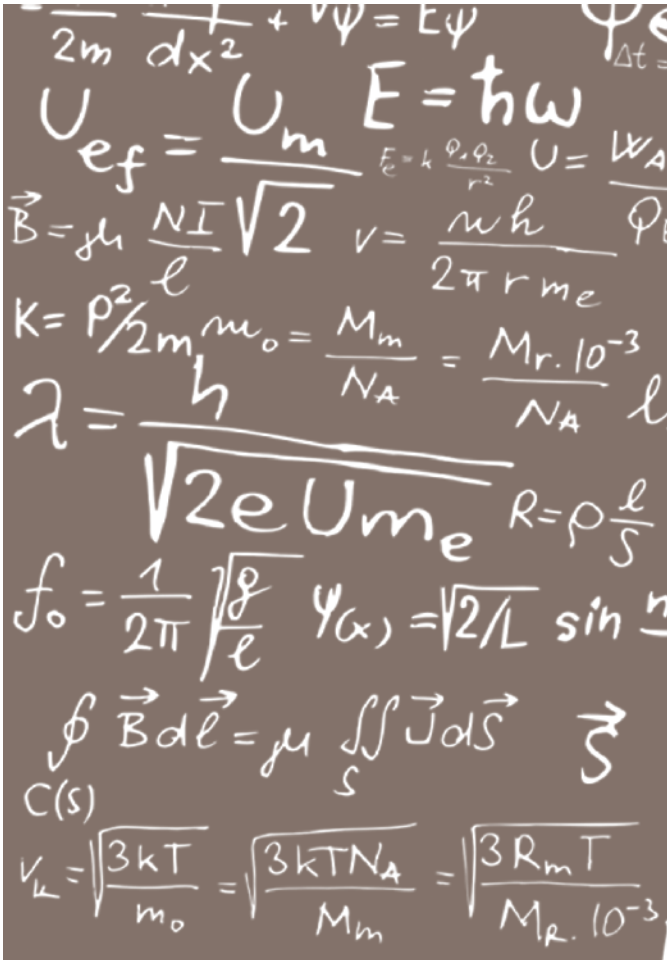
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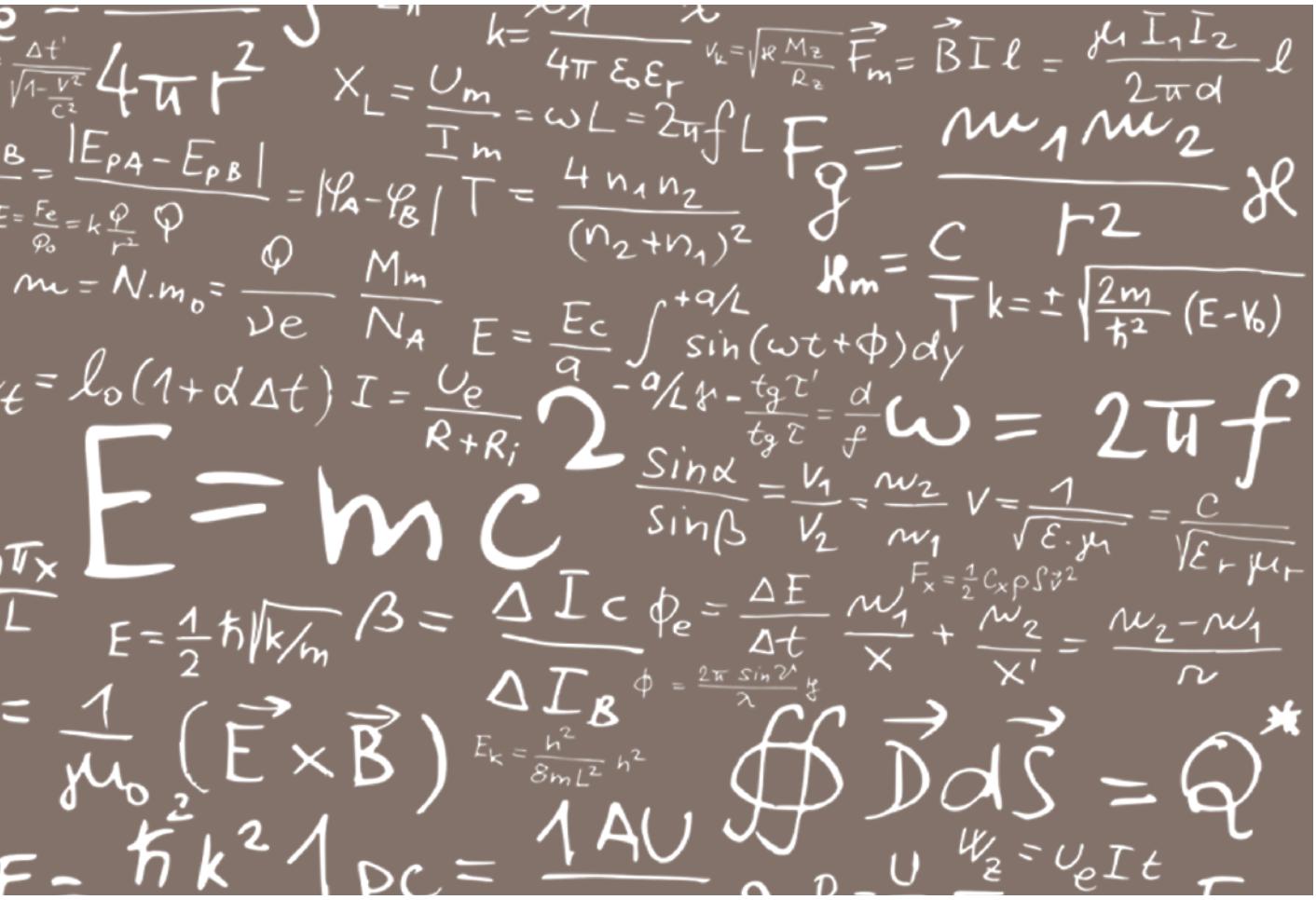
K = p²/2m
λ = h
R = ρ l/S
sin
C(S)



There are **no limits**
to what **science** can explore.

Ernest Solvay

The International Solvay Institutes for Physics and Chemistry,
founded by Ernest Solvay, acknowledge with gratitude the generous support of

The Solvay Family

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FONDATION
DAVID ET ALICE
VAN BUUREN

HOTEL METROPOLE

Contents

A word from the **President**

The year 2015 was a year without an International Conference in either Physics or Chemistry. Yet, it was a very productive year, not only because many of the scientific activities were of the highest quality, but also because they were the product of collaboration between the Institutes and other research centers in Belgium, Europe and the world. It is one of our goals to draw outstanding researchers to Brussels, inspiring the curiosity, passion and engagement of the young scientific community.

No fewer than 4 workshops were organized and 6 sponsored by the Institutes, assembling young people and seasoned researchers to discuss varied fields from the “String Theory Universe” to the “Atomic and Molecular Collision Mechanisms”. Thirteen colloquia provided a unique access to renowned international scientist to our local students drawn from all Belgian universities.

Two International chairs were organized: in Chemistry, Professor Andreas Manz, the founding father of the “lab-on-a-chip” spoke about new capabilities in measurements of molecular parameters and in Physics Professor Peter Zoller presented the recent advancements in building quantum computers and quantum simulators.

The annual Public Lecture this year celebrated 100 years of Einstein’s general relativity: Professor Reinhard Genzel and Professor Vlatcheslav Mukhanov shared respectively their knowledge and vision on black holes and the expanding Universe. The theatre was full and the lecturers answered with delight the various questions from the public which made the event a joyful and inspiring event.

Lastly we had the pleasure of welcoming back for the third time the Advisory Committee, led by professor Lars Brink. They provided a frank assessment of our activities and strategic guidance for our future initiatives. Their report is as usual, extremely well written and informative.

I would like to end by expressing my gratitude to Professor Marc Henneaux, director, Professor Alex Sevrin, deputy director for physics, Professor Lode Wyns, deputy director for Chemistry, Professors Glenn Barnich, Ben Craps and Anne De Wit, assistants to the director, and the members of the local organizing committees for presenting activities of an outstanding quality. I express my special thanks to the back office team, Dominique and Isabelle that plan and execute every detail of these events seamlessly. Lastly I would like to thank the members of the board of directors for their guidance and all our donors that continue to support our activities and help the Solvay Institutes remain a symbol of scientific excellence.

Jean-Marie Solvay
President

A word from the **Director**

The year 2015 marked the hundredth anniversary of Einstein's general theory of relativity – the theory that describes gravity in a manner compatible with the relativity principle. To celebrate this remarkable intellectual achievement, which completely revolutionized our views on space, time and gravity, the annual public event of the International Solvay Institutes was devoted to "One hundred years of Einstein's general relativity". It took place on October 18 at Flagey. Two areas where general relativity plays a key and spectacular role provided the themes of the lectures: cosmology and black hole physics. The lecture hall was fully packed and the event was a remarkable success. We thank the two lecturers, Professors Reinhard Genzel and Viatcheslav Mukhanov, for their splendid talks that captivated the audience on the wonders and mysteries of our universe.

Another highlight of the year 2015 was the visit of the Solvay International Advisory Committee. This Committee is composed of distinguished scientists who have the task of periodically evaluating all the scientific activities of the Solvay Institutes, make suggestions if appropriate, report to the Board of Directors and provide advice for future developments. In 2015, the Committee visited the Institutes for the third time. The report of their visit is enclosed on page 185. The general evaluation of the activities of the Solvay Institutes made by the Advisory Committee is extremely positive. This is a great encouragement. Periodic reviews by an external eye are extremely healthy. I am very grateful for the careful work done by the International Advisory Committee and wish to thank all its members, and especially its chair Professor Lars Brink, for their evaluation and advice.

The year 2015 also witnessed a change in the Board of Directors of the Institutes. This gives me the opportunity to greet the new Members who joined the Board. I look forward to working with them in this unique organization that are the International Solvay Institutes!

I would also like to thank Franz Bingen, who finished his terms as effective Board Member, for the remarkable and tireless assistance he provided to the Institutes for more than 40 years, as Vice-President and Treasurer. His vigilant

collaboration has been extremely precious to go through the financial difficulties of the last decade, of which the Institutes successfully came out. I am pleased that Franz will continue serving the Institutes as Honorary Board Member.

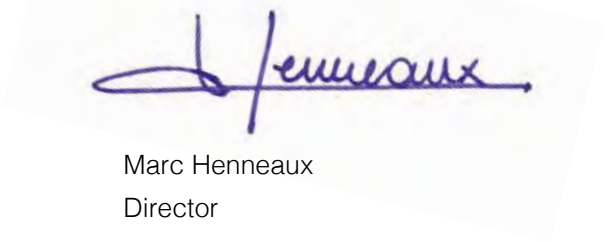
The report that follows reviews in detail the activities organized or supported by the International Solvay Institutes during the year 2015. These activities (chairs, workshops, colloquia, graduate school in theoretical physics) attracted to Brussels hundreds of scientists and covered a wide spectrum of exciting scientific developments. I will just briefly mention in this introductory section the annual international Solvay Chairs in Physics and Chemistry, respectively created in 2006 and 2008. The 2015 Solvay Professor in Chemistry was Professor Andreas Manz, from KIST Europe, Saarbrücken (Germany). The 2015 Jacques Solvay Chair in Physics was held by Professor Peter Zoller from the University of Innsbruck, (Austria). Both chair holders gave brilliant opening lectures explaining the most pressing challenges in their respective fields of investigation: “Lab on Chip - Technology - 10x smaller means 100x faster” and “A Quantum Leap in Quantum Information - Building Quantum Computers and Quantum Simulators with Cold Atoms and Ions”. These lectures were attended by many students and researchers from the ULB, the VUB and other Belgian universities.

This activity report also describes the research carried in the groups of the Director and of the Scientific Secretaries of the International Scientific Committee for Chemistry and the International Scientific Committee for Physics. The research highlights of other researchers connected with the Institutes are also outlined.

The research of the group of the Director benefited from the direct and most precious support of the Solvay family and the Solvay group, as well as from generous gifts from Messrs. Collen, de Selliers de Moranville and Thijssen. I heartily thank them all.

The activities described in this report would not have been possible without the help of the sponsors of the International Solvay Institutes, to whom I would like to express our gratitude. These are the Université Libre de Bruxelles, the Vrije Universiteit Brussel, the Solvay Company, the Belgian National Lottery, the Brussels-Capital Region, the Fédération Wallonie-Bruxelles, the Vlaamse Regering, BNP-Paribas Fortis, the David & Alice Van Buuren Foundation, the Hôtel Métropole and last but not least – and as recalled above -, the Solvay family: Mme Solvay, Anne-Christine Solvay, Carole Solvay, Marina Solvay and Jean-Marie Solvay who continue with the same conviction a century-old tradition of support to fundamental research.

The remarkable efficiency and commitment of Dominique Bogaerts and Isabelle Van Geet in the management of the activities of the Institutes, is again gratefully acknowledged.



Marc Henneaux
Director


Cosmological Frontiers in Fundamental Physics

General Information

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President

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Vice-President & Treasurer

Dean of the Faculty of Science VUB

Gino Baron
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Emeritus Professor VUB

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of the ULB

Eric Boyer de la Giroday

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Eddy Van Gelder

Chairman of the Board of Directors
of the VUB

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Honorary Director of the Solvay Institutes

Jean-Louis Vanherweghem
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Irina Veretennicoff
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Scientific Secretary of the International Committee for Chemistry

Freddy Dumortier
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Hervé Hasquin
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Marc Henneaux
Professor ULB
Director

Franklin Lambert
Emeritus Professor VUB

Alexander Sevrin
Professor VUB
Deputy Director for Physics and Scientific Secretary of the International Committee for Physics

Marina Solvay

Lode Wyns
Former Vice-rector for Research VUB
Deputy Director for Chemistry

Management and **Staff**

Director	Professor Marc Henneaux (ULB)
Deputy Director for Physics	Professor Alexander Sevrin (VUB)
Deputy Director for Chemistry	Professor Lode Wyns (VUB)

The Director is assisted in his scientific tasks by:

- The International Scientific Committees for Physics and Chemistry, who are fully responsible for the scientific organization of the "Conseils Solvay".
- The Scientific Assistants to the Director and the Local Scientific Committees, who help him for the organization of all the other activities (workshops, colloquia, chairs).

Assistants to the Director	Professor Anne De Wit (ULB) Professor Glenn Barnich (ULB) Professor Ben Craps (VUB)

He is assisted in his management tasks by the administrative staff.

Office manager	Ms Dominique Bogaerts
Researchers logistic support	Ms Marie-France Rogge
Project coordinator	Ms Isabelle Van Geet
Accounting officer	Ms Chantal Verrier

How to **reach us**

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Website: http://www.solvayinstitutes.be

International Scientific Committee for **Physics**

The International Scientific Committees for Physics and Chemistry are responsible for the scientific organization of the "Conseils Solvay".

They are in charge of defining the general theme of the conferences and of selecting a chair person.

Members are appointed for a 6-year period term, renewable once.

Chair

Professor David Gross
2004 Nobel Laureate
Kavli Institute for Theoretical Physics
Santa Barbara, USA

Scientific Secretary

Professor Alexander Sevrin
Vrije Universiteit Brussel (Belgium)

Members

Professor Roger Blandford
Stanford University (USA)

Professor Steven Chu
1997 Nobel Laureate
University of Berkeley (USA)

Professor Robbert Dijkgraaf
IAS Princeton (USA)

Professor Bertrand Halperin
Harvard University (USA)

Professor Gerard 't Hooft
1999 Nobel Laureate
Spinoza Instituut, Utrecht (The Netherlands)

Professor Giorgio Parisi
Università La Sapienza, Roma (Italy)

Professor Pierre Ramond
University of Florida, Gainesville (USA)

Professor Klaus Von Klitzing
1985 Nobel Laureate
Max-Planck-Institut, Stuttgart (Germany)

Professor Peter Zoller
University of Innsbruck (Austria)

International Scientific Committee for **Chemistry**

Chair

Professor Kurt Wüthrich
2002 Nobel Laureate
Scripps Research Institute, La Jolla, USA and ETH-Zürich, Switzerland

Scientific Secretary

Professor Anne De Wit
Université Libre de Bruxelles (Belgium)

Members

Professor Gerhard Ertl
2007 Nobel Laureate
Fritz-Haber-Institut der Max-Planck-Gesellschaft Berlin (Germany)

Professor Graham Fleming
University of Berkeley (USA)

Professor Robert H. Grubbs
2005 Nobel Laureate
California Institute of Technology, Pasadena (USA)

Professor Roger Kornberg
2006 Nobel Laureate
Stanford University (USA)

Professor Harold W. Kroto
1996 Nobel Laureate
University of Sussex, Brighton (UK)

Professor Henk N.W. Lekkerkerker
Utrecht Universiteit (The Netherlands)

Professor K.C. Nicolaou
Rice University (USA)

Professor JoAnne Stubbe
Massachusetts Institute of Technology, Cambridge (USA)

Professor George M. Whitesides
Harvard University, Cambridge (USA)

Professor Ahmed Zewail
1999 Nobel Laureate
California Institute of Technology, Pasadena (USA)

International **Advisory** Committee

In 2008, the Board of Directors of the International Solvay Institutes decided to set up an International Advisory Committee. The International Advisory Committee of the Solvay Institutes is composed of distinguished scientists who have the task of periodically evaluating all the scientific activities of the Solvay Institutes (outside the Sovay Conferences which are run by the respective Scientific Committees), report to the Board of Directors and provide advice for future developments.

Members are appointed for a 6-year period term, renewable once.

The 2015 report of the Advisory Committee is available on page 185.

Chair

Professor Lars Brink
Chalmers University of Technology
Göteborg (Sweden)

Members

Professor Leticia Cugliandolo
Université Pierre et Marie Curie – Paris VI (France)

Professor Ben Feringa
University of Groningen (The Netherlands)

Professor Karen I. Goldberg
University of Washington (USA)

Professor Hermann Nicolai
Max-Panck-Institut für Gravitationsphysik,
Golm (Germany)

Professor Hirosi Ooguri
California Institute of Technology, Pasadena (USA)

Professor Jacques Prost
Ecole Supérieure de Physique et de Chimie Industrielles (ESPCI), Paris (France)

Professor Gunnar von Heijne
Stockholm University (Sweden)

2015 Chemistry for the Future Solvay Prize

Professor Ben Feringa, member of the Advisory Committee, received the 2015 Chemistry for the Future Solvay Prize. This Prize, created in 2013 by the Solvay Group on the occasion of its 150th anniversary, commemorates the vision of Ernest Solvay and his unique role in the development of fundamental science.
Our warmest congratulations go to him.

Local Scientific Committees for **Physics and Chemistry**

The Local Scientific Committees help the Director for the organization of the Workshops, Colloquia, Chairs and Doctoral School.

Members are appointed for a 3-year period term

Local Scientific Committee for **Physics**

Chair

Professor Marc Henneaux (ULB, Brussels)

Members

Professor Ben Craps (VUB, Brussels)
Professor Jan Danckaert (VUB, Brussels)
Professor Anne De Wit (ULB, Brussels)
Professor Pierre Gaspard (ULB, Brussels)
Professor Jean-Marc Gérard (UCL, Louvain)
Professor Joseph Indekeu (KU Leuven)
Professor Philippe Lambin (FUNDP, Namur)
Professor Alexander Sevrin (VUB, Brussels)
Professor Petr Tinyakov (ULB, Brussels)
Professor Christian Van den Broeck (UHasselt)
Professor Sophie Van Eck (ULB, Brussels)

Local Scientific Committee for **Chemistry**

Chair

Professor Lode Wyns (VUB, Brussels)

Members

Professor Annemie Bogaerts (U. Antwerp)
Professor Jean-Luc Bredas (Georgia Institute of Technology, Atlanta, USA)
Professor Pierre-François Coheur (ULB, Brussels)
Professor Pierre De Clercq (UGent)
Professor Gert Desmet (VUB, Brussels)
Professor Anne De Wit (ULB, Brussels)
Professor Pierre Gaspard (ULB, Brussels)
Professor Paul Geerlings (VUB, Brussels)
Professor Yves Geerts (ULB, Brussels)
Professor Marc Henneaux (ULB, Brussels)
Professor Roberto Lazzaroni (UMons)
Professor André Matagne (ULg, Liège)

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Università di Firenze and INOA, Italy

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Centro de Estudios Científicos, Valdivia, Chile

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1997 Nobel Laureate
Ecole Normale Supérieure, Paris, France

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1967 Nobel Laureate
Max-Planck Institut, Göttingen, Germany

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2013 Nobel Laureate
Université Libre de Bruxelles, Belgium

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St Petersburg, Russia

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Moscow, Russia

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1987 Nobel Laureate
Collège de France, Paris, France

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1995 Nobel Laureate
Massachusetts Institute of Technology
Cambridge, USA

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University of Chicago, USA

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Moscow State University, Russia

Professor Roald Sagdeev
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Professor E.C.G. Sudarshan
University of Texas, Austin, USA

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1957 Nobel Laureate
Chinese University Hong Kong & Tsinghua University, Beijing, China

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Willox Ralph


Celebrating
100 years
of Einstein's
General
Relativity

Public Lectures

12th Solvay **Public Event**

"One hundred years of Einstein's general relativity"

18 October 2015

Einstein's theory of gravity – also known as "general relativity" – is one of the intellectual jewels of the 20th century. Developed in 1915 by Einstein in order to make the gravitational force compatible with the relativity principle, which implies that no signal can propagate faster than light, this theory has revolutionized our views of space and time.

The greatest physicists marvelled at Einstein's theory. Paul Dirac, 1933 Nobel Laureate in Physics, considered it as "the greatest scientific discovery that was ever made". Another Nobel laureate, Lev Landau (1962) regarded it as "the most beautiful of all existing theories". Einstein himself said that "scarcely anyone who fully understands this theory can escape from its magic".

Among the spectacular predictions of Einstein's theory of gravity are "black holes" – objects, the gravitational pull of which is so strong that nothing, not even light, can escape from them – and the "big bang", a yet to be understood event out of which our universe originated.

On the occasion of the centenary of general relativity, it was quite natural to choose Einstein's theory of gravity as the theme of the annual Solvay public lectures, which took place at the Flagey building on October 18, 2015 in front of a full house.

Professor Reinhard Genzel (Max Planck Institute Munich) and Viatcheslav Mukhanov (LMU Munich) delivered brilliant and fascinating talks on the black hole at the center of our galaxy and on the quantum origin of structure (galaxies) in our universe, respectively.

The International Solvay Institutes warmly thank the two speakers who accepted to deliver a lecture. They are very busy persons and the Institutes value very much the time that they spent to make their 12th public event a great success.

Programme

15:00 - 15:20	Opening by Professor Marc Henneaux
15:20 - 16:10	"Massive Black Holes and the Evolution of Galaxies" Lecture by Professor Reinhard Genzel
16:10 - 16:20	Question session
16:20 - 16:50	Solvay Awards Ceremony
16:50 - 17:40	"From Nothing to the Universe" Lecture by Professor Viatcheslav Mukhanov
17:40 - 17:50	Question session
17:50 - 17:55	Closing

A tradition that goes back to 2005

In 2005, the International Solvay Institutes initiated the tradition of organizing an annual public event during which distinguished scientists deliver lectures on the state-of-the-art in their field of research with an overview of the most pressing current issues. Organized jointly with the ULB, the VUB and the Solvay Group, this event popularizes science and aims at making it more attractive to the younger generations. The talks are given in English but simultaneous interpretations in Dutch and French are provided. The event closes with a drink offered to all the participants, which allows the public to interact more closely with the invited scientists. The event is free.

Speakers

Professor Reinhard Genzel
(Max Planck Institute, Munich)

Professor Dr. Reinhard Genzel is one of the directors at MPE, Honorary Professor of Physics at the Ludwig-Maximilian University in Munich (since 1989) and Full Professor in the Physics Department of the University of California, Berkeley (since 1999). He received his Ph.D. in physics and astronomy in1978 at the University of Bonn. During the years 1978-80 he was a Postdoctoral Fellow at the Center for Astrophysics in Cambridge, Massachusetts, focusing on radio very long baseline interferometry and mid-infrared studies of Galactic star forming regions, from 1980 to 1982 Miller Fellow at the University of Berkeley working on far-infrared spectroscopy, from 1981 to 1985 Associate and Full Professor at the Department of Physics doing research in infrared and submillimeter astrophysics and studies of the Interstellar Medium. In 1986 he was appointed Director at MPE where he and his group have been carrying out a program of studying the Galactic Center, active galactic nuclei and star formation in galaxies at high-redshift with state of the art infrared instruments developed at the Institute.

For his research, Professor Genzel received many honours and awards including Otto Hahn Medal of the Max-Planck Society (1980), Newton Lacy Pierce Prize of the American Astronomical Society (1986), Einstein Medal of the Albert-Einstein-Gesellschaft AEG (Albert Einstein Society), Bern, Switzerland (2007), Shaw Prize of The Shaw Prize Foundation, Hong Kong (2008), Premio Galileo, Fondazione Premio Galileo 2000, Italy (2009), Karl Schwarzschild Prize, Astronomische Gesellschaft AG (German Astronomical Society) (2011).

Research interests

- Astrophysics of galactic nuclei
- Star formation and dynamics of galaxies
- Massive Black holes
- Experimental infrared, submillimeter, and millimeter astronomy

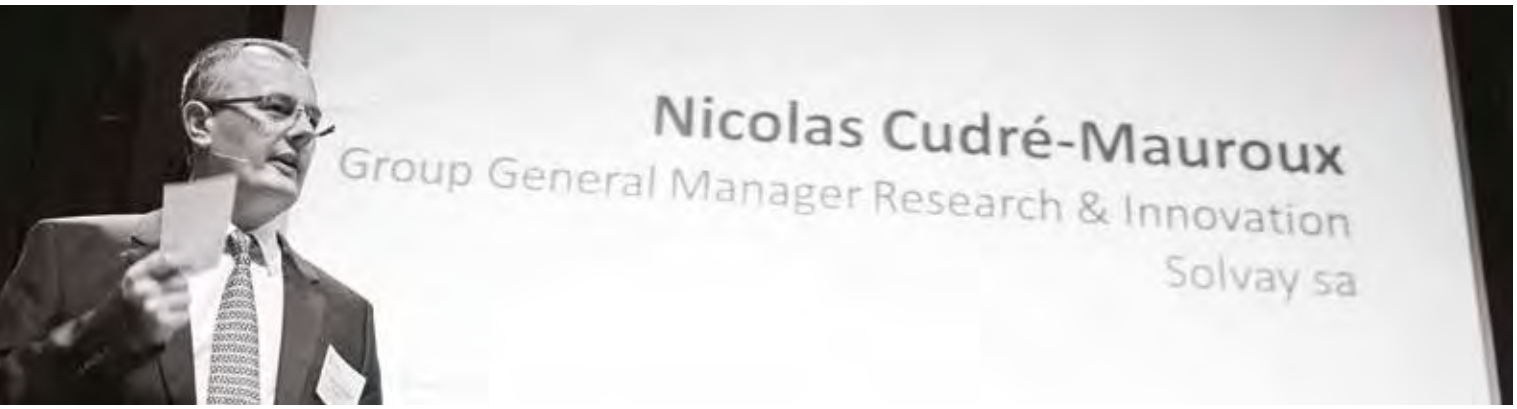
Professor Viatcheslav Mukhanov
(LMU, Munich)

Viatcheslav Mukhanov is a professor of astroparticle physics and cosmology at Ludwig-Maximillians-Universität in Munich. Born in Russia, he was graduated from the Physical-Technical Institute in Moscow and took a Ph.D. in theoretical physics there in 1982. He began his career as a research scientist at Moscow's Institute for Nuclear Research and became the senior scientist in 1991 after spending a year as a visiting professor at Brown University and at Tufts University. In 1992, he joined the faculty of the ETH (Swiss Federal Institute of Technology) in Zurich where he remained until accepting his present position in 1997. Dr. Mukhanov was the first scientist in his native country to recognize the power of the "many worlds" interpretation of quantum mechanics and published several important early papers on the approach, which envisages the entire universe as a quantum system. He was also the first author of the theory of density perturbations in inflationary cosmology. In 1981, he predicted that a remnant spectrum of the perturbations may have seeded large-scale structure formations in the universe and may have left an imprint on the cosmic microwave background anisotropy.

His work was recognized in 1988 by a Gold Medal of the Academy of Sciences of the USSR.

He has also received the Klein Medal of the Stockholm University, the Tomalla Prize of the Tomalla Foundation for Gravity Research in Switzerland (both with Alexei Starobinsky), the Amaldi Medal from the Italian Society for General Relativity and Gravitational Physics, the Gruber Prize in Cosmology (2013) and the Max Planck Medal (2015).

Solvay **Awards Ceremony**



A short Solvay Awards ceremony took place between the two lectures, during which brilliant young scientists who had been distinguished for their master or doctoral work in the fields of physics, chemistry or engineering at the ULB and the VUB, were rewarded by the Solvay Company. Nicolas Cudré-Mauroux, Group Research & Innovation General Manager at Solvay, gave the awards to the laureates.

2013 & 2014 Solvay **Awards Laureates**

Souhaib Ben Taieb (ULB)
Nicolas Cauche (ULB)
Marie Collard (ULB)
Ward de Paepe (VUB)
Ahmed El Mallahi (ULB)
Federico Galli (VUB)
Kassem Ghaddar (ULB)
Vincent Ginis (VUB)
Matthieu Goursaud (ULB)
Pierre Henneaux (ULB)
Matěj Karasek (ULB)
Quentin Labtani (ULB)
Lionel Marcelis (ULB)
Azadeh Mohammadi (ULB)
Catharina Olsen (ULB)
Sven Pletincx (VUB)
Quentin Rayée (ULB)
Dounia Saadallah (ULB)
Seppe Terryn (VUB)
Gilles Tondreau (ULB)
Ludovic Troian-Gautier (ULB)
Laure Twyffels (ULB)
Tom Van Assche (VUB)
Thomas Vanfleteren (ULB)
Hilke Verbruggen (VUB)
Sophie Viaene (VUB)
Stéphane Vranckx (ULB)
Perry Walters (VUB)
Wout Weijtjens (VUB)

Professors Mukhanov and Englert

Mr. K. Debackere, Mr. D. Janssen and Mr. J-M. Solvay

Mr. J. van Rijckevorsel and Mr. N. Cudré-Mauroux

International Solvay Chairs

International Solvay **Chairs**

The International Solvay Chair programme enables the Institutes to invite in Brussels eminent scientists for a period of one to two months in order to give lectures on their work to researchers in the corresponding fields, not only from the ULB and the VUB, but also from other Belgian universities and abroad.

The programme started in 2006 for physics. In 2011 the physics chair was renamed the International "Jacques Solvay Chair in Physics" in memory of Jacques Solvay, who was president of the Institutes for more than 50 years.

The chair programme in chemistry was launched in 2008 thanks to a generous grant from the Solvay Company, which the Institutes gratefully acknowledge.

2015 International Jacques Solvay **Chair in Physics**

Professor Peter Zoller
University of Innsbruck, Austria

The first half of the tenth International Chair in Physics took place in October of 2015. The Chair was held by Professor Peter Zoller (University of Innsbruck, Austria), a leading figure in quantum optics and quantum information. Professor Zoller came back for the second half of his stay in February of 2016.

In addition to fundamental developments on the interaction of light with matter, Professor Zoller made pioneering contributions to quantum computing and quantum communication. He remarkably bridged quantum information and solid state physics. In 1995, he suggested with Ignacio Cirac a model of quantum computer, which is based on the interaction of lasers with cold ions confined in an electromagnetic trap. This idea opened one of the most promising lines for the development of a scalable quantum computer.

The inaugural lecture delivered by Professor Zoller was devoted to exciting questions at the frontiers of quantum computing and quantum simulation.

During his stays in Brussels, Professor Zoller is hosted in the group of Professors Pierre Gaspard and Nathan Goldman (ULB).

Inaugural Lecture

"A Quantum Leap in Quantum Information : Building Quantum Computers and Quantum Simulators with Cold Atoms and Ions"

6 October 2015

On a microscopic scale our world is governed by quantum physics. Apart from fundamental questions and 'mysteries' of quantum physics, learning how to control this microscopic world is also an opportunity for new applications and quantum technologies - potentially more powerful than their classical counterparts. In this lecture we discuss recent progress in building quantum computers and quantum simulators. We will focus on quantum optical systems of atoms and ions manipulated by laser light, providing prime examples of quantum systems, which can be controlled on the level of single quanta. This includes a discussion of trapped ions as a universal quantum processor, and digital and analog quantum simulation of strongly correlated quantum matter with atoms in optical lattices. We conclude with an outlook on a 'quantum internet' and building a 'quantum annealer'.

Peter Zoller studied physics at the University of Innsbruck and held then various postdoctoral positions and visiting professor positions at the University of Southern California, the University of Auckland in New Zealand, the Joint Institute for Laboratory Astrophysics (JILA) of the University of Colorado and the University Paris-Sud (Orsay).

In 1991, Peter Zoller was appointed Professor of Physics and JILA Fellow at JILA and at the Physics Department of the University of Colorado, Boulder. At the end of 1994, he accepted a chair at the University of Innsbruck, where he has worked ever since.

The vitality of Professor Zoller's ideas and concepts is recognized worldwide. One of his fascinating suggestions has been to build a quantum simulator with cold atoms and use it to research so far unexplained phenomena in high temperature superconductors.

For his remarkable achievements, Peter Zoller received many awards. These include the Wolf Prize in Physics in 2013, the Pascal Medal in 2011, the Humboldt Research Award in 2010, the Franklin Medal also in 2010, the 2008 BBVA Foundation Frontiers of Knowledge Award, the Dirac Medal (2006), the Max Planck Medal of the German Physical Society in 2005, as well as the Wittgenstein Award in 1998, which is Austria's highest scientific distinction. Professor Zoller is a member of various academies around the world and is regularly invited to the most prestigious institutions (Harvard, Leiden, Caltech, Technion, LMU Munich).

Professor Zoller is a Member of the Solvay Scientific Committee for Physics, in charge of the organization of the Solvay Conferences on Physics.

Lecture **1**

"Towards quantum simulation of lattice gauge theories with atom in optical lattices"

15 October 2015

Cold bosonic or fermionic atoms loaded into optical lattices provides a toolbox for engineering many-body quantum systems. In the past this has led to a very fruitful interaction with condensed matter physics, building quantum simulators of strongly correlated systems with cold atoms. In this talk we will be interested in quantum simulation of lattice gauge theories on the level of toy models in high energy physics.

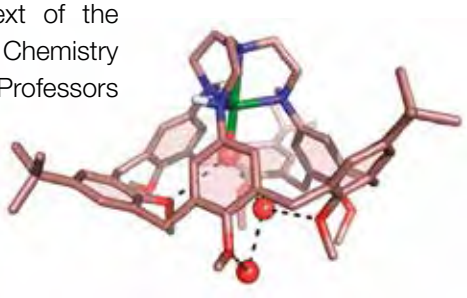
Examples to be discussed are the Schwinger Model, non-Abelian SU(N) and U(N) models as so-called 'quantum link models', and CP(N-1) models related to SU(N) quantum magnetism.

2014 & **2015** Solvay **Chairs in Chemistry**

2014 Solvay Chair in Chemistry

Professor Richard Royce Schrock
2005 Nobel Laureate in Chemistry
MIT, USA

The last lectures of the 2014 Solvay Chair in Chemistry, held by Professor Richard Royce Schrock (2005 Nobel Laureate in Chemistry, MIT, USA) took place on April 30 and 5 May, 2015.



The stay in Brussels of Professor Richard Schrock in the context of the 2014 Solvay Chair in Chemistry has initiated a very fruitful collaboration with the research group of Professors Ivan Jabin and Gwilherm Evano (ULB), resulting in publications, the first of which is: *Calix[6]azacryptand Ligand with a Sterically Protected Tren-Based Coordination Site for Metal Ions*, Sara Zahim, Lasantha A. Wickramasinghe, Gwilherm Evano, Ivan Jabin, Richard R. Schrock, and Peter Müller, Organic Letters (2016) in press.

Lecture **1**

"Recent Advances in Olefin Metathesis by Molybdenum and Tungsten Catalyst"

One of the most important developments in the last five years in olefin metathesis chemistry employing Mo or W catalysts has been the synthesis and application of M(NR)(CHCMe$_2$R') (OR) (Pyrrolide) (MonoAlkoxidePyrrolide or MAP) complexes, especially those in which OR is a sterically demanding terphenoxide such as 2,6-dimesitylphenoxide (OHMT). MAP species under the right circumstances have proven to be Z-selective in a variety of olefin metathesis reactions, among them enantioselective ring-opening/ cross-metatheses, ROMP to give highly stereoregular polymers, ethenolysis of internal olefins such as oleates, coupling of terminal olefins, cross coupling of terminal olefins, and synthesis of macrocyclic natural products. An important second recent development has been the synthesis of a variety of tungsten oxo alkylidene complexes. Oxo complexes can be "activated" by binding B(C$_6$F$_5$)$_3$ to the oxo ligand and are likely to be analogs of metathesis catalysts found in classical metathesis catalyst systems. Recent applications of metathesis includes stereoregular ring-opening metathesis polymerization to give cis,isotactic or cis,syndiotactic polymers as well as alternating AB copolymers. These and other subjects will be explored as time allows.

Lecture **2**

"Reduction of Dinitrogen Catalytically to Ammonia with Protons and Electrons"

In 2003 we reported the first catalytic reduction of dinitrogen with protons and electrons. The process employs a molybdenum complex that contains a hexaisopropylterphenyl-substituted triamidoamine ligand ([HIPTN$_3$N] Mo, Figure 1). Dinitrogen is bound end-on in the trigonal coordination pocket and is reduced through a stepwise addition of protons ([2,6-lutidinium] BAr'$_4$ (Ar' = 3,5-(CF$_3$)$_2$C$_6$H$_3$)) and electrons (decamethylchromocene). Dinitrogen is reduced in heptane to yield 7-8 equivalents of NH$_3$ with the remaining electrons being used to make dihydrogen. Eight of the proposed intermediates in the Chatt-like reduction sequence have been isolated and characterized crystallographically and extensive calculations of the mechanism of reduction in the [HIPTN$_3$N] Mo system support the proposed mechanism.

A second example of the catalytic reduction of dinitrogen employs a Mo(0) complex, [Mo(L)(N$_2$)$_2$]$_2$(m-N$_2$)]$_2$ (where L is a "PNP pincer" ligand). Protons are added in the form of 2,6-lutidinium triflate, and electrons are added employing cobaltocene. No mechanistic details for this system have been elucidated. Both systems employ Mo catalysts, an acid that is readily reduced, and an organometallic reducing agent. Both are limited by loss of ligand from the metal. Both produce hydrogen as a byproduct (~1 equivalent or more). Recent synthesis of a TREN ligand that could lead to a more robust catalyst and higher turnovers will be described.

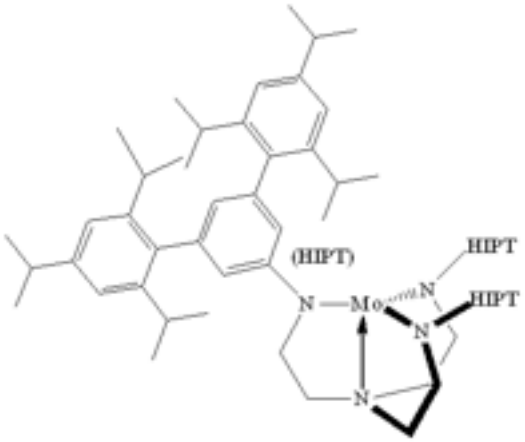


Figure 1. The Mo(III) core of [HIPTN$_3$N]Mo complexes.

2015 Solvay Chair in Chemistry

Professor Andreas Manz
KIST Europe, Saarbrücken, Germany

Andreas Manz has a diploma and PhD degree in Chemistry from the ETH Zürich. He conducted most of his early research at Ciba-Geigy in Basel, Switzerland, before holding several teaching and institute director positions at Imperial College, the ISAS institute in Dortmund and Berlin and the University of Saarland.

Andreas Manz is one of the pioneers in microchip technology used for chemical applications. He has been involved in the development of high speed analyzers and is generally considered as the founding father of the "lab-on-a-chip" field, currently revolutionizing the analytical and life sciences at a fast pace. He published some of the most seminal papers in this field.

He is the recipient of many prestigious awards, such as the Werner Prize of the Swiss Chemical Society in 1995, the Merck Award for Analytical Chemistry in 1996, the Pfizer Research Award in 2000, the Royal Society of Chemistry Nanotechnology Award in 2002, and many more.

In 2001, he founded the "lab-on-a-chip" journal, a journal of the Royal Society of Chemistry (UK).

His didactic and highly entertaining lecture style makes him a heavily solicited speaker at conferences and in companies.

The eighth International Chair in Chemistry was held by Professor Andreas Manz from KIST Europe, Saarbrücken (Germany), a pioneer in microchip technology used for chemical applications. Professor Manz is involved in the development of high speed analyzers based on capillary electrophoresis, liquid chromatography and flow injection analysis, and is a leading world expert in miniaturisation for chemistry, physics, biology, materials science and bioengineering.

His inaugural lecture, given on the 31st of August 2015, explained the fascinating ideas underlying the "lab-on-a-chip" field, which currently revolutionizes the analytical and life sciences.

During his stay in Brussels, which took place from August 25 through the end of September 2015, Professor Manz was hosted in the groups of Professors Anne De Wit (ULB) and Gert Desmet (VUB).

Inaugural Lecture

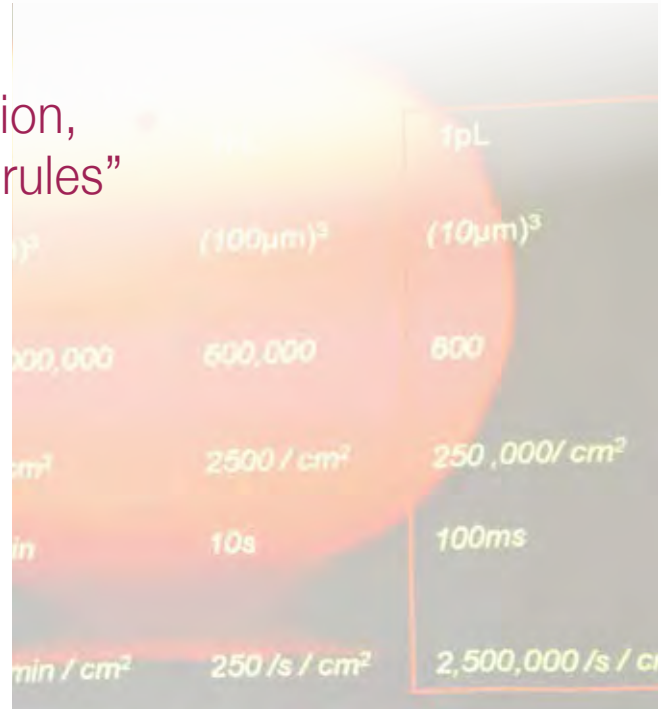
Lab on chip
“Technology 10x smaller means 100x faster”

For chemistry and the life sciences, measurement of molecular parameters is of growing importance. Particularly, the presence of a certain molecule and its amount can play a key role, for example, in deciding about medical treatment, about the outcome of a forensic investigation, or in the future of experimental research in life sciences. Since the late 1980s, my laboratory explored miniaturizing parts, or even an entire laboratory down to chip size, increasing the throughput of chemical analysis, limiting its need for large sample volumes and potentially reducing the cost for access to the molecular information. I will emphasize scaling laws and chip technology for microfluidics, provide different examples of “lab on chip” devices and discuss possible future directions.

Lecture **1**

Lab on chip
“Scaling laws, miniaturization, concept and chip design rules”

An elephant walks by slowly moving his legs, whereas a mouse moves its legs much faster. We are all aware of such differences in frequency, possibly less aware of its relationship with scaling laws. I will discuss scaling laws focusing on molecular diffusion and miniaturization, particularly for simple chemical reactions and separations. I will also give examples on how to plan chip design, channel layout and associated manufacturing.



Lecture **2**

Lab on chip
"Flow behaviour, pumping, valving"

Trees grow "into the sky", and your physics teacher probably told you that water in a pipe can only rise to a maximum of 10 meters. In the bible, Moses is dividing the seas and everybody could walk on the dry ocean floor. Weird phenomena? No, not necessarily. On the small scale, you can expect flow to be generated or influenced not only by hydrostatics or external pressure, but also by osmosis, by capillarity and by electrokinetics. New engineering opportunities are opened for pumping and valving at this scale. I will show some examples of pumping and valving on microfluidics chips, mostly from my own lab.

Lecture **3**

Lab on chip
"Extractions, mixing, chemical reactions"

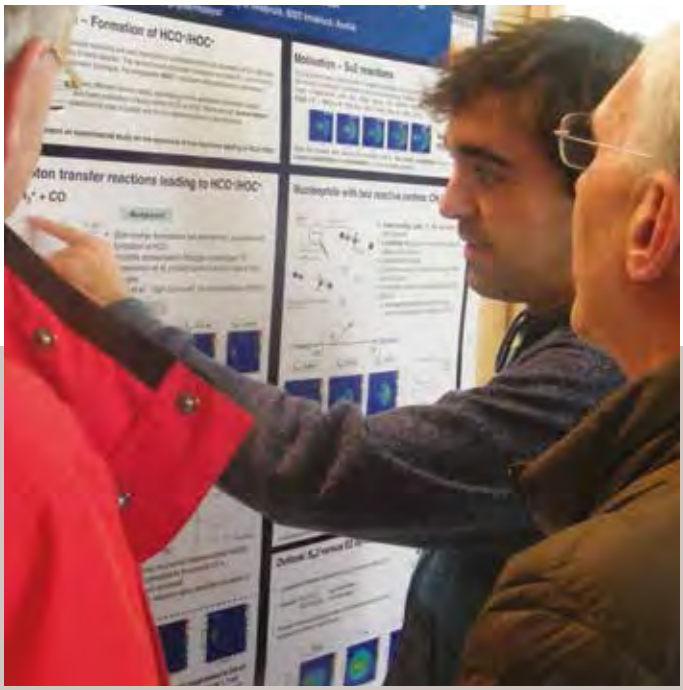
If you take your coffee with sugar, you need a spoon to stir it. If you need to discover a new pharmaceutical compound, you need millions of compounds tested. And million of spoons? Fortunately, microfluidics can enhance mixing enough to allow rapid chemical reactions or bioassays. Theoretically speaking, a testing of millions of compounds should be possible within seconds. I will show some microfluidics examples to chemical reactions and bioassays aiming to realize this dream, mostly taken from my own lab.

Prof. Manz, Mr. P. Maestro and Mr. N. Cudré-Mauroux

Lecture **4**

Lab on chip
"Separations, detection"

Need a plate of spaghetti? After boiling, you separate them from the water. Need a cup of tea? In this case you will get rid of the leaves, not the flavor and colour. You have separated groups of molecules from each other! Very similarly, separations like chromatography or electrophoresis play a crucial role in state-of-the-art quality control of chemicals and pharmaceuticals, and increasingly for the future of clinical diagnostics, forensics or drug discovery. I will emphasise on microfluidic chip-based molecular separations and detection schemes, including electrophoresis, electrochemiluminescence and plasma emission spectrometry, mostly from my own lab.


Formation of HCO+/HOC+
Motivation - SuS reactions
Multidentate with two reactive centres CH

Workshops and Schools

organised by the Institutes

Workshop on

"Le Charme Discret de la **Symétrie**"

in honour of **Professor Marc Henneaux**

5 | 6 March 2015

Workshop on

"Le Charme Discret de la **Symétrie**"

in honour of Professor Marc Henneaux

5 - 6 March 2015

On the exact date of his 60th birthday, The International Solvay Institutes organized a scientific workshop in honour of its Director, Marc Henneaux, dedicated to research topics close to his own interests. It complemented the meeting "Quantum Mechanics of Fundamental Systems IX", held in Valdivia, Chile, December 28-29, 2014 with the same purpose.

The meeting gathered some 110 colleagues and collaborators from all over the world, including almost all of his 15 PhD students to date. Communications by Stanley Deser and David Gross, which were not able to physically attend, were also presented.

Scientific & **Organizing** Committees

Glenn Barnich (ULB, Belgium)
Dominique Bogaerts (Solvay Institutes, Belgium)
Fabienne De Neyn (ULB, Belgium)
Alexander Sevrin (VUB, Belgium)
Jean-Marie Solvay (Solvay Institutes, Belgium)
Philippe Spindel (UMONS, Belgium)
Isabelle Van Geet (Solvay Institutes, Belgium)
Antoine Van Proeyen (KU Leuven, Belgium)

Invited Participants include

Riccardo Argurio (ULB, Belgium)
Maximo Bañados (PUC, Chile)
Laurent Baulieu (LPTHE, France)
Karin Bautier (ULB, Belgium)
Xavier Bekaert (U. de Tours, France)
Nicolas Boulanger (UMONS, Belgium)
Friedemann Brandt (Leibniz U., Germany)
Lars Brink (Chalmers U., Sweden)
Sandrine Cnockaert (ULB, Belgium)
Geoffrey Compère (ULB, Belgium)
Radu Constantinescu (U. of Craiova, Romania)
Olivier Coussaert (ULB, Belgium)
Ben Craps (VUB, Belgium)
Thibault Damour (IHES, France)
Sophie de Buyl (ULB, Belgium)
Christine De Mol (ULB, Belgium)
Anne De Wit (ULB, Belgium)
Stephane Detournay (ULB, Belgium)
Alain Dresse (Bamboost, Belgium)
François Englert (ULB, Belgium)
Frank Ferrari (ULB, Belgium)
Jean Fisch (ULB, Belgium)
Jean-Marie Frère (ULB, Belgium)
Pierre Gaspard (ULB, Belgium)
Gaston Giribet (UBA, Argentina)
Andrés Gomberoff (UNAB, Chile)
Gustavo Lucena Gómez (IOP, Czech Republic)
Joaquim Gomis (Barcelona U., Spain)
Philippe Grégoire (ULB, Belgium)
Thomas Hertog (KU Leuven, Belgium)
Bernard Julia (ENS, France)
Axel Kleinschmidt (AEI, Golm, Germany)
Cristian Martínez (CECs, Chile)
Luca Mezincescu (Miami U., USA)
Viatcheslav Mukhanov (LMU, Germany)
Hermann Nicolai (AEI, Golm,Germany)
Daniel Persson (Chalmers U., Sweden)
Pierre Ramond (UF, Gainesville, USA)
Soo-Jong Rey (Seoul National U., Korea)
Augusto Sagnotti (SNS, Italy)
Christiane Schomblond (ULB, Belgium)
Adam Schwimmer (Weizmann Institute, Israel)
Kostas Skenderis (Southampton U., UK)
Andrei Slavnov (Russian A. of Science, Russia)
Ricardo Troncoso (CECs, Chile)
Michel Tytgat (ULB, Belgium)
Claude Viallet (LPTHE, France)
Peter West (King's College London, UK)
André Wilch (Düsseldorf, Germany)
Jorge Zanelli (CECs, Chile)

Programme

Thursday 5 March 2015

Morning session chaired by Lars Brink

Opening Address	by Jean-Marie Solvay, President of the Solvay Institutes
Hermann Nicolai	*N=8 supergravity and standard model fermions*
Adam Schwimmer	*Penrose-Brown-Henneaux transformations and trace anomalies*
Andrei Slavnov	*Soliton solutions of classical equations of motion in the formulation of the Yang-Mills theory*

Afternoon session chaired by Luca Mezincescu

Peter West	*E_{11} and Dualities*
Kostas Skenderis	*Conformal field theory in momentum space*
Daniel Persson	*Infinite-dimensional U-duality and automorphic forms on Kac-Moody groups*
Banquet	

Friday 6 March 2015

Morning session chaired by Joaquim Gomis

Laurent Baulieu	*Ghost and shadows, and finitness questions in supersymmetry*
Soo-Jong Rey	*Let’s Dump Charge and Spin Up Black Hole! - Part (2)*
Bernard Julia	*Exceptional confluences: from Halphen-Painlevé to field-string theory and back*

Afternoon session chaired by François Englert

Axel Kleinschmidt	*K(E10) as R-symmetry group*
Pierre Ramond	*Goûts et Symétries: la Symétrie des Saveurs*
Slava Mukhanov	*Inflation without Selfreproduction*

Participants

Argurio Riccardo (ULB, Belgium)
Bañados Maximo (PUC, Chile)
Barnich Glenn (ULB, Belgium)
Baulieu Laurent (LPTHE, France)
Bautier Karin (ULB, Belgium)
Bekaert Xavier (U de Tours, France)
Binon Freddy (ULB, Belgium)
Boon Jean Pierre (ULB, Belgium)
Boulanger Nicolas (UMONS, Belgium)
Brandt Friedemann (Leibniz U., Germany)
Brayeur Lionel (VUB, Belgium)
Brink Lars (Chalmers U., Sweden)
Bzowski Adam (KU Leuven, Belgium)
Campoleoni Andrea (ULB, Belgium)
Chemissany Wissam (Stanford, USA)
Chialva Diego (UMONS, Belgium)
Cnockaert Sandrine (ULB, Belgium)
Compere Geoffrey (ULB, Belgium)
Conde Pena Eduardo (ULB, Belgium)
Constantinescu Radu (U. of Craiova, Romania)
Cortese Mombelli Ignacio (ULB, Belgium)
Corvilain Pierre (ULB, Belgium)
Coussaert Olivier (ULB, Belgium)
Craps Ben (VUB, Belgium)
Damour Thibault (IHES, France)
De Buyl Sophie (ULB, Belgium)
De Mol Christine (ULB, Belgium)
De Wit Anne (ULB, Belgium)
Detournay Stéphane (ULB, Belgium)
Donnay Laura (ULB, Belgium)
Douxchamps Laure-Anne (ULB, Belgium)
Dresse Alain (Bamboost, Belgium)
Englert François (ULB, Belgium)
Fazzi Marco (ULB, Belgium)
Fernandez Adrian (UCM, Spain)
Ferrandiz Oscar (ULB, Belgium)
Ferrari Frank (ULB, Belgium)
Fisch Jean (ULB, Belgium)
Forcella Davide (ULB, Belgium)
Frère Jean-Marie (ULB, Belgium)
Fuentealba Oscar (CECs, Chile)
Gaspard Pierre (ULB, Belgium)
Giacomelli Simone (ULB, Belgium)
Giribet Gaston (UBA, Argentina)
Goldman Nathan (ULB, Belgium)
Gomberoff Andres (UNAB, Chile)
Gómez Gustavo Lucena (ULB, Belgium)
Gomis Joaquim (PI, Canada)
Gonzalez Hernan (ULB, Belgium)
Grégoire Philippe (ULB, Belgium)
Gregori Paolo (ULB, Belgium)
Hambye Thomas (ULB, Belgium)
Hartong Jelle (ULB, Belgium)
Hertog Thomas (KU Leuven, Belgium)
Hortner Sergio (ULB, Belgium)
Julia Bernard (ENS, France)
Kleinschmidt Axel (AEI, Golm, Germany)
Leclercq-Willain Christiane (ULB, Belgium)
Lekeu Victor (ULB, Belgium)
Leonard Amaury (ULB, Belgium)
Lepage-Jutier Arnaud (ULB, Belgium)
Leston Mauricio (U. of Buenos Aire, Argentina)
Lindgren Jonathan (VUB/ULB, Belgium)
Mao Pujian (ULB, Belgium)
Martínez Cristian (CECs, Chile)
Massar Serge (ULB, Belgium)
Mezincescu Luca (Miami U., USA)
Mognetti Bortolo Matteo (ULB, Belgium)
Mukhanov Viatcheslav (LMU, Germany)
Nardone Pasquale (ULB, Belgium)
Nicolai Hermann (AEI, Golm, Germany)
Oblak Blagoje (ULB, Belgium)
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Persson Daniel (Chalmers U., Sweden)
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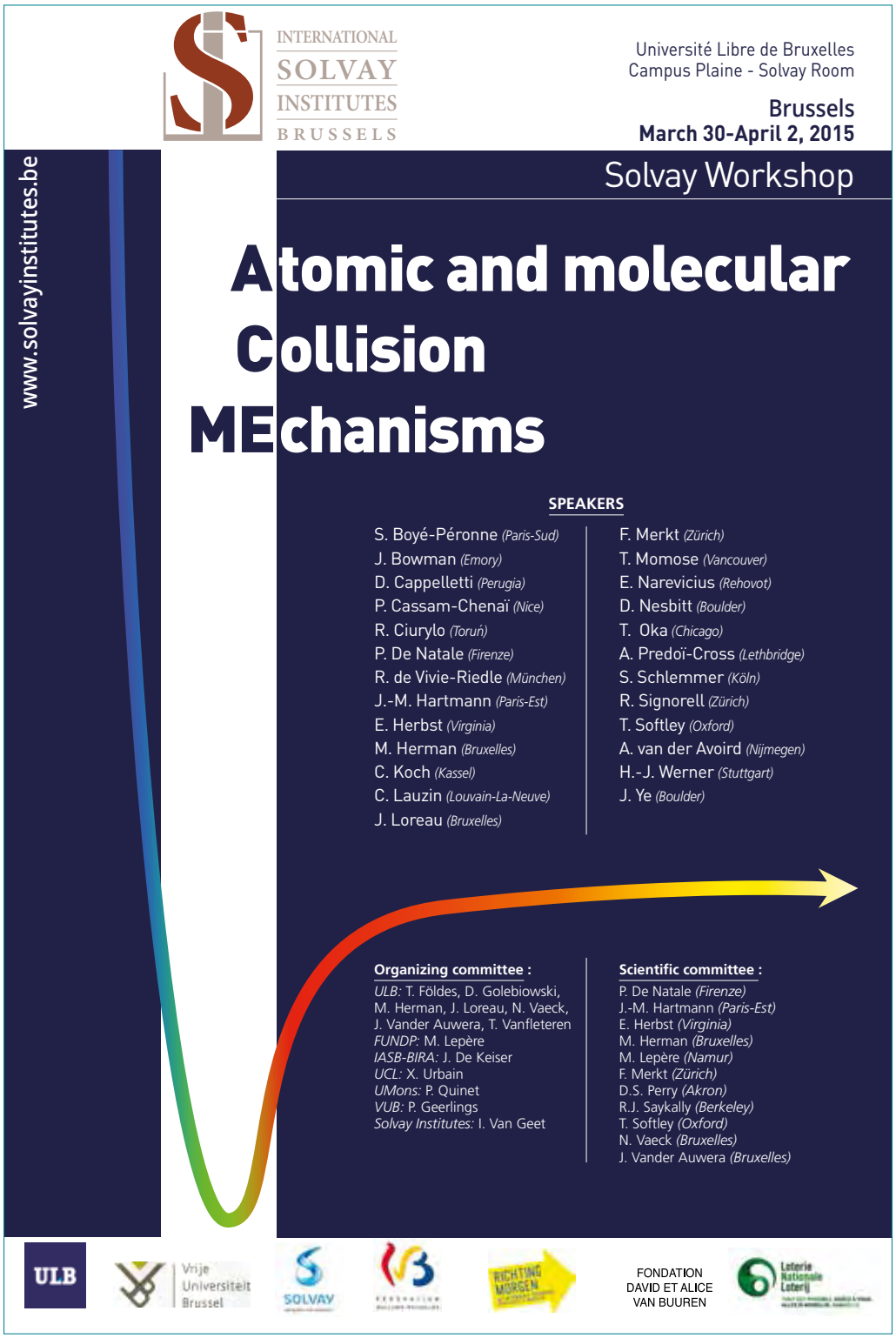
Weynants Roger (KMS-ERM, Belgium)
Wilch André (Düsseldorf, Germany)
Zanelli Jorge (CECs, Chile)
Zwikel Céline (ULB, Belgium)

Workshop on

"Atomic and molecular collision mechanisms - **ACME**"

30 March | 2 April 2015



Workshop on

"Atomic and molecular collision mechanisms - **ACME**"

30 March - 2 April 2015

The temperature at the Earth surface is about 300 K, then evolves down to some 150 K at the upper limit of the atmosphere. Even colder, extraterrestrial environments are well identified in the Solar system, down to 50 K e.g. in the atmosphere of Neptune. Temperature further drops between 10 and 20 K in the coma of comets and may even get lower in the interstellar medium. Molecules are present in all of these media, supporting chemistry, and the origin of life. Today, dedicated, sophisticated instrumental means allow the most extreme of these conditions to be matched and even exceeded in the laboratory. Collision mechanisms and their evolution with decreasing temperature are of primary relevance in the related reactive processes. For the lowest temperatures these mechanisms still remain to be fully unravelled and there is a need for continued progress in measurement and modelling. Chemistry at ultralow temperatures, the formation of dimers and larger aggregates, the understanding and active control of collision processes at the molecular level, and their atmospheric and astrophysical applications define a very active, challenging and multidisciplinary research field that lies at the heart of the ACME workshop.

Organizing Committee

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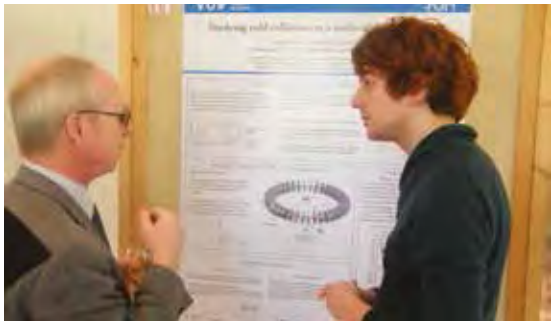
J. Vander Auwera (Bruxelles, Belgium)



Speakers

S. Boyé-Péronne (Paris-Sud, France)
J. Bowman (Emory, USA)
D. Cappelletti (Perugia, Italy)
P. Cassam-Chenaï (Nice, France)
R. Ciurylo (Toruń, Poland)
P. De Natale (Firenze, Italy)
J.-M. Hartmann (Paris-Est, France)
E. Herbst (Virginia, USA)
M. Herman (Bruxelles, Belgium)
C. Koch (Kassel, Germany)
C. Lauzin (Louvain-La-Neuve, Belgium)
J. Loreau (Bruxelles, Belgium)
F. Merkt (Zürich, Switzerland)
T. Momose (Vancouver, Canada)
E. Narevicius (Rehovot, Israel)
D. Nesbitt (Boulder, USA)
T. Oka (Chicago, USA)
A. Ross (Lyon, France)
S. Schlemmer (Köln, Germany)
R. Signorell (Zürich, Switzerland)
T. Softley (Oxford, UK)
A. van der Avoird (Nijmegen, The Netherlands)
H.-J. Werner (Stuttgart, Germany)
J. Ye (Boulder, USA)

Contributed Talks

A. Bergeat et al (Bordeaux, France)
A. Canosa et al (Rennes, France)
S. Hoekstra et al (Groningen, The Netherlands)
Y. Scribano et al (Montpellier, France)
D. Savin et al (New York, USA)

Programme

Monday 30 March 2015

Session 1 chaired by D. Gauyacq in honour of Jacques Liévin

Welcome speeches	by Marc Henneaux, Director of the Solvay Institutes, Nathalie Vaeck, co-organizer and Dolorès Gauyacq, session chairwoman
C. Lauzin	*High resolution pulsed-field-ionization zero-kinetic-energy photoelectron spectroscopic study of water*
S. Boyé-Péronne	*VUV photoionization of cyanoacetylene: towards a better characterization of the cation vibronic structure*
P. Cassam-Chenaï	*The generalized mean field configuration interaction method: how far a direct product wave function ansatz can go*
J. Bowman	*The central role of the potential in reaction dynamics and energy transfer*
H.-J. Werner	*Accurate calculation of molecular properties using explicitly correlated wave functions*

Tuesday 31 March 2015

Session 2 chaired by J. De Keyser - Half collisions

J. Loreau	*Bound states and scattering of NH3-noble gas complexes*

Contributed talk

Y. Scribano et al	*Quantum trajectory capture for complex-forming reactions*
M. Herman	*High-resolution overtone spectroscopy and dynamics of van der Waals complexes*
A. Van der Avoird	*Collision-induced spectra of hydrogen and nitrogen from quantum calculations with an anisotropic potential*
D. Nesbitt	*Atomic and Molecular Collisions at the Gas-Liquid Interface: From Energy Transfer to Stereodynamics*

Session 3 chaired by S. Hogan - Cold ions, molecules and collisions

E. Narevicius	*Chemistry with Cold Molecules: from Universality to Quantum Resonances*
F. Merkt	*Collisional and spectroscopic experiments with cold samples of one-, two- and three-electron molecules*
T. Softley	*Cold collisions of decelerated molecules and laser cooled ions*

Colloquium Solvay chaired by A. Sevrin

J. Ye	*Ultracold molecules* *New frontiers in quantum & chemical physics*

Session 4 - Poster session /Buffet

Wednesday 1 April 2015

Session 5 - Intramolecular events and control

D. Cappelletti — *Catching the role of chemical interactions in neutral complexes of helium and neon by molecular beam experiments and charge displacement calculations*

Contributed talk

A. Canosa et al — *Experimental and theoretical study of the CN + CH_3CN reaction at very low temperature: Evidence of a competition between tunnelling and adduct stabilization at temperatures below 160 K?*

P. De Natale — *Novel sources and spectroscopic techniques for precision spectroscopy of cold molecules*

C. Koch — *Non-resonant light control of ultracold collisions*

Contributed talk

A. Bergeat et al — *Crossed-beam inelastic scattering experiments at energies approaching the cold regime*

A. Ross — *Efficient collisional energy transfer in electronic spectra of small polar molecules*

Session 6 chaired by P. Quinet - Planetary atmospheres

J. Vander Auwera — *Line shape parameters from Fourier transform infrared spectra*

Contributed talk

S. Hoekstra et al — *Ultracold trapped SrF molecules - for precision spectroscopy and as a platform for quantum simulation*

J.-M. Hartmann — *Infrared probing of molecule-wall collisions in/and porous media*

R. Ciurylo — *Spectral line shapes affected by collisions in theory and experiment*

R. Signorell — *Photoemission from aerosol particles: from nanosolutions to electron mean free paths*

Banquet

Thursday 2 April 2015

Session 7 chaired by X. Urbain - The interstellar medium

T. Momose	*Nuclear spin conservation and interstellar chemistry*
Contributed talk	
D. W. Savin et al	*Merged Beams Studies for Astrobiology*
S. Schlemmer	*Spectroscopy of Cold Molecular Ions*
E. Herbst	*Complex Molecules in Regions of Stellar and Planetary Formation*
T. Oka	*Interplay between collisions and radiative effects in the analyses of diffuse interstellar bands*
M. Herman, N. Vaeck, T. Softley	Closing

Participants

Antinolo Maria (Ciudad Real, Spain)
Bergeat Astrid (Bordeaux, France)
Bouhali Islem (Tunis, Tunisia)
Bowman Joel (Emory, USA)
Boyé-Péronne Séverine (Paris-Sud, France)
Canosa Andre (Rennes, France)
Cappelletti David (Perugia, Italy)
Carrascosa Eduardo (Innsbruck, Austria)
Cassam-Chenaï Patrick (Nice, France)
Ciurylo Roman (Toruń, Poland)
De Keyser Johan (Bruxelles, Belgium)
De Natale Paolo (Firenze, Italy)
de Ruette Nathalie (Stockholm, Sweden)
Dupre Patrick (Dunkerque, France)
Foldes Tomas (Bruxelles, Belgium)
Gauyacq Dolorès (Paris, France)
Geerlings Paul (Bruxelles, Belgium)
Gibbons Andrew (Bruxelles, Belgium)
Golebiowski Dariusz (Bruxelles, Belgium)
Hartmann Jean-Michel (Paris-Est, France)
Harvey Jeremy (KU Leuven, Belgium)
Herbst Eric (Virginia, USA)
Herman Michel (Bruxelles, Belgium)
Hoekstra Steven (Groningen, The Netherlands)
Hogan Stephen (London, UK)
Jankunas Justin (EPFL, USA)
Karman Tijs (Nijmegen, The Netherlands)
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Launoy Thibaut (Bruxelles, Belgium)
Lauzin Clément (Louvain-La-Neuve, Belgium)
Lepère Muriel (Namur, Belgium)
Liévin Jacques (Bruxelles, Belgium)
Loreau Jérôme (Bruxelles, Belgium)
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Momose Takamasa (Vancouver, Canada)
Narevicius Ed (Rehovot, Israel)
Nesbitt David (Boulder, USA)
Oka Takeshi (Chicago, USA)
Palmeri Patrick (Mons, Belgium)
Quinet Pascal (Bruxelles, Belgium)
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Ross Amanda (Lyon, France)
Santos Ludovic (Bruxelles, Belgium)
Savin Daniel Wolf (New York, USA)
Schlemmer Stephan (Köln, Germany)
Scribano Yohann (Montpellier, France)
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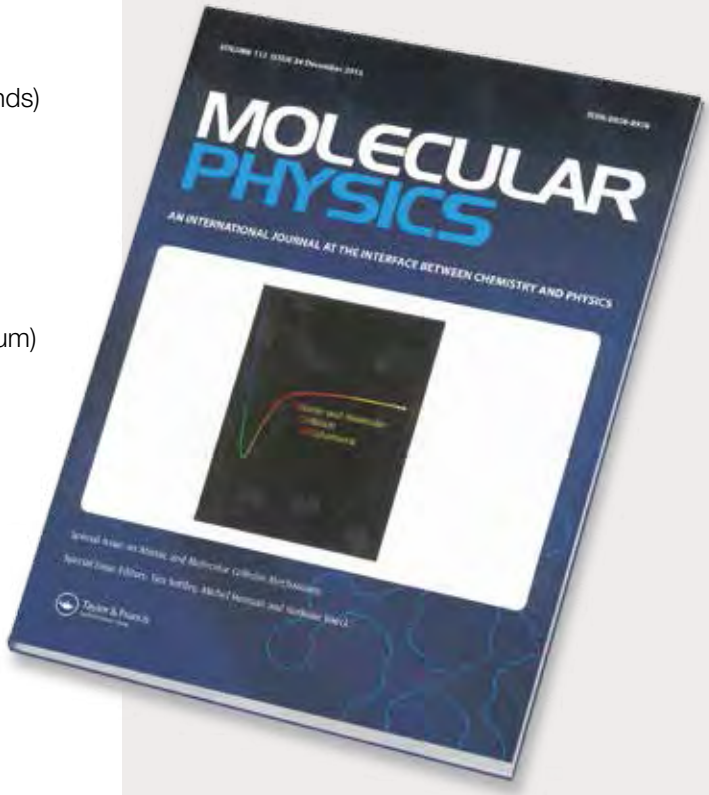
Softley Tim (Oxford, UK)
Steer Edward (Oxford, UK)
Sutcliffe Brian (Bruxelles, Belgium)
Toscano Jutta (Oxford, UK)
Urbain Xavier (Bruxelles, Belgium)
Vaeck Nathalie (Bruxelles, Belgium)
van der Avoird Ad (Nijmegen, The Netherlands)
van der Poel Aernout (Amsterdam, The Netherlands)
Vander Auwera Jean (Bruxelles, Belgium)
Vanfleteren Tomas (Bruxelles, Belgium)
Werner Hans-Joachim (Stuttgart, Germany)
Ye Jun (Boulder, USA)



Solvay-Francqui Workshop on

"Neutrinos: from Reactors to the Cosmos"

27 | 29 May 2015

INTERNATIONAL SOLVAY INSTITUTES BRUSSELS

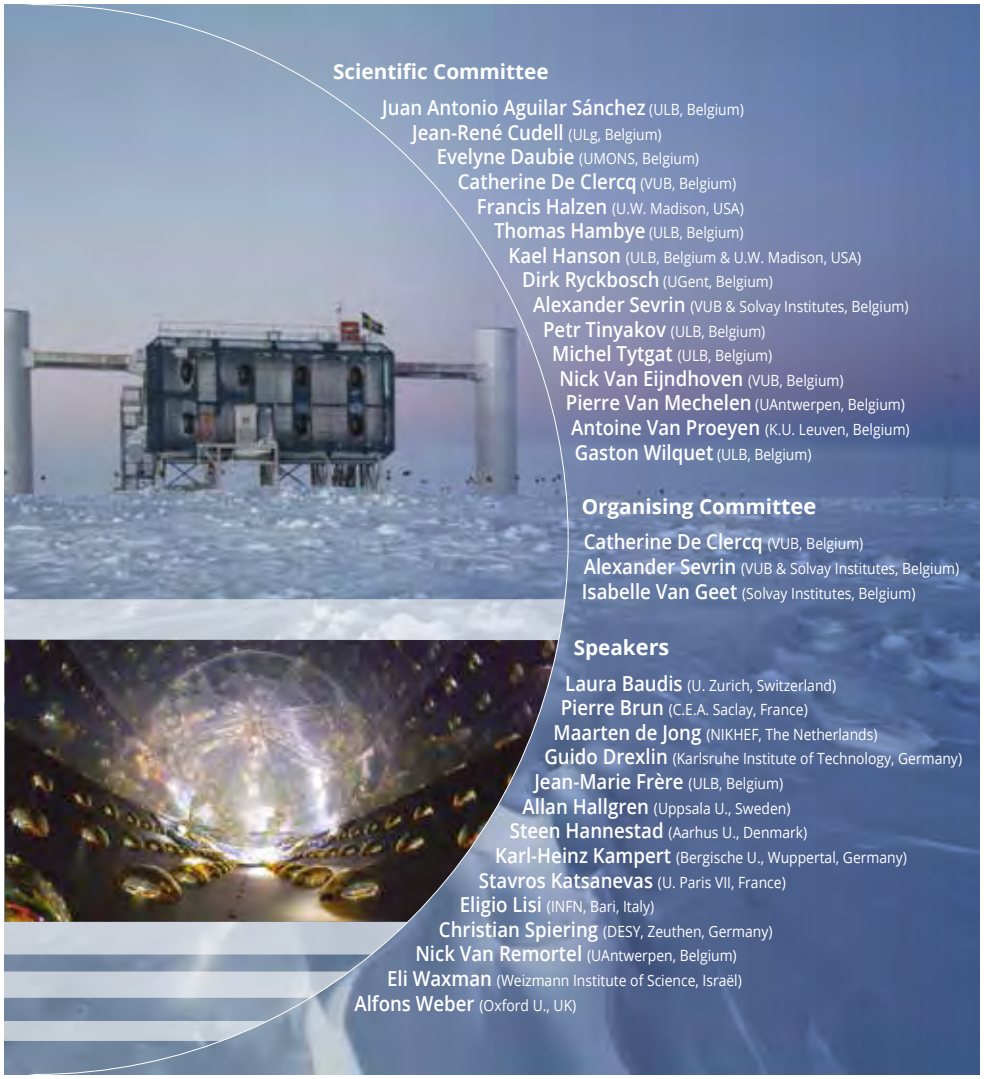
www.solvayinstitutes.be

Université Libre de Bruxelles
Campus Plaine - Solvay Room

Brussels
27 - 29 May, 2015

Solvay-Francqui Workshop on

Neutrinos: from Reactors to the Cosmos



Scientific Committee

Juan Antonio Aguilar Sánchez (ULB, Belgium)
Jean-René Cudell (ULg, Belgium)
Evelyne Daubie (UMONS, Belgium)
Catherine De Clercq (VUB, Belgium)
Francis Halzen (U.W. Madison, USA)
Thomas Hambye (ULB, Belgium)
Kael Hanson (ULB, Belgium & U.W. Madison, USA)
Dirk Ryckbosch (UGent, Belgium)
Alexander Sevrin (VUB & Solvay Institutes, Belgium)
Petr Tinyakov (ULB, Belgium)
Michel Tytgat (ULB, Belgium)
Nick Van Eijndhoven (VUB, Belgium)
Pierre Van Mechelen (UAntwerpen, Belgium)
Antoine Van Proeyen (K.U. Leuven, Belgium)
Gaston Wilquet (ULB, Belgium)

Organising Committee

Catherine De Clercq (VUB, Belgium)
Alexander Sevrin (VUB & Solvay Institutes, Belgium)
Isabelle Van Geet (Solvay Institutes, Belgium)

Speakers

Laura Baudis (U. Zurich, Switzerland)
Pierre Brun (C.E.A. Saclay, France)
Maarten de Jong (NIKHEF, The Netherlands)
Guido Drexlin (Karlsruhe Institute of Technology, Germany)
Jean-Marie Frère (ULB, Belgium)
Allan Hallgren (Uppsala U., Sweden)
Steen Hannestad (Aarhus U., Denmark)
Karl-Heinz Kampert (Bergische U., Wuppertal, Germany)
Stavros Katsanevas (U. Paris VII, France)
Eligio Lisi (INFN, Bari, Italy)
Christian Spiering (DESY, Zeuthen, Germany)
Nick Van Remortel (UAntwerpen, Belgium)
Eli Waxman (Weizmann Institute of Science, Israël)
Alfons Weber (Oxford U., UK)

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Solvay-Francqui Workshop on

"Neutrinos: from Reactors to the Cosmos"

27 - 29 May 2015

The aim of the workshop was two-fold:

- We have reviewed the status of our knowledge of neutrino properties, through a review of recent results obtained by oscillation experiments at accelerators and reactors, and by more direct measurements related to the neutrino mass and type.
- We have discussed the role of neutrinos as messengers from the most violent events in the universe. The discussion of cosmic neutrinos has been framed in a multi-messenger framework covering cosmic ray and gamma ray experiments. The program also covered the role of neutrinos in cosmology, and in dark matter searches.

The workshop was organized on the occasion of the International Francqui Chair 2014 awarded to Professor Francis Halzen (UW Madison), PI of the IceCube neutrino experiment. It was co-organized by the Francqui Foundation and the International Solvay Institutes.

Organizing Committee

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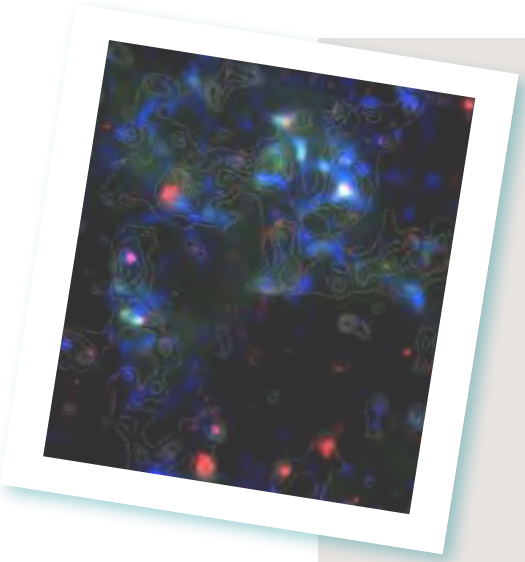
Speakers



Laura Baudis (U. Zurich, Switzerland)
Maarten de Jong (NIKHEF, The Netherlands)
Carlos de los Heros (Uppsala Univ., Sweden)
Marcos Dracos (CNRS, U. de Strasbourg)
Guido Drexlin (Karlsruhe Inst. of Technology, Germany)
Malcolm Fairbairn (King's College London, UK)
Ettore Fiorini (INFN, Milano Bicocca, Italy)
Jean-Marie Frère (ULB, Belgium)
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Stavros Katsanevas (U. Paris VII, France)
Stefan Klepser (DESY, Germany)
Eligio Lisi (INFN, Bari, Italy)
Mauro Mezzetto (INFN, Padova, Italy)
Christian Spiering (DESY, Germany)
Nick Van Remortel (UAntwerpen, Belgium)
Eli Waxman (Weizmann Institute, Israel)
Alfons Weber (Oxford U., UK)

Programme

Wednesday 27 May 2015

Session chaired by Alexander Sevrin

Welcome on behalf of the Solvay Institutes, the Francqui Foundation and the Organising Committee

Session chaired by Catherine De Clercq

Jean-Marie Frère	*An introductory talk: are neutrinos different?*
Eli Waxman	*The origin of cosmic neutrinos and the high-energy sky, a theoretical perspective*
Christian Spiering	*Cosmic neutrinos, an experimental overview*

Session chaired by Dirk Ryckbosch

Karl-Heinz Kampert	*Cosmic Rays, an experimental overview*
Stefan Klepser	*High Energy Gamma rays, an experimental overview*

Session chaired by Nick Van Eijndhoven

Thomas Hambye	*Leptogenesis*
Francis Halzen	*IceCube extension plans*
Maarten De Jong	*KM3NET and ANTARES extension plans*

Poster session and walking dinner

Thursday 28 May 2015

Session chaired by Antoine Van Proeyen

Laura Baudis	*Direct dark matter detection experiments, an overview*

Session chaired by Jean René Cudell

Carlos de los Heros	*Indirect search for dark matter with neutrinos*
Malcolm Fairbairn	*Theoretical view on dark matter results and expectations from the next generation of data and the LHC*

Session chaired by Michel Tytgat

Eligio Lisi	*Phenomenology of neutrino oscillations*
Alfons Weber	*Recent results from long-baseline neutrino oscillation experiments at accelerators*

Session chaired by Evelyne Daubie

Marcos Dracos	*Recent results from reactor experiments and prospects for the future*
Mauro Mezzetto	*Future long baseline facilities at accelerators*
Banquet	

Friday 29 May 2015

Session chaired by Petr Tiniakov

Guido Drexlin	*Direct neutrino mass measurement*
Ettore Fiorini	*Neutrinoless double beta decay*

Session chaired by Juan Antonio Aguilar Sánchez

Nick Van Remortel	*Short-baseline results and sterile neutrinos*
Stavros Katsanevas	*A report by Appec on the expected evolution of astroparticle physics in Europe, and world-wide*

Participants

Aguilar Sánchez Juan Antonio (ULB, Belgium)
Angus Garry (VUB, Belgium)
Barnich Glenn (ULB, Belgium)
Baudis Laura (U. Zürich, Switzerland)
Brayeur Lionel (VUB, Belgium)
Brun Pierre (C.E.A. Saclay, France)
Casier Martin (VUB, Belgium)
Corvilain Pierre (ULB, Belgium)
Cudell Jean-René (ULg, Belgium)
Daubie Evelyne (UMONS, Belgium)
De Clercq Catherine (VUB, Belgium)
de Jong Maarten (NIKHEF, The Netherlands)
de los Heros Carlos (Uppsala Univ., Sweden)
de Vries Krijn (VUB, Belgium)
De Wasseige Gwenhal (VUB, Belgium)
Dhen Mikael (ULB, Belgium)
Dracos Marcos (CNRS, U. de Strasbourg, France)
Drexlin Guido (Karlsruhe Inst. of Technology, Germany)
El Aisati Chamae (ULB, Belgium)
Fairbairn Malcolm (King's College London, UK)
Favart Laurent (ULB, Belgium)
Fiorini Ettore (INFN, Milano Bicocca, Italy)
Frère Jean-Marie (ULB, Belgium)
Giacchino Federica (ULB, Belgium)
Gustafsson Michael (Guttingen University)
Halzen Francis (U.W. Madison, USA)
Hambye Thomas (ULB, Belgium)
Hannestad Steen (Aarhus U., Denmark)
Hanson Kael (U.W. Madison, USA)
Heeck Julian (ULB, Belgium)
Heereman David (ULB, Belgium)
Ismailati Rina (UGent-VUB, Belgium)
Kampert Karl-Heinz (Bergische U., Wuppertal, Germany)
Katsanevas Stavros (U. Paris VII, France)
Korntheuer Michael (ULB, Belgium)
Kunnen Jan (VUB, Belgium)
Labare Mathieu (UGent, Belgium)
Lisi Eligio (INFN, Bari, Italy)
Lopez Honorez Laura (VUB, Belgium)
Lunemann Jan (VUB, Belgium)
Maggi Giuliano (VUB, Belgium)
Mawatari Kentarou (VUB, Belgium)
Mezzetto Mauro (INFN, Padova, Italy)
Michiels Ianthe (UGent, Belgium)
Moortgat Celine (UGent, Belgium)
Ndayilzeye David (ULB, Belgium)
Pinat Elisa (ULB, Belgium)
Raab Christoph (ULB, Belgium)
Ryckbosch Dirk (UGent, Belgium)
Sacton Jean (ULB, Belgium)
Sevrin Alexander (VUB & Solvay Inst., Belgium)
Simoes Catarina (ULg, Belgium)
Spiering Christian (DESY, Germany)
Tinyakov Petr (ULB, Belgium)
Toscano Simona (VUB, Belgium)
Tytgat Michel (ULB, Belgium)
Van Eijndhoven Nick (VUB, Belgium)
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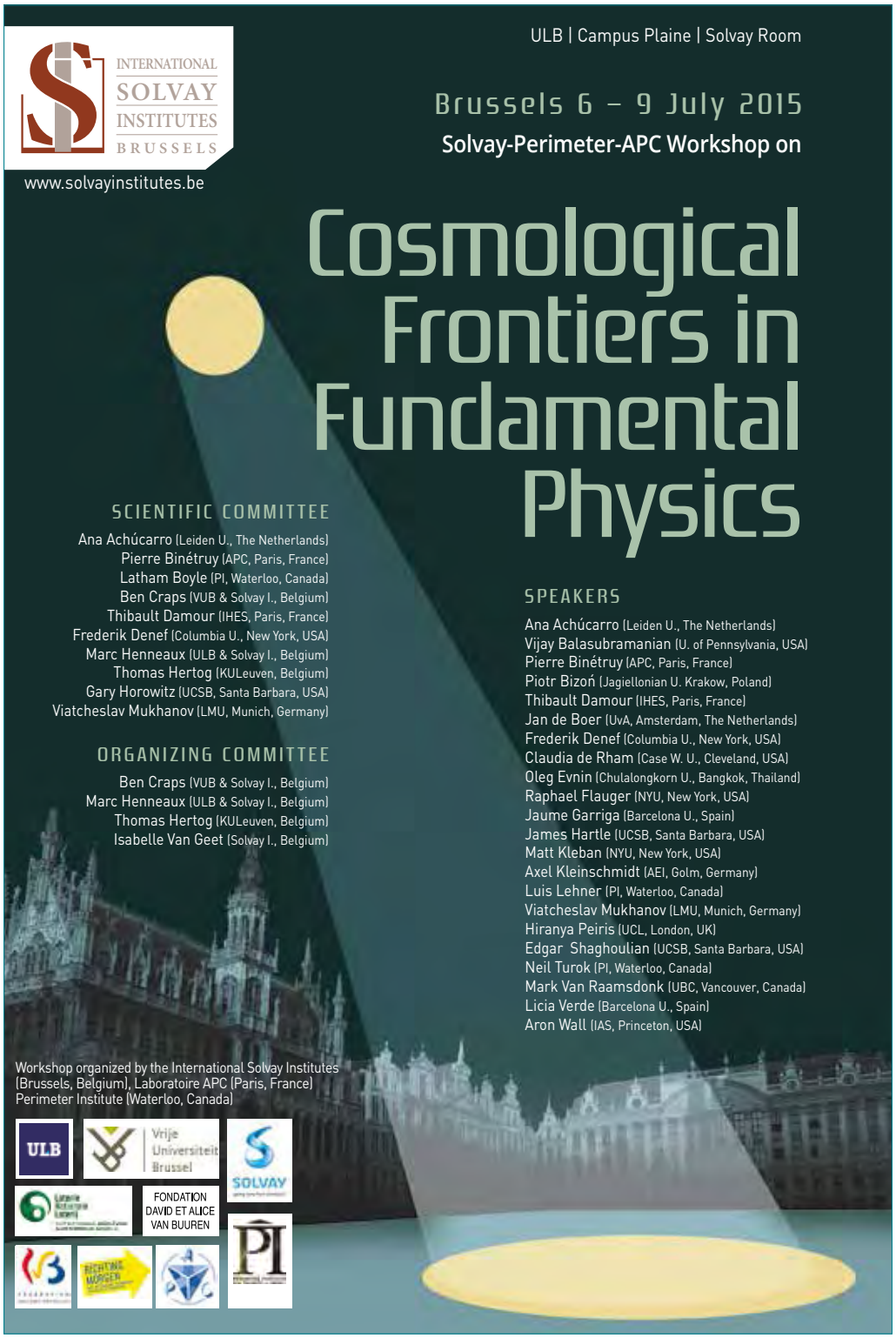
Vereecken Matthias (VUB, Belgium)
Vilain Pierre (ULB, Belgium)
Waxman Eli (Weizmann Institute, Israel)
Weber Alfons (Oxford U., UK)
Wilquet Gaston (ULB, Belgium)

Solvay-Perimeter-APC Workshop on

"Cosmological Frontiers in **Fundamental Physics**"

6 | 9 July 2015

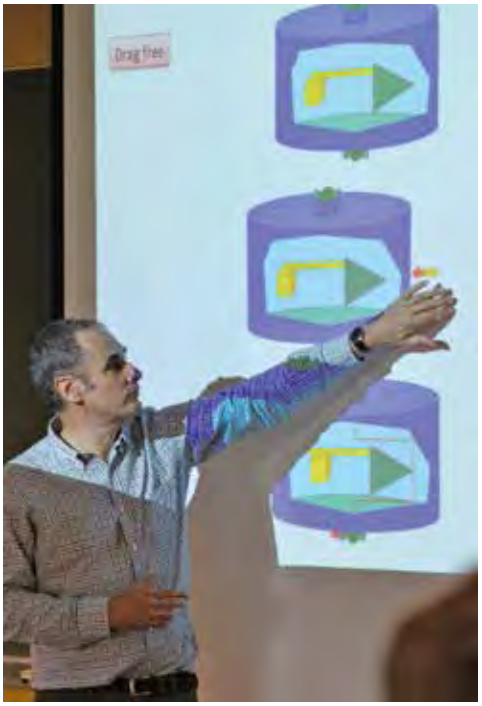


Solvay-Perimeter-APC Workshop on

"Cosmological Frontiers in **Fundamental Physics**"

6 - 9 July 2015

The workshop was part of a series organized jointly by the International Solvay Institutes, APC (University Paris VII, France) and the Perimeter Institutes (Waterloo, Canada). The series aimed to discuss, in an informal setting, recent developments at the interface of cosmology and fundamental physics. The previous edition was held by the APC in June 2014. The 2015 edition was held in the context of the ERC Advanced Grant "SyDuGraM".



Organizing Committee

Ben Craps (VUB & Solvay I., Belgium)
Marc Henneaux (ULB & Solvay I., Belgium)
Thomas Hertog (KU Leuven, Belgium)
Isabelle Van Geet (Solvay I., Belgium)

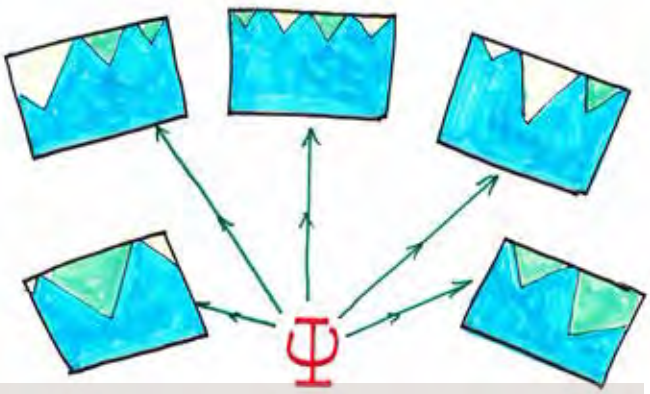
Scientific Committee

Ana Achúcarro (Leiden U., The Netherlands)
Pierre Binétruy (APC, Paris, France)
Latham Boyle (PI, Waterloo, Canada)
Ben Craps (VUB & Solvay I., Belgium)
Thibault Damour (IHES, Paris, France)
Frederik Denef (Columbia U., USA)
Marc Henneaux (ULB & Solvay I., Belgium)
Thomas Hertog (KU Leuven, Belgium)
Gary Horowitz (UCSB, Santa Barbara, USA)
Viatcheslav Mukhanov (LMU, Munich, Germany)

Speakers

Ana Achúcarro (Leiden U., The Netherlands)
Pierre Binétruy (APC, Paris, France)
Piotr Bizoń (Jagiellonian U. Krakow, Poland)
Thibault Damour (IHES, Paris, France)
Frederik Denef (Columbia U., New York, USA)
Jan de Boer (UvA, Amsterdam, The Netherlands)
Oleg Evnin (Chulalongkorn U., Bangkok, Thailand)
Raphael Flauger (NYU, New York, USA)
Jaume Garriga (Barcelona U., Spain)
James Hartle (UCSB, Santa Barbara, USA)
Stephen Hawking (Cambridge U., UK)
Matt Kleban (NYU, New York, USA)
Axel Kleinschmidt (AEI, Golm, Germany)
Luis Lehner (PI, Waterloo, Canada)
Viatcheslav Mukhanov (LMU, Munich, Germany)
Hiranya Peiris (UCL, London, UK)
Edgar Shaghoulian (UCSB, Santa Barbara, USA)
Neil Turok (PI, Waterloo, Canada)
Mark Van Raamsdonk (UBC, Vancouver, Canada)
Licia Verde (Barcelona U., Spain)
Aron Wall (IAS, Princeton, USA)

No one spacetime but an ensemble of possible ones



Programme

Monday 6 July 2015

Welcome by Marc Henneaux, Director of the Solvay Institutes

Session chaired by Ben Craps

Piotr Bizoń	*Resonant dynamics and the instability of anti-de Sitter Spacetime*
Luis Lehner	*The rich and suprising dynamics of AdS in the non-linear regime*
Oleg Evnin	*Nonlinear perturbations of AdS spacetime: an analytic approach*

Session chaired by Thomas Hertog

Jim Hartle	*One Bubble to Rule them All*
Jaume Garriga	
Stephen Hawking	*A Smooth Exit from Eternal Inflation*
Frederik Denef	*Discussion*

Tuesday 7 July 2015

Session chaired by Pierre Binétruy

Thibault Damour	*Quantum Dynamics of a Supersymmetric Mixmaster Universe, and a Possible Quantum Avoidance of Cosmological Singularities*
Axel Kleinschmidt	*Hidden symmetries in gravity and the standard model*
Mark Van Raamsdonk	*The quantum information / quantum gravity correspondence*

Session chaired by Marc Henneaux

Aron Wall	*Focussing of Entropy*
Matt Kleban	*Unwinding Inflation*

Colloquium Solvay

Neil Turok	*Shocks in the Early Universe, and their possible consequences*

Wednesday 8 July 2015

Session chaired by Slava Mukhanov

Licia Verde	*The evolved universe: from observations to fundamental Physics*
Hiranya Peiris	*The very early universe: from observations to fundamental Physics*

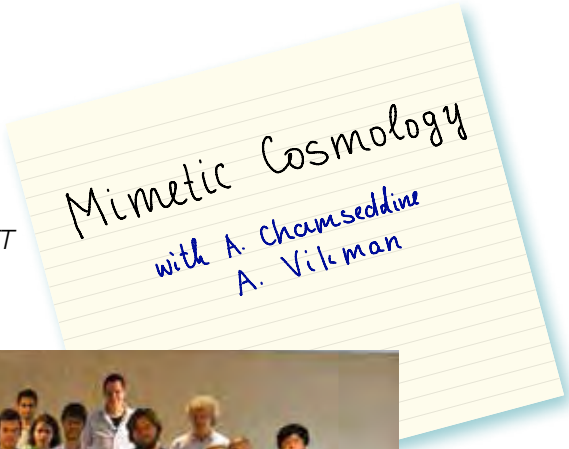
Session chaired by Thibault Damour

Pierre Binétruy	*Prospects for gravitational wave detection*
Neil Turok	*A perfect bounce*
Ana Achúcarro	*Discussion*
Banquet	

Thursday 9 July 2015

Session chaired by Neil Turok

Slava Mukhanov	*Mimetic Cosmology*
Edgar Shaghoulian	*Recent developments in dS/CFT*
Jan de Boer	



Participants

Aalsma Lars (UvA, The Netherlands)
Achucarro Ana (Leiden U., The Netherlands)
Barnich Glenn (ULB, Belgium)
Bernamonti Alice (KU Leuven, Belgium)
Binétruy Pierre (APC, Paris, France)
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Bobev Nikolay (KU Leuven, Belgium)
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Braden Jonathan (University College London, UK)
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Cisterna Adolfo (Universidad Austral de Chile)
Clesse Sebastien (University of Namur, Belgium)
Compère Geoffrey (ULB, Belgium)
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De Boer Jan (UvA, Amsterdam, The Netherlands)
De Jonckheere Tim (VUB, Belgium)
Denef Frederik (Columbia U., USA)
Detournay Stéphane (ULB, Belgium)
Diaz Dorronsoro Juan (KU Leuven, Belgium)
Donnay Laura (ULB, Belgium)
Douxchamps Laure-Anne (ULB, Belgium)
Dutta Souvik (U. of Illinois Urbana-Champaign, USA)
Ema Yohei (University of Tokyo, Japan)
Espinosa Joseph R. (IFAE, Spain)
Evnin Oleg (Chulalongkorn U., Bangkok, Thailand)
Flauger Raphael (NYU, New York, USA)
Fleig Philipp (IHES, France)
Fumagalli Jacopo (Nikhef, The Netherlands)
Galli Federico (KU Leuven, Belgium)
Garriga Jaume (Barcelona U., Spain)

Giribet Gaston (ULB, Belgium)
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Hawking Stephen (Cambridge U., UK)
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Hörtner Sergio (ULB, Belgium)
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Kim Nakwoo (Kyung Hee U. Korea)
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Kleinschmidt Axel (AEI, Golm, Germany)
Korovin Yegor (Max Planck Institute, Germany)
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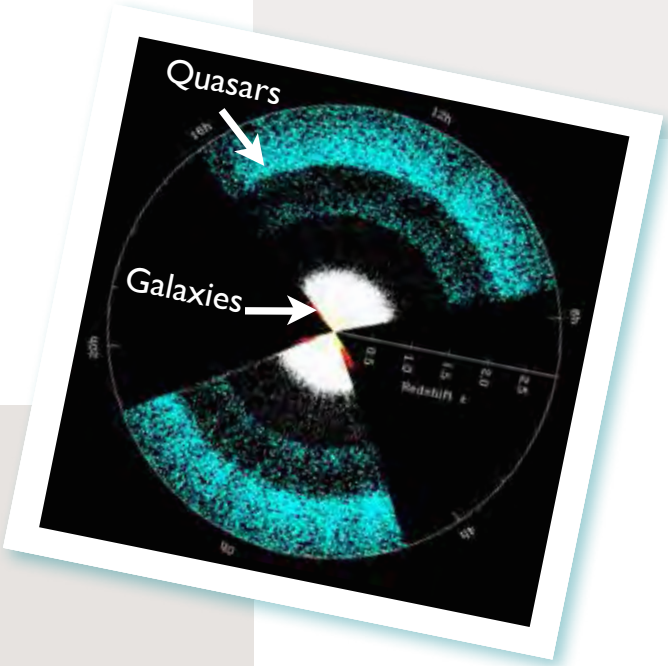
Lemmens Tom (KU Leuven, Belgium)
Lepage-Jutier Arnaud (ULB, Belgium)
Lucena Gómez Gustavo (AEI-MPG, Golm, Germany)
Marzolla Andrea (ULB, Belgium)
Masahiro Takimoto (University of Tokyo, Japan)
Matulich Javier (CECs, Chile)
Mertens Thomas (Ghent University, Belgium)
Min Vincent (UvA & KU Leuven, Belgium)
Monten Ruben (KU Leuven, Belgium)
Mukhanov Slava (LMU, Munich, Germany)
Nguyen Huu Chuong (ULB, Belgium)
Oblak Blagoje (ULB, Belgium)
Oliveri Roberto (ULB, Belgium)
Parikh Maulik (Arizona State U., USA)
Peiris Hiranya (UCL, London, UK)
Postma Marieke (Nikhef, The Netherlands)
Ranjbar Arash (ULB, Belgium)

Ripperda Bart (KU Leuven, Belgium)
Rocha Granado Diego (Ghent U., Belgium and Rio de Janeiro State U., Brazil)
Schillo Marjorie (KU Leuven, Belgium)
Schoots Leo (U. of Utrecht, The Netherlands)
Seraj Ali (IPM, Iran)
Sevrin Alexander (VUB, Belgium)
Shaghoulian Edgar (UCSB, Santa Barbara, USA)
Spindel Philippe (UMONS, Belgium)
Thompson Daniel (VUB, Belgium)
Truijen Brecht (KU Leuven, Belgium)
Turok Neil (PI, Waterloo, Canada)
Tziveloglou Pantelis (VUB, Belgium)
Van den Bleeken Dieter (Bogazici University, Turkey)
van der Woerd Ellen (KU Leuven, Belgium)
van Muiden Jesse (University of Antwerp, Belgium)
Van Proeyen Antoine (KU Leuven, Belgium)
Van Raamsdonk Mark (UBC, Vancouver, Canada)
Van Riet Thomas (ULB, Belgium)
Van Tent Bartjan (Université Paris-Sud, France)
Vanhoof Joris (VUB, Belgium)
Verde Licia (Barcelona U., Spain)
von Hausegger Sebastian (U. of Copenhagen, Niels Bohr Institute, Denmark)
Vreys Yannick (KU Leuven, Belgium)
Wall Aron (IAS, Princeton, USA)
Way Gary (Trinity College, U. of Dublin, UK)
Williams Matt (KU Leuven, Belgium)
Zwikel Céline (ULB, Belgium)



Modave Summer School in **Mathematical Physics**

13 | 18 September 2015

Modave Summer School in **Mathematical Physics**

13 - 18 September 2015

The eleventh edition of the Modave Summer School in Mathematical Physics took place from 13 to 18 September 2015. It was organized by PhD students from ULB, VUB and KU Leuven with the support of the International Solvay Institutes. The aim of the Modave Summer School in Mathematical Physics was to study recent topics in theoretical physics of fundamental interactions. In practice, the school consisted of a series of lectures, supposed to begin with the basics, be synthetic and as self-contained as possible.

Organizing Committee

Gabriele Conti (KUL), Laura Donnay (ULB), Laure-Anne Douxchamps (ULB), Marco Fazzi (ULB), Amaury Leonard (ULB), Jonathan Lindgren (VUB), Pujian Mao (ULB), Andrea Marzolla (ULB), Ruben Monten (KUL), Blagoje Oblak (ULB), Brecht Truijen (KUL), Ellen van der Woerd (KUL) and Yannick Vreys (KUL).

Lectures

- Amaury Leonard, *BRST quantization and anomalies* (6 hours)
- Nabil Iqbal, *Entanglement in field theory and gravity* (5h)
- Blagoje Oblak, *Partition functions in 3D gravity* (6h)
- Laura Donnay, *Dimensional reduction of 3D gravity* (4h)
- Hongbao Zhang, *Applied AdS/CFT by numerics* (4h)

The proceedings of the summer school will be published in Proceedings of Science, the open access online journal organized by SISSA, the International School for Advanced Studies based in Trieste.

BRST quantization and anomalies

Amaury Leonard

We review at length the classical hamiltonian treatment of constrained systems. We consider the Dirac formalism, its classification of constraints and its induced symplectic structure over the reduced phase space. This is applied to electromagnetism and the geometric aspects are studied. Generally covariant systems (where the time variable is itself gauge dependent) are also considered. The algebraic tools of cohomology are then introduced and applied to the construction of the extended phase space and the introduction of ghosts. Unicity and existence theorems for the extended ection are established. Quantization is briefly considered. Finally, anomalies are linked with the BRST cohomology and the Wess-Zumino descent equations obtained.

Entanglement in field theory and gravity

Nabil Iqbal

This course consisted of introductory lectures on the various incarnations of entanglement entropy. Topics covered included an overview of the basic properties of entanglement entropy, its structure in quantum field theory, its computation in two-dimensional conformal field theory, a simple application to c-theorems in two dimensions, and the Ryu-Takayanagi formula and its extensions in holography.

Partition functions in 3D gravity

Blagoje Oblak

We consider gravity on three-dimensional AdS space-times and study its partition function with the (optimistic) goal of identifying the putative dual, two-dimensional conformal field theory. The course starts with a broad reminder on CFTs, Virasoro characters and partition functions, including the Cardy entropy formula. Then we move on to 3D gravity on AdS and introduce Brown-Henneaux boundary conditions, showing in particular that the central charge of the dual CFT takes a specific, known value. Finally, we study semi-classical aspects of 3D gravity, including BTZ black hole entropy, the one-loop partition function of gravitons around AdS, and the Farey tail sum that leads to a famously unphysical spectrum of primary states.

Dimensional reduction of 3D gravity

Laura Donnay

In these lectures, we review in details the result of Coussaert-Henneaux-van Driel showing that the asymptotic dynamics of (2+1)- dimensional gravity with negative cosmological constant is described at the classical level by Liouville theory. Boundary conditions implement the asymptotic reduction in two steps: the first set reduces the SL(2,R) x SL(2,R) Chern-Simons action, equivalent to the Einstein action, to a non-chiral SL(2,R) Wess-Zumino-Witten model, while the second set imposes constraints on the WZW currents that reduce further the action to Liouville theory. We discuss the issues of considering the latter as an effective description of the dual conformal field theory describing AdS3 gravity beyond the semi-classical regime.

Applied AdS/CFT by numerics

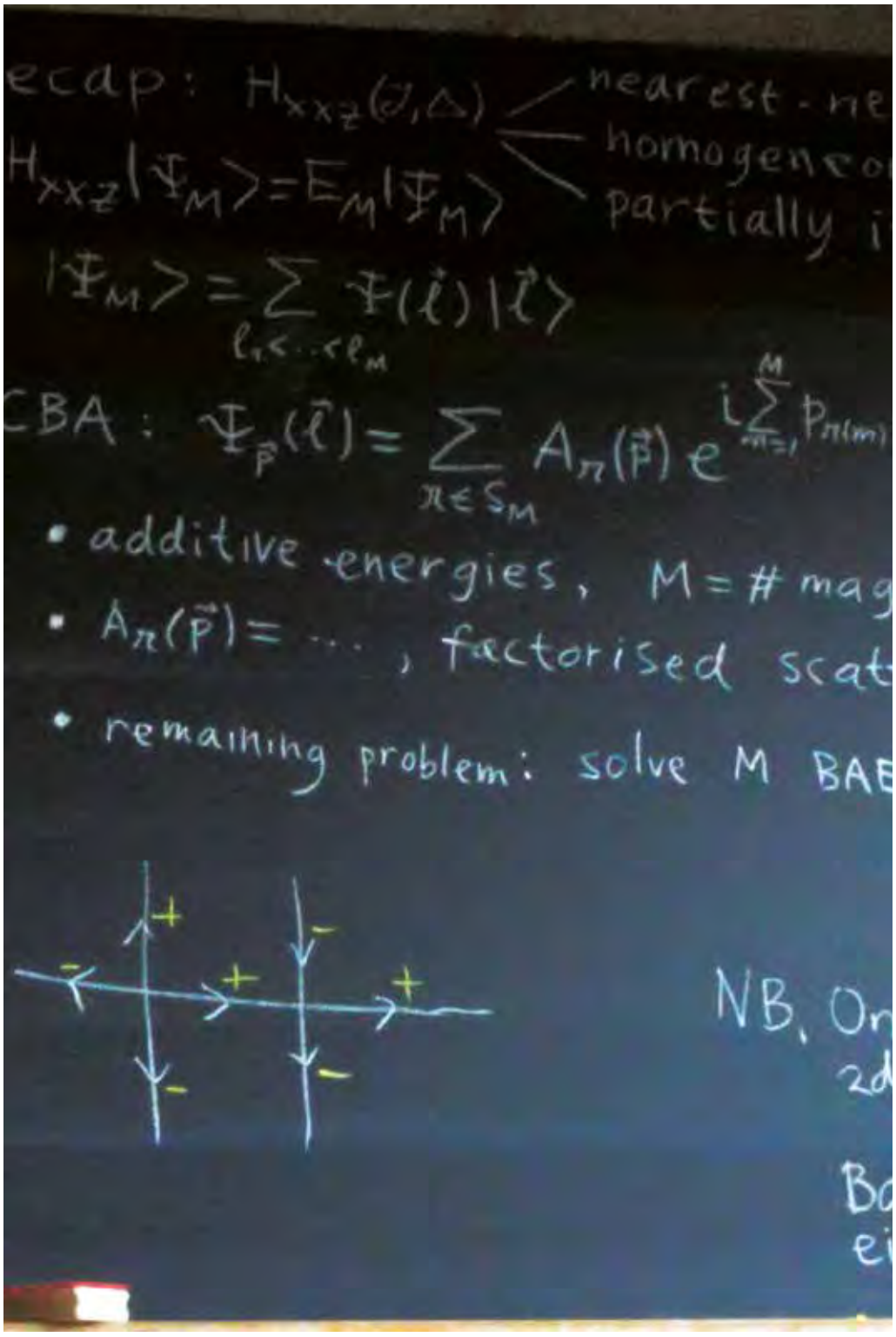
Hongbao Zhang

After a poor man's introduction to AdS/CFT, I would like to take holographic superfluids as concrete example to demonstrate various concepts and techniques used in applied AdS/CFT, which include holographic renormalization, free energy, linear response theory, quasi-normal modes, entanglement entropy and so forth. In particular, I will pay much attention to how numerics helps us to solve various problems in applied AdS/CFT.

Participants

Thomas BASILE (Université de Mons)
Gabriele CONTI (KUL)
Tim DE JONCKHEERE (VUB)
Saskia DEMULDER (VUB)
Laura DONNAY (ULB)
Kate ECKERLE (Columbia University, New York)
Marco FAZZI (ULB)
Paolo GREGORI (ULB and University of Turin)
Nabil IQBAL (University of Amsterdam)
Rob KLABBERS (Hamburg University)
Jules LAMERS (Utrecht Univeristy)
Victor LEKEU (ULB)
Amaury LEONARD (ULB)
Jonathan LINDGREN (VUB)
Pujian MAO (ULB)
Andrea MARZOLLA (ULB)
Ruben MONTEN (KUL and Columbia University, New York)
Kevin MORAND (Tours University)
Daniel NAEGELS (ULB)
Blagoje OBLAK (ULB)
Roberto OLIVERI (ULB)
Arash RANJBAR (ULB)
Yoonji SUH (Sogang University, Seoul)
Ellen VAN DER WOERD (KUL)
Yannick VREYS (KUL)
Hongbao ZHANG (VUB)
Céline ZWIKEL (ULB)

"Quantum Field Theory, Strings and Gravity"



The International Doctoral School

"Quantum Field Theory, Strings and Gravity"

The aim of the Amsterdam-Brussels-Geneva-Paris Doctoral School on "Quantum Field Theory, Strings and Gravity" is to provide first-year PhD students with advanced courses in theoretical physics that help bridge the gap between Master-level courses and the most recent advances in the field. Responsible for the organization as well as for teaching the courses are the ULB, the VUB, the University of Amsterdam, various institutions in Paris led by Ecole Normale Supérieure, and various institutions in Switzerland led by ETH Zürich.

The program typically starts at the end of September/beginning of October and consists of three times three weeks of lectures in three cities among Amsterdam, Brussels, Geneva (CERN) and Paris (depending on the year), with a one-week break between the segments. This way, the students are exposed to several institutes, each with their own research and teaching culture, and to professors from the various institutes. Last but not least, they get to meet fellow students from neighboring institutes and countries, who will be their peers and colleagues throughout (and possibly beyond) their PhD studies.

Organizing Institutions

Institute for Theoretical Physics
Universiteit van Amsterdam, The Netherlands

Laboratoire de Physique Théorique
École Normale Supérieure, Paris, France

Physique Théorique et Mathématique and
Theoretical Particle Physics
ULB/VUB, Brussels, Belgium

Institute for Theoretical Physics
ETH Zürich, Switzerland

Programme

Paris (5 - 23 October 2015)

Quantum Field Theory - Adel Bilal

General Relativity - Luc Blanchet

2^d Conformal Field Theory

Supersymmetry

Amsterdam (2 - 20 November 2015)

Introduction to Supergravity - Antoine van Proeyen

Introduction to String Theory
Marco Billo & Alberto Lerda

Supersymmetric Gauge and Conformal Field Theories
Nikolay Bobev

Black Holes and Quantum Gravity - Bartek Czech

Cosmology

Geneva (30 November - 18 December 2015)

String theory II - Boris Pioline and Julian Sonner

AdS/CFT - Kyriakos Papadodimas

Topological Strings - Hans Jockers

Instantons & large N - Marcos Marino

Lie algebras for physicists - Axel Kleinschmidt

Participants

Aalsma Lars (University of Amsterdam)

Arias Cesar (Universidad Andres Bello)

Chekeres Olga (University of Geneva)

Cosnier-Horeau Charles (UPMC)

Demaerel Thibaut (KU Leuven)

Demulder Saskia (Vrije Universiteit Brussel)

Driezen Sibylle (Vrije Universiteit Brussel)

Kruthoff Jorrit (University of Amsterdam)

Lemmens Tom (KU Leuven)

Lokhande Sagar Fakirchand (University of Amsterdam)

Loukas Orestis (University of Bern)

Luyten Vincent (Vrije Universiteit Brussel)

Min Vincent (KU Leuven)

Naegels Daniel (Université Libre de Bruxelles)

Park Minkyu Yukawa (Institute for Theoretical Physics, Kyoto University)

Ribeiro de Melo Édypo (University of Groningen)

Scopellit Vincenzo (Leiden University)

Silva Pimenta Leandro (Université Paris Diderot – Paris 7)

Vardanyan Valeri (Universiteit Leiden)

Vielma Manuel (University of Geneva)

Vos Gideon (University of Groningen)

Werkman Pelle (University of Groningen)

Zan Bernardo (EPFL)

Colloquia

Towards a general theory of **chemical evolution**

Professor Lee Cronin
University of Glasgow, UK

10 February 2015

What is life? How did life start on planet earth ca. 3.5 billion years ago, and which molecules/chemical systems lead to biology? Is there a general theory of evolution that extends to all matter? Can we make or evolve life from scratch in a matter of hours? These are fantastically interesting questions but in this lecture, rather than look back into the past, we will look to the future and discuss how chemists may go about creating new types of truly synthetic (artificial life, new or 'inorganic' biology). In embarking upon this quest we will be asking the question: "What is the minimal chemical system that can undergo Darwinian evolution?" and in doing so looking towards the concept of 'adaptive matter' and evolvable materials and chemical systems. The aim is inorganic biology, or more simply, a living system that does not use the current chemical infrastructure utilized by biology.

Gravitational Waves from Coalescing Binary **Black Holes**

Professor Thibault Damour
Institut des Hautes Etudes Scientifiques, France

4 March 2015

A network of ground-based interferometric gravitational wave detectors (LIGO/VIRGO...) is currently being upgraded, and should, in a few years, reach a sensitivity enabling them to detect the gravitational waves emitted by coalescing compact binaries: i.e. binary systems made of black holes and/or neutron stars. This prospect has motivated renewed theoretical studies of the motion and radiation of relativistic two-body systems. I will review the recent analytical studies of (comparable-mass) two-body systems, and their comparison to numerical relativity results. Particular attention will be given to the recently developed "Effective One Body" approach to the motion and radiation of binary systems.

Animals as our **eyes** and **ears** in the world

Professor Martin Wikelski
Max-Planck, Munich, Germany

24 March 2015

Modern animal ecology is starting to understand and monitor the wealth of information encoded in the behavior of wild animals on a global level. Especially the study of animal movement is entering a golden age because we now have the technology, the big data possibilities and the theoretical underpinnings to provide fundamentally new insight into the bio-treasure of collective life on the planet. I will highlight advances and future directions that allow us to understand the enigmas of: 1) Mechanisms and patterns of selection: Where, when and why an animal dies. Knowing this will answer the ultimate question about selection pressures, and help us advance conservation. 2) Ontogeny: How an individual develops its movements during its lifetime. 3) Environmental constraints: What the external surroundings are upon which an individual decides. 4) Social constraints: How an individual decides based on the decisions of other animals around it and interacting with it. We can and should involve the public in interacting and communicating with animals. Where this is done, often in native cultures, animals are already used as indicators and sentinels for biological and earth processes. Modern observational tools now allow us to interact with animals in unforseen ways and change our perception about the connectivity of life on the planet. Thus, wild animals will become the seeing-eye dog for humankind.

Ultracold molecules – a new frontier for quantum physics and chemistry

Professor Jun Ye
JILA, National Institute of Standards and Technology and University of Colorado, USA

31 March 2015

Molecules cooled to ultralow temperatures provide fundamental new insights to strongly correlated quantum systems, molecular interactions and chemistry in the quantum regime, and precision measurement. Complete control of molecular interactions by producing a molecular gas at very low entropy and near absolute zero has long been hindered by their complex energy level structure. Recently, a range of scientific tools have been developed to enable the production of molecules in the quantum regime. Here, molecular collisions follow full quantum descriptions. Chemical reaction is controlled via quantum statistics of the molecules, along with dipolar effects. Further, molecules can be confined in reduced spatial dimensions and their interactions precisely manipulated via external electromagnetic fields. For example, by encoding a spin-1/2 system in rotational states, we realize a spin lattice system where many-body spin dynamics are directly controlled by long-range and anisotropic dipolar interactions. These new capabilities promise further explorations of strongly interacting and collective quantum effects in exotic quantum matter.

The **Music** of the **Sphere**

Professor Roger Blandford
KIPAC, Stanford University, USA

28 April 2015

There has been remarkable progress in observational cosmology since the discovery of the cosmic microwave background in 1964 and culminating in the recently announced results from the Planck satellite.

Essentially all reliable evidence is consistent with a remarkably simple description of the expanding universe that follows the laws of basic physics insofar as we have deduced them in the laboratory but has to be supplemented by three ingredients that we are only beginning to understand:

- an epoch called "inflation" that occurred during the earliest moments of the universe
- "dark matter" which is five times as abundant as regular matter
- a universal "cosmological constant" which was proposed by Einstein in 1917.

Each of these ingredients represents a frontier in fundamental physics.

In this talk, I shall discuss some of the ways through which we have arrived at this description, emphasising the use of a "wave" description of the cosmos to complement the "direct" description that we get from our telescopes. I shall also describe some new approaches that can be followed to use these observations to advance our astronomical description of the overall arrangement of the luminous galaxies, stars and gas that we see around us today.

On the road to **Fault Tolerant Quantum Computation**

Professor David DiVincenzo
RWTH Aachen & Peter Grünberg Institute, Jülich, Germany

19 May 2015

Only long after the basic foundations of quantum physics were laid was it realized that the quantum aspects of the world provide new tools, both for fast computation and for the maintenance of security and privacy, which were completely unforeseen by classical physics. The “quantum money” concept of Wiesner, and the fast factoring algorithm of Shor, have launched us on a quest to physically realize these capabilities. Qubits are extremely sensitive to noise, but progress in the lab, which I will highlight with examples from solid-state systems, are now close to achieving the necessary conditions for a large scale quantum computer to be possible. I will show what experimentalists are hoping to achieve in the next 5-10 years towards this goal.

The physical chemistry of **sickle cell anemia**

Professor Peter G. Vekilov
University of Houston, USA

26 May 2015

Sickle cell anemia is a debilitating genetic disease, which affects hundreds of thousands babies born each year worldwide. Its primary pathogenic event is the formation of long fibers (with 14 molecules in the cross section) of a mutant, sickle cell, hemoglobin (HbS). Fiber formation is a first order phase transition, and, thus, sickle cell anemia is one of a line of diseases (Alzheimer's, Huntington's, prion, etc.) in which nucleation initiates pathophysiology. I will summarize recent results, which show that the homogeneous nucleation of HbS polymers follows a two-step mechanism with metastable dense liquid clusters serving as precursor to the ordered nuclei of the HbS polymer. The evidence comes from data on: the rates of fiber nucleation and growth, and nucleation delay times; the interaction of fibers with polarized light; and mesoscopic metastable HbS clusters in solution. The presence of a precursor in the HbS nucleation mechanism potentially allows low-concentration solution components to strongly affect the kinetics of nucleation. We show that the free heme leads to orders of magnitude faster nucleation and that its removal prevent polymerization.

The presence of soluble heme in the erythrocytes has never been considered as a factor for the disease pathology, owing to its putative low concentration. We develop a sensitive method based on enzymatic catalysis and luminescence to determine the concentration of free heme in erythrocytes. We find that the average free heme concentration in sickle cell patients is 45±10 mM, in sickle-trait individuals, 33±4 mM, and in healthy adults, 21±2 mM, about 100´ higher than previously determined. We show that the release of heme from hemoglobin is autocatalytic, i.e., the presence of free heme induces stronger heme release. Free heme contributes to both polymerization-related and polymerization-independent mechanisms of sickle cell anemia; hence, the found high concentrations suggest that it may be an important factor for sickle cell pathology and the target of novel treatment strategies.

These findings suggest that variations of the concentrations of the components of the red cell cytosol, e.g., heme, in patients might account for the high variability of the disease in genetically identical patients. In addition, these components can potentially be utilized for control of HbS polymerization and treatment of the disease.

Shocks in the **Early Universe**, and their possible consequences

Professor Neil Turok
Perimeter Institute, Waterloo, Canada

7 July 2015

In the last few years, cosmology has converged on a remarkably simple phenomenological fit: the LCDM (Lambda Cold Dark Matter) model. Many basic features of this model pose deep mysteries: the dark energy and dark matter, the initial singularity and the final de Sitter phase. In this talk, I will explain an unexpected prediction of the model which we have recently discovered, namely the breakdown of linear perturbation theory in the radiation-dominated early phase. The scale-invariant, linear curvature perturbations assumed in the model become oscillating acoustic modes once they cross the Hubble radius. Although their amplitude is small - of order a part in ten thousand - they oscillate through many periods. After around ten thousand oscillations, the waves steepen and form shocks. The shocks create entropy and the shock collisions create vorticity. I will describe how this vorticity may lead to some dramatic consequences, including the growth of primordial magnetic fields.

Lab on Chip Technology **10 x smaller** means **100 x faster**

Professor Andreas Manz
KIST Europe, Saarbrücken, Germany

31 August 2015

For chemistry and the life sciences, measurement of molecular parameters is of growing importance. Particularly, the presence of a certain molecule and its amount can play a key role, for example, in deciding about medical treatment, about the outcome of a forensic investigation, or in the future of experimental research in life sciences. Since the late 1980s, my laboratory explored miniaturizing parts, or even an entire laboratory down to chip size, increasing the throughput of chemical analysis, limiting its need for large sample volumes and potentially reducing the cost for access to the molecular information. I will emphasize scaling laws and chip technology for microfluidics, provide different examples of “lab on chip” devices and discuss possible future directions.

A **Quantum Leap** in Quantum Information

Building Quantum Computers and Quantum Simulators with **Cold Atoms and Ions**

Professor Peter Zoller
University of Innsbruck, Austria

6 October 2015

On a microscopic scale our world is governed by quantum physics. Apart from fundamental questions and 'mysteries' of quantum physics, learning how to control this microscopic world is also an opportunity for new applications and quantum technologies - potentially more powerful than their classical counterparts. In this lecture we discuss recent progress in building quantum computers and quantum simulators. We will focus on quantum optical systems of atoms and ions manipulated by laser light, providing prime examples of quantum systems, which can be controlled on the level of single quanta. This includes a discussion of trapped ions as a universal quantum processor, and digital and analog quantum simulation of strongly correlated quantum matter with atoms in optical lattices. We conclude with an outlook on a 'quantum internet' and building a 'quantum annealer'.

Simultaneous Tuning of **Activation** and **Repression** in Intrinsic **Disorder-Mediated Allostery**

Professor Vincent Hilser
Johns Hopkins University, USA

20 October 2015

Intrinsically disordered proteins (IDPs) present a functional paradox because they lack stable tertiary structure, but nonetheless play a central role in signaling. Like their structured protein counterparts, IDPs can transmit the effects of binding an effector ligand at one site to another functional site, a process known as allostery. Because allostery in structured proteins has historically been interpreted in terms of propagated structural changes that are induced by effector binding, it is not clear how IDPs, lacking such well-defined structures, can allosterically affect function. Here we show mechanistically how IDPs allosterically transmit signals through a probabilistic process that originates from the simultaneous tuning of both activating and repressing ensembles of the protein, using human glucocorticoid receptor as a model. Moreover, GR modulates this signaling by producing translational isoforms with variable disordered regions. We expect this ensemble model of allostery will be important in explaining signaling in other IDPs.

Some Highlights in **Relativistic Quantum** Chemistry of **Heavy Elements**

Professor Pekka Pyykkö
University of Helsinki, Finland

17 November 2015

The Relativistic Theory of Atoms and Molecules (RTAM) has become a vast field of about 17000 papers, see the bibliography[1], rtam.csc.fi. The fundamentals at Dirac-Fock-Breit level, including simple treatments of the Lamb shift, seem to be under control[2]. Numerous reviews exist on these effects in Inorganic Chemistry[3,4] and qualitative estimates on them have entered most textbooks of Inorganic Chemistry. The main message is that many of the differences between the Periods 5 and 6 can be explained by relativistic effects. Some examples are the difference between silver and gold, between cadmium and mercury, or between tin and lead. Most of the voltage of the lead battery is due to relativity[4]. Some further issues in simple bonding theory are the covalent radii[5], or the concept of oxidation states[6].

[1] P. Pyykkö, J. Comp. Chem. 34 (2013) 2667
[2] P. Pyykkö, Chem. Rev. 112 (2012) 371
[3] P. Pyykkö, Chem. Rev. 88 (1988) 563
[4] P. Pyykkö, Ann. Rev. Phys. Chem. 63 (2012) 45
[5] P. Pyykkö, J. Phys. Chem. A 119 (2014) 2326
[6] P. Pyykkö, W.-H. Xu, Chem. Eur. J. 21 (2015)

From white dwarfs to Gravitational Collapse: The emergence of **Relativistic Astrophysics**

Professor Luisa Bonolis
Max Planck Institute, Germany

8 December 2015

This year we are celebrating the centenary of the Einstein field equations, the capstone of the general theory of relativity. Over these one hundred years the theory has evolved from a revolutionary mathematical theory with a limited empirical basis to an observationally and experimentally based cornerstone of modern physics and cosmology. However, just a few years after the spectacular confirmation of one of its few empirical predictions - the gravitational deflection of light - the theory of general relativity entered what has been called a "low-watermark period", during which it was perceived by physicists as a highly formalistic subject, and remained cut off from the mainstream of physics.

Things definitely changed in the 1960s, when general relativity became an extremely vital research stream of theoretical physics in connection with major astrophysical discoveries. Quasars, the Cosmic Microwave Background radiation and pulsars - soon identified as rotating neutron stars - led to the recognition that physical processes and astrophysical objects exist in the universe that are understandable only in terms of the general theory of relativity.

Why were relativists in the 1960s able to react so quickly to new astrophysical discoveries? Which developments prepared and laid the conditions for the emergence of a new field combining General Relativity with Astrophysics?

Recent results of historical research will be presented, outlining some relevant aspects of this complex process, that contributed to lay the foundations for the establishment of general relativity as a standard working tool of theoretical astrophysics.

Workshops and Activities

sponsored by the Institutes

Particle Physics after the 2013 Nobel Prize

A colloquium dedicated to François Englert
organised by the Belgian National Committee for Pure and Applied Physics

Royal Academy, Brussels, Belgium
28 March 2015

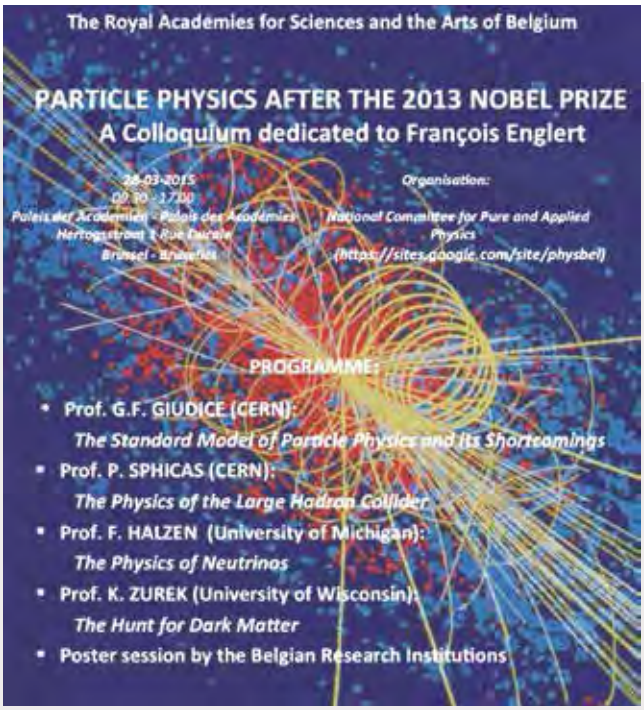
Programme

The Standard Model of Particle Physics and its Shortcomings
Prof. Gian Francesco GIUDICE, CERN

The Physics of the Large Hadron Collider
Prof. Paris SPHICAS, CERN and Univ. Athens

The Physics of Neutrinos
Prof. Francis HALZEN, University of Wisconsin

The Hunt for Dark Matter
Prof. Kathryn ZUREK, University of Berkeley



2015 Annual Scientific Meeting of the **Belgian Physical Society**

University of Liège, Belgium
13 May 2015

Scientific and **organizing** committees

Peter Schlagheck (ULg)
Jozef Ongena (RMA)
Gilles de Lentdecker (ULB)
Matthieu Verstraete (ULg)
John Martin (ULg)
Diego Aristizabal (ULg)
Denis Grodent (ULg)
Geoffroy Lumay (ULg)
Mieke de Cock (KUL)
Christelle Prosperi (ULg)
Christophe Becco (ULg)

Plenary speakers

Professor Alain Aspect
Institut d'Optique, Palaiseau, France
The atomic Hong-Ou-Mandel effect: a milestone in quantum atom optics

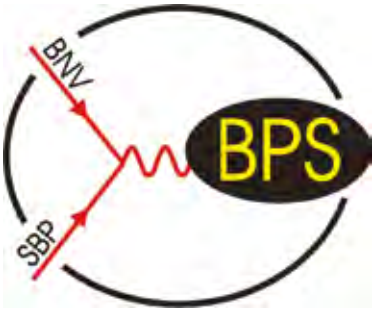
Professor Andre Stesmans
KU Leuven, Belgium
Efficient blue light emitting diodes: A breakthrough in enlightening the world

Young scientist oral presentation contest

Vincent Ginis (VUB)	*Transforming Cerenkov Detection*
Gwendolyn Lacroix (UMons)	*Study of the Confined and Deconfined Phases gf QCD within the Quasiparticle Approximation*
Nick van den Broeck (UAntwerp)	*Nano-optics shines light on the quest for metallic hydrogen*

Parallel sessions

- *Physics and Education*
  Chairperson: Prof. Mieke de Cock (KUL)
- *Fundamental Interactions, Particle and Nuclear Physics*
  Chairperson: Dr. Diego Aristizabal (ULg)
- *Condensed Matter and Nanostructure Physics*
  Chairperson: Prof. Matthieu Verstraete (ULg)
- *Biological, Medical, Statistical, and Mathematical Physics*
  Chairperson: Prof. Geoffroy Lumay (ULg)
- *Atoms, Molecules, Optics, and Photonics*
  Chairperson: Prof. John Martin (ULg)
- *Astrophysics, Geophysics, and Plasma Physics*
  Chairperson: Prof. Denis Grodent (ULg)



Workshop on

"About various kinds of **interactions**"

in honour of Philippe Spindel

Université de Mons, Belgium
4 - 5 June 2015

Scientific committee

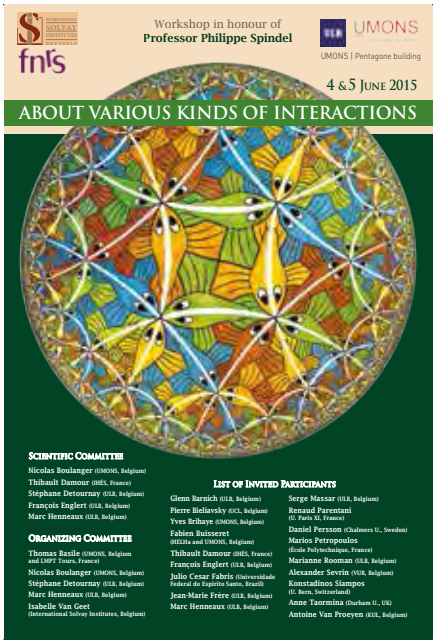
Nicolas Boulanger (UMONS, Belgium)
Thibault Damour (IHÉS, France)
Stéphane Detournay (ULB, Belgium)
François Englert (ULB, Belgium)
Marc Henneaux (ULB, Belgium)

Organizing committee

Nicolas Boulanger (UMONS, Belgium)
Stéphane Detournay (ULB, Belgium)
Marc Henneaux (ULB, Belgium)

with the kind and precious help of

Thomas Basile (UMONS, Belgium and LMPT Tours, France)
and
Isabelle Van Geet (International Solvay Institutes)



Programme

BARNICH Glenn	*The quantum Coulomb solution as a coherent state of unphysical photons. A physical toy model for black hole microstates*
BIELIAVSKY Pierre	*Introduction to non-formal deformation quantization*
DAMOUR Thibault	*Hidden Hyperbolic Kac-Moody Structures in Supergravity and a Possible Quantum Avoidance of Cosmological Singularities*
ENGLERT François	*On the quantum fate of classical horizons*
FRÈRE Jean-Marie	*The ruler and the rubber band ... understanding physical laws*
HENNEAUX Marc	*Cosmological Models In Eleven-Dimensional Supergravity: A Modern Perspective*
MASSAR Serge	*Certified quantum randomness*
PARENTANI Renaud	*Analogue Gravity Experiments, theoretical status and recent advances*
PERSSON Daniel	*Fricke S-duality and BPS-state counting*
PETROPOULOS Marios	*Holographic fluids, duality and integrability*
ROOMAN Marianne	*A little walk from physical to biological complexity*
SEVRIN Alex	*Physics in Low Dimensions: A Long Walk that Started with Philippe*
VAN PROEYEN Antoine	*Nilpotent multiplets in supergravity and anti-D3 branes*

Workshop on

Nonlinear **PDE**s

ULB, Brussels, Belgium
7 - 11 September 2015

Organizers

D. Bonheure (chair)
B. Casteras
J. Foldes
B. Noris
M. Nys
A. Saldaña
C. Troestler

Scientific committee

X. Cabre
J. P. Gossez
P. Polacik
T. Weth
M. Willem

Main speakers

J.A. Carrillo
M. del Pino
J. Dolbeault
A. Farina
F. Gazzola
M. Grossi
H.C. Grunau
F. Hamel
M. Loss
A. Pistoia
P. Quittner
P. Souplet
S. Terracini
J. Van Schaftingen
J. Wei

Thematic sessions

- *Schrödinger equations*
  chaired by S. Cingolani, L. Jeanjean, M. Squassina
- *Higher order PDEs and systems*
  chaired by E. Moreira dos Santos, B. Noris, H. Tavares
- *Parabolic PDEs*
  chaired by J. Földes, A. Saldaña

This workshop is part of the program MIS F.4508.14 funded by the FNRS.

The **String Theory** Universe, 21st **European string** workshop and 3rd **COST MP1210** meeting

Leuven, Belgium
7-11 September 2015

The conference was dedicated to all aspects of superstring, supergravity and supersymmetric theories. The themes covered topics related to

- Gauge/Gravity Duality
- String Phenomenology
- Cosmology and Quantum Gravity

Scientific committee

Riccardo Argurio
Alejandra Castro
Anna Ceresole
Gabriele Honecker
Yolanda Lozano
Dieter Lüst
Silvia Penati
Mukund Rangamani
Alex Sevrin
Kelly Stelle
David Tong
Antoine Van Proeyen

Organizing committee

Riccardo Argurio
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Ben Craps
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Antoine Van Proeyen
Thomas Van Riet

Journée Scientifique de la **Société Royale de Chimie**

Chimie aux **Interfaces**

ULB, Brussels, Belgium
8 October 2015

Introduction

Prof. A. De Wit (Présidente de la Section de Bruxelles de la SRC)

Prof. C. Herman-Buess (Présidente de la SRC)

Dr. Carine Lefèvre
(Coatings Research Institute)
Les peintures intelligentes, la chimie au service de la fonctionnalité

Emilie Halin
(UMons)
Extraction magnétique sélective de molécules organiques en phase aqueuse: conception et évaluation d'un système original basé sur des nanoparticules modifiées par des récepteurs macrocycliques

Nicolas Biot
(UNamur)
Experimental study of SBIs between benzo-ß-tellurophene and pyridine derivatives

Adrien Devolder
(ULB)
Contribution à l'étude de la symétrie, de la structure électronique et des propriétés vibrationnelles des dichalcogénures de métaux de transition

Prof. Philippe Marcus
(Ecole Nat. Sup. de Chimie de Paris)
Chimie des surfaces et corrosion des métaux et alliages

Prof. Thomas Doneux
(Université libre de Bruxelles)
Electrochimie et biointerfaces: vecteurs de science, outils d'analyse

Damien Dewez
(UCL)
Vers la synthèse du fragment central de l'acide okadaïque

Valérie Schwanen
(ULg)
Ultrafast photoinduced charge transfer in small gold clusters functionalized by a chromophore ligand

Prof. Jean Pinson
(Université de Paris Diderot)
L'électrogreffage, une méthode efficace pour la fonctionnalisation de surfaces

Remise des Prix

Workshop on

String Theory, Particle **Physics** and **Cosmology**

GGI, Florence, Italy
26 - 30 October 2015

The workshop took place at the GGI, Florence, October 26-30, 2015. The goal of this workshop was to address recent developments in accommodating both particle physics and cosmology constraints, and consolidating prospects for predictions, and to foster dialog between theory and data. Invited speakers and participants included on the one hand expert phenomenologists familiar with current and near-future experiments (ranging from colliders to satellite experiments), and on the other hand theorists, both model builders and more formal string theorists.

Organizers

Riccardo Argurio (ULB)
Marcus Berg (Karlstad)
Matteo Bertolini (SISSA)
Gabriele Honecker (Mainz)
Enrico Pajer (Utrecht)
Diederik Roest (Groningen)
Sakura Schafer-Nameki (King's College London)

Topics and **Speakers** included

- Cosmology
  Paolo Creminelli (ICTP)
  Raphael Flauger (Carnegie Mellon)
  Liam McAllister (Cornell)
  Hiranya Peiris (UCL)
- Particle Physics
  Steve Abel (Durham)
  Matt Reece (Harvard)
  Giovanni Villadoro (ICTP)
- String Phenomenology
  Jim Halverson (KITP)
  Fernando Quevedo (Cambridge/ICTP)
  Roberto Valandro (ICTP)
  Irene Valenzuela (Madrid)
  Timo Weigand (Heidelberg)


METROPOLE
HOTEL

EPS
Historic Sites Award Ceremony

EPS Historic Sites **Award Ceremony**

Hotel Metropole

24 October 2015

At the initiative of Ernest Solvay, the Hotel Metropole hosted in 1911 the first Solvay Council dedicated to what soon would be called “The Theory of Radiation and the Quanta”. This was the first of a series of meetings, called “Solvay Conferences”.

The success of the meeting led Ernest Solvay, with the help of Hendrik Lorentz, to found the International Solvay Institutes. His legacy and interest has been taken up and continued by his family over the next five generations.

The Solvay family and the Fregat Commander Peter Degraer, Advisor to the Military Household of His Majesty the King.

The participants were 23 eminent scientists including Einstein, Kamerlingh Onnes, Lorentz, Nernst, Perrin, Planck, Rutherford, Curie, Sommerfeld and Wien. The insights and exchange of ideas between the participants laid the basis for modern quantum mechanics. The Council thus had a profound influence on the development of physics and chemistry in the twentieth century, in recognition of which the European Physical Society decided to bestow its Historic Site Award to Hotel Metropole.

The ceremony

Welcome addresses were presented by Mr. Freddy Thielemans, Honorary Mayor and representative of the present-day Mayor of Brussels, by Jef Ongena, President of BPS, Marc Henneaux, Director of the Solvay Institutes and by Jean-Marie Solvay as President of the Solvay Institutes and representing the Solvay family.

Christophe Rossel, President of EPS then portrayed EPS and the EPS Historic Site program.

The much appreciated keynote address was entitled ‘The First Solvay Council on Physics: Legend and Facts’, delivered by Franklin Lambert from Solvay Institutes and the Free University of Brussels (Vrije Universiteit Brussel – VUB).

The attendance included members of Belgian and European academic and political institutions. Guests of honour were the many descendants of participants to the historic Solvay Council: fourteen family members of the Nobel Laureates that were present in 1911, three descendants of Ernest Solvay, and Mr. Wielemans, heir to the family that founded this famous hotel.

A commemorating plaque was unveiled in the lobby of the Hotel by the president of EPS, Christophe Rossel, and the president of BPS, Jef Ongena, following an academic session attended by 80 participants.

Christophe Rossel and Jef Ongena, after unveiling of the EPS Historic Site plaque. It is now prominently located on top of the historic picture of the 1911 participants in the lobby of Hotel Metropole.

Partial reenactment of the historic picture of the first Solvay Council 1911.

***Seated** (L-R): Dieter Klingmüller [W. Nernst [4]], Ursula Klingmüller [W. Nernst [4]], Jean-Marie Solvay [E. Solvay [5]], Anna de Haas [H. Lorentz [4]], Yann Lapicque [J.-B. Perrin [4]], Françoise Chapuis [J.-B. Perrin [3]], Paul Siebertz [W. Wien [3]], Maria Rüchardt [W. Wien [3]], Pierre Joliot [M. Curie [3]].*

***Standing** (L-R): Florian Baier [A. Sommerfeld [4]], Monika Baier [A. Sommerfeld [3]], Nathalie Ferrard [A. Einstein [5]*], Mary Fowler [E. Rutherford [4]], Catherine Kamerlingh Onnes [4], Jeanne Kamerlingh Onnes [4]*

[3] *granddaughter or grandson*
[4] *great granddaughter or -grandson*
[5] *great great grandson*
[5]* *great great granddaughter of Caesar Koch, uncle of Albert Einstein.*

The celebration was complemented by the publication of a European Physical Journal Special Topic issue entitled “The Early Solvay Councils and the Advent of the Quantum Era” (EPJ ST, Vol. 224, Nr 10, September 2015), edited by Franklin Lambert, Frits Berends and Michael Eckert.

Seminars

Seminars

The list below gives the joint inter-university weekly seminars co-organized by the International Solvay Institutes and the research groups in theoretical and mathematical physics of the ULB, the VUB and the KU Leuven. It also gives the group seminars of the research team of the Director.

January

- *Torsion free structures for M-theory moduli spaces from exceptional generalized geometry*
  Carlos Shabazi (CEA Saclay)
- *Anomaly-induced effective action and Starobinsky model of inflation*
  Ilya Shapiro
- *Wilson loops in ABJM theory at two loops: framing factors and transcendentality*
  Gastón Giribet
- *Limits of conformal field theories*
  Stefan Fredenhagen
- *3^d Vasiliev theory at the second order*
  Pan Kessel

February

- *Warped Geometry and Minimal Warped Holography*
  Blaise Rollier
- *Superselection rule for the cosmological constant in three-dimensional spacetime*
  Alfredo Pérez
- *Quantum higher spins and AdS/CFT*
  Arkady A. Tsytlin (Imperial, UK)
- *Consistently violating the non-Gaussian consistency relation*
  Gonzalo A. Palma (U. Chile, Santiago)
- *Phase transition of five-dimensional Anti-de Sitter black holes*
  Gastón Giribet
- *Extremal chiral ring states in AdS/CFT are described by free fermions*
  David Berenstein (UC Santa Barbara, USA)
- *Ambitwistors and the Scattering Equations*
  David Skinner (Cambridge, UK)
- *The Thermal Scalar and Random Walks in Curved Spacetime*
  Thomas Mertens (UGent)
- *Unwinding Inflation and Brane Dynamics*
  Marjorie Schillo (KU Leuven)

March

- *Model building after LHC8*
  Diego Redigolo (LPTHE Paris)
- *Entwinement and the reconstruction of space*
  Vijay Balasubramanian (Pennsylvaina U., USA & VUB)
- *2^d SCFTs from 4d SCFTs and Their Gravity Duals*
  Marcos Crichigno (Utrecht)
- *Open String Field Theory and D-branes*
  Carlo Maccaferri
- *Supertubes, alive & kicking*
  Andrea Puhm
- *Mellin amplitudes: the scattering amplitudes of Conformal Field Theory*
  Joao Penedones (U. Porto, Portugal)
- *Higher spin extension of cosmological spacetimes in three dimensions: asymptotic symmetries and thermodynamics*
  David Tempo (ULB & CECs, Valdivia, Chile)

April

- *The Fate of Antibranes*
  Fridrik Gautason (KU Leuven)
- *Anisotropic Holographic Insulators and Homes' Relation*
  Rene Meyer (IPMU, Japan)
- *Expansion of Lie algebras and accidental symmetries in Lovelock theories*
  Nelson Merino
- *Three Dimensional Bigravity as a New Model for AdS/CFT Extensions*
  Andrés Goya
- *The consistency between the equivalence principle and gravitational time dilation: Do clocks really slow down?*
  Rob Scott
- *Exact correlation functions in 4d N = 2 SCFTs*
  Marco Baggio (ETH Zürich, Switzerland)
- *Higher spin dS/CFT*
  Arnaud Lepage-Jutier (ULB)
- *BPS black holes in 4d gauged supergravity*
  Kiril Hristov
- *Gauged supergravities: a window on (non) geometric string compactifications*
  Gianguido Dall'Agata (INFN Padova, Italy)
- *Universal Properties of Supersymmetric Partition Functions*
  Lorenzo de Pietro (Weizmann Institute, Israel)
- *de Sitter QFT and IR divergences from the perspective of the Wavefunction*
  Tarek Anous
- *A topologically twisted index for 3d SUSY gauge theories*
  Francesco Benini (Imperial, UK)
- *F-theory and the geometry of symmetries*
  Timon Weigand (U. Heidelberg, Germany)

May

- *Probing the chiral and deconfinement transition in a magnetic field using soft wall QCD models*
  David Dudal (UGent & KU Leuven)
- *Integrable λ-Deformations and AdS spacetimes*
  Dan Thompson (VUB & International Solvay Institutes)
- *Hunting SUSY at the LHC*
  Zach Marshall (LBNL, Berkeley)
- *Minimal unitary representations, AdS/CFT dualities and higher spin algebras and their deformations*
  Murat Guaydin (Penn State, USA)
- *Grassmannian Geometry of Scattering Amplitudes*
  Jaco Bourjaily (NBI, Copenhagen, Denmark)
- *Large spin systematics in CFT*
  Agnese Bissi (Oxford U.)

June

- *Hydrodynamics of p-wave superconductors*
  Raúl Arias

July

- *Three dimensional gravity with a conformally coupled scalar field: Chern-Simons-like formulation and black hole thermodynamics*
  Marcela Cárdenas

September

- *Complex linear Goldstino multiplet and supergravity*
  Sergei Kuzenko
- *External sources as a new approach to the integrability problem of surface charges*
  Cedric Troessaert

October

- *Our universe and de Sitter Supergravity*
  Renata Kallosh (Stanford University)
- *Disorder in AdS/CFT*
  Leopoldo Pando-Zayas (University of Michigan)
- *Extra-dimensional gravity: searching for solutions beyond GR*
  Jorge Ovalle
- *Topological defects in open string field theory*
  Martin Schnabl (AS CR, Prague)
- *Causality in Lovelock theories of gravity*
  Harvey Reall (University of Cambridge)
- *Supergravity and the cosmological constant*
  Eric Bergshoeff (University of Groningen)
- *Geometrical Actions for 3D Gravity*
  Patricio Salgado-Rebolledo
- *Number theory meets Higgs physics*
  Claude Duhr (UCL & CERN)
- *W infinity and affine Yangian*
  Tomas Prochazka
- *Geometry, Modularity and Entanglement in WCFT*
  Diego Hofman (University of Amsterdam)
- *Cold holographic matter and a color group-breaking instability*
  Javier Tarrio (ULB)

November

- *A quantum mechanical model for Holography*
  Troels Hamark (Niels Bohr Institute, Copenhagen)
- *Universal entanglement of singular surfaces*
  *Pablo Bue*no (KU Leuven)
- *3d Higher spins coupled to scalars*
  Pan Kessel
- Marco Astorino
- *Entanglement dynamics in 2d CFT*
  Alice Bernamonti (KU Leuven)
- *D-brane moduli stabilisation and large field inflation*
  Fernando Marchesano (Universidad Autónoma de Madrid)
- *Deformed N=8 supergravity from massive IIA and its Chern-Simons duals*
  Adolfo Guarino
- *Integrability and Exact results in N=2 gauge theory*
  Elli Ponomi (DESY and National Technical University of Athens)
- *Large Field Inflation - String Theory & Phenomenology*
  Alexander Westphal (DESY, Hamburg)

December

- *2d gravity with non-conformal matter and Mabuchi theory*
  Harold Erbin
- *Bulk quartic vertices from boundary four-point correlators*
  Xavier Bekaert (Tours)
- *SL(2) \times R^+ exceptional field theory and F-theory*
  Chris Blair (VUB)
- *Probe Branes with Kinks and Noise*
  Daniel Arean
- *Supersymmetric and Non-Supersymmetric Black Hole Microstates*
  David Turton (IPhT, Saclay)
- *Localization on twisted spheres and supersymmetric GLSM in 2d*
  Cyril Closset (SUNY Stony Brook)

Research

Research

These sections describe successively

- The research carried in the groups of Professors Marc Henneaux, Director, and Alexander Sevrin, Deputy-Director for Physics and Scientific Secretary of the International Scientific Committee for Physics (Research on Gravitation, Strings and Cosmology)

- The research carried in the group of Professor Anne De Wit, Scientific Secretary of the International Scientific Committee for Chemistry

- The research highlights of other scientists connected with the Institutes

Research on **Gravitation, Strings** and **Cosmology**

Groups of Professors

Marc Henneaux (ULB) and Alexander Sevrin (VUB)

Researchers

Permanent members

Riccardo Argurio (ULB)
Vijay Balasubramanian (10 % - VUB)
Glenn Barnich (ULB)
Andrès Collinucci (ULB)
Geoffrey Compère (ULB)
Ben Craps (VUB)
Stéphane Detournay (ULB)
François Englert (ULB, Honorary Member of the Institutes)
Oleg Evnin (10 % - VUB)
Frank Ferrari (ULB)
Marc Henneaux (ULB)
Axel Kleinschmidt (Max-Planck-Institute, Potsdam)
Alexander Sevrin (VUB)

Visiting professor

Gastón Giribet (Sabbatical, Buenos Aires)

Postdoctoral members

Jay Armas (ULB)
Chris Blair (VUB)
Andrea Campoleoni (ULB)
Eduardo Conde Pena (ULB)
Ignacio Cortese Mombelli (ULB)
Davide Forcella (ULB)
Simone Giacomelli (ULB)
Hernán González Leiva (ULB)
Jelle Hartong (ULB)
Michael Kay (ULB)
Alexey Koshelev (VUB)
Arnaud Lepage-Jutier (ULB)
Jiang Long (ULB)
Laura Lopez Honorez (10% assistant professor VUB)
Alberto Mariotti (10% assistant professor VUB)
Kentarou Mawatari (10% assistant professor VUB)
Andrea Mezzalira (ULB)
Christoffer Petersson (ULB)
Waldemar Schulgin (ULB)
Anastasios Taliotis (VUB)
Massimo Taronna (ULB)
David Tempo (ULB)
Daniel Thompson (10% assistant professor VUB)
Pantelis Tziveloglou (VUB)
Hongbao Zhang (VUB)

Graduate students

Dries Coone (VUB)
Karen De Causmaecker (VUB)
Tim De Jonckheere (VUB)
Saskia Demulder (VUB)
Laura Donnay (ULB)
Laure-Anne Douxchamps (ULB)
Sibylle Driezen (VUB)
Marco Fazzi (ULB)
Paolo Gregori (ULB)
Sergio Hörtner (ULB)
Victor Lekeu (ULB)
Amaury Leonard (ULB)
Jonathan Lindgren (ULB-VUB)
Vincent Luyten (VUB)
Pujian Mao (ULB)
Andrea Marzolla (ULB)
Daniel Naegels (ULB)
Kévin Nguyen (VUB)
Blagoje Oblak (ULB)
Roberto Oliveri (ULB)
Pablo Pais (ULB)
Arash Ranjbar (ULB)
Patricio Salgado Rebolledo (ULB)
Joris Vanhoof (VUB)
Matthias Vereecken (VUB)
Céline Zwikel (ULB)

Research summary

Of all the fundamental forces (electromagnetism, gravitation, weak and strong nuclear forces), gravity remains the most mysterious. In spite of its remarkable successes, Einstein's general theory of relativity, which has led to an unprecedented geometrization of physics, is an unfinished revolution. Fully unravelling the mysteries of the gravitational force is a long-term research goal.

The group has a long-standing interest and a demonstrated expertise in quantum gravity, quantum field theory, string theory and M-theory, black holes, cosmology, the cosmological constant problem ("dark energy") and the novel mathematical structures underlying these questions. These challenging areas raise many of the most profound issues in theoretical physics.

A central thread in the study of gravity and the fundamental interactions is the concept of symmetry (global and local). Some of the general background is given below.

General **framework**

The standard model of particle physics is based on quantum field theory, a framework that reconciles Poincaré invariance with quantum mechanics and allows one to understand the electromagnetic and the two types of nuclear interactions. The fourth fundamental interaction, gravitation, is described by Einstein's theory of general relativity. Experiments as well as theoretical arguments indicate that neither the standard model, nor general relativity can be complete.

Purely theoretical attempts at generalizations are constrained, of course, by mathematical consistency and the need to incorporate the previous theories in the domains where they have been successful. Additional guiding principles are needed, though. Symmetry is such a principle and pervades most of the research carried out in theoretical high energy physics.

The Yang-Mills type theories for the three microscopic forces of elementary particle physics are invariant under Poincaré symmetries, the symmetry group of flat space-time. These theories admit in addition certain internal symmetries known as gauge symmetries. In general relativity, gravitation arises when going from a flat to a curved spacetime, and Poincaré symmetries become part of the gauge group of diffeomorphisms.

In models that go beyond the existing theories, other symmetries come to the front.

(i) **Supersymmetry**

Supersymmetry is a natural extension of Poincaré symmetry in the presence of fermionic matter fields. One objective of the Large Hadron Collider at CERN in Geneva is to test supersymmetric extensions of the standard model.

Supersymmetry is also an important ingredient of string theory, a model for unification of the four fundamental interactions and for a microscopic formulation of gravity. At low energy, higher dimensional theories of gravitation emerge that include supersymmetry as part of their gauge group together with supersymmetric extensions of Yang-Mills gauge theories.

(ii) **Dualities**

One of the first theoretical extensions of Maxwell's theory of electromagnetism has been the inclusion of magnetic sources. The introduction of such sources is motivated by the desire to preserve invariance under duality rotations, a symmetry of the source-free equations. The solution that is dual to the Coulomb solution describing a static point-particle electron is a magnetic monopole. In some sense, black hole solutions in gravitational theories are the analog of the Coulomb solution to Maxwell's theory.

In nonlinear theories like Yang-Mills theories, dualities relate a strongly coupled regime to one at weak coupling, where standard perturbative computations may be performed. In supersymmetric situations, these dualities become tractable. Finally, dualities between different string theories as well as holographic duality between gauge and gravity theories feature prominently in most of the recent developments in string theory.

(iii) **Hidden symmetries**

Hidden symmetries in gravity and string theory arise in compactifications of supergravity theories and among the string duality groups. The algebraic structure of these symmetries is related to infinite-dimensional Lorentzian Kac-Moody algebras, in particular those of E_{10} and E_{11}.

Research carried out in **2015**

We have continued our research along the general directions outlined above. This has led to 124 published papers and preprints submitted for publication. These are listed on pages 146-155. Specific achievements by some researchers from the group are described in the subsequent pages.

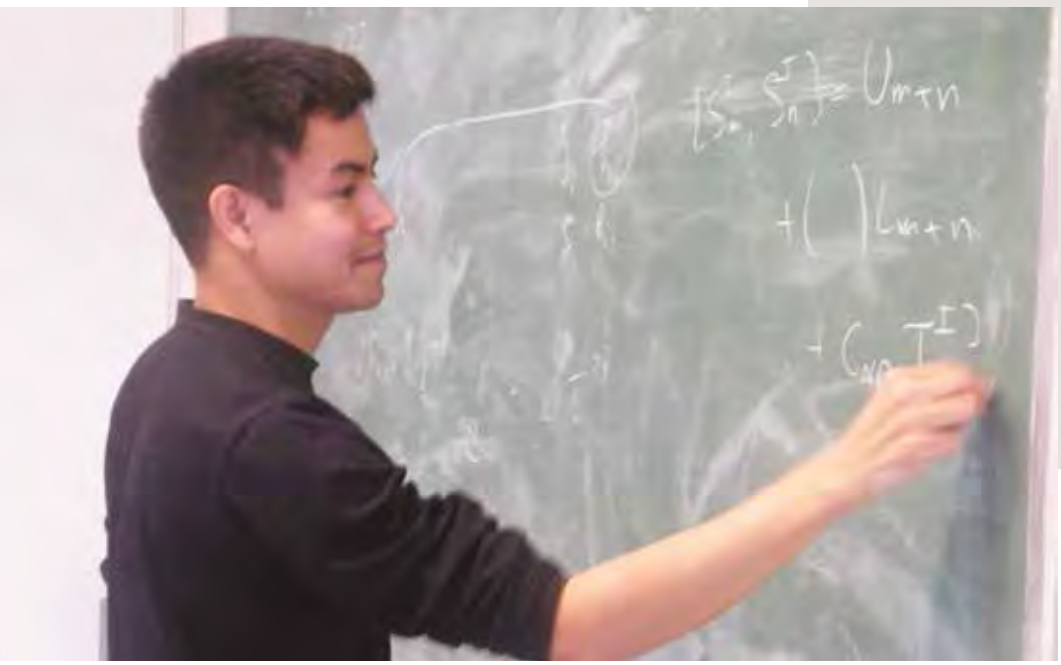
Support to the research of the director

The research of the director and of his group has benefited, as in the previous years, of gifts from the Solvay family. This support was extended by additional gifts from Messrs. Collen, de Selliers de Moranville and Thijssen. This generous support was precious to cover international collaborations as well as doctoral and postdoctoral grants to researchers. It is most gratefully acknowledged.

Researchers who directly benefited from this support

David **Tempo** (Marina Solvay Fellowship)

Thanks to a special gift of Mrs. Marina Solvay, the “Marina Solvay Fellowship” was created in 2012. The fellowship enables a brilliant young researcher to pursue his career as a postdoctoral fellow in the group of “physique théorique et mathématique” of the ULB.



Dr. David Tempo was the second holder of the Marina Solvay fellowhip, in 2015. He got his PhD degree at the University of Concepción (Chile) in 2010. After a postdoctoral stay at CECs (Valdivia), he joined the UBL group in October of 2014. His research focuses on different aspects of gravitation and higher energy physics with a special interest in those related with conserved charges in gravitation and the asymptotic structure of spacetime.

Lower dimensional gravity: a useful arena for developing new ideas and insights

The quantization of the gravitational field is one of the most challenging problems nowadays in theoretical physics. Although this problem has been unsolved for approximately one century, recently, as a way to go forward in the pursuit of a solution, more simple gravitational theories have been considered, so that they capture some of the fundamental features of the problem. In this sense, three-dimensional gravity has been shown to be a fruitful arena until now. In particular, this has been the source of numerous contributions in the understanding of the dynamics of spacetime, e.g. through the study of the asymptotic structure of spacetime, black holes and their thermodynamics.

During 2015, my main research interests have been focused on exploring the possible nontrivial effects of relaxing the asymptotic structure of spacetime on the canonical generators of the asymptotic symmetries, for some compelling theories of gravity in vacuum, and also coupled to matter fields in three-dimensions. The existence of black hole solutions in these gravity theories becomes a very unique playground to developing insight on the generic features of the gravitational interaction. In this context two different cases were widely studied and are briefly explained below:

Electrically charged **black holes**

The electrically charged black hole solution in the Einstein-Maxwell theory with negative cosmological constant in three spacetime dimensions can be considered as the natural analogue of the four dimensional Kerr-Newman-AdS black hole. This charged black hole then appears to be a more realistic object than the neutral one, since it possesses a curvature singularity at the origin (surrounded by an event horizon). However, it has been shown to exhibit somewhat pathological properties. Indeed, the energy is unbounded from below, and for a fixed value of the mass, the electric charge possesses no upper bound. These unusual properties seem to indicate that the solution might be unstable. Furthermore, if one takes into account that both, the black hole geometry and the Einstein-Maxwell Lagrangian are well behaved, this becomes a very puzzling situation.

This problem was addressed in collaboration with colleagues of CECs. Remarkably, in stark contrast with the somewhat known pathological behaviour for this standard case; it was found that for a certain class of holographic boundary conditions the energy spectrum of an electrically charged (rotating) black hole was nonnegative, and for a fixed value of the mass, the electric charge turned out to be bounded from above. Noteworthy, our approach also revealed that requiring preservation of the full conformal group singles out this very special set of boundary conditions; opening the possibility of studying holography along the lines of the AdS3/CFT2 correspondence as well as in context of holographic superconductors.

Black holes endowed with higher **spin fields**

The study of black holes solutions carrying higher spin charges has attracted in recent years a great deal of attention. However, although the causal structure is difficult to define given that the spacetime geometry associated with the metric is not invariant under the higher spin gauge transformations, it is still possible to define without ambiguity entropy, temperature and chemical potentials conjugate to the higher spin charges. In this context, a very special class of black holes (extremal black holes) appears to be those whose charges are such that lie precisely on the boundary of the allowed region where a sensible thermodynamics can be defined. In four dimensions this class of black holes has shown to possess exceptional features that, in supersymmetric theories, can often be related to the fact that they possess supersymmetry and saturate Bogomol'nyi bounds.

Searching for a simplest set up to digging more into the properties of extremal black holes in presence of higher-spin fields has led us to investigate the anti-de Sitter hypergravity in three dimensions. It was found that the hypersymmetric black holes turn out to be extreme, albeit not all extreme black holes are hypersymmetric. Indeed, these hypersymmetric black holes fulfil nonlinear bounds on the charges that follow from the asymptotic algebra. Therefore, hypersymmetry enables one to obtain interesting bounds on the charges, just as those in supersymmetry.

Waldemar **Schulgin** (Marina Solvay Fellowship)

Dr. Waldemar Schulgin was the first holder of the Marina Solvay fellowship.

He got his PhD degree in 2007 from the Ludwig Maximilian University in Munich (Germany). After a postdoctoral stay at the Ecole Normale Supérieure in Paris (France) from September 2007 through August 2009, he held a second postdoctoral position in the «Mitchell Institute for Fundamental Physics and Astronomy» (Texas A&M University, USA) from September 2009 though August 2012. He joined the ULB group in September 2012. His research work deals with string theory, quantum gravity and supergravity. A more detailed description of it can be found in the 2013 activity report.

Eduardo **Conde Pena**

Dr. Eduardo Conde Pena got his PhD degree at the University of Santiago de Compostela in 2012. He joined the ULB group in October of that same year. His area of investigation covers string theory and quantum gauge field theory.

Paolo **Gregori**

Paolo Gregori is doing research towards his PhD degree under the supervision of Frank Ferrari (ULB). He is working on quantum gravity, string theory and gauge theories.

Sergio **Hörtner**

Sergio Hörtner completed his PhD thesis in 2015 under the direction of Marc Henneaux (ULB). His work deals with higher spin gravity and duality. He currently holds a postdoctoral fellowship at the Centro de Estudios Científicos (Chile).

Arash **Ranjbar**

Arash Ranjbar is doing research towards his PhD degree under the supervision of Marc Henneaux (ULB). He is working on gauged supergravity models and string theory.

Research interests of some other members

Simone **Giacomelli**
Postdoctoral fellow ULB

Supersymmetric theories, **confinement** and **string** theory

A remarkable achievement of theoretical physics in the twentieth century is the description of particle interactions using field theory; a framework which unifies quantum mechanics and relativity. In this context one of the main problems in modern particle physics is confinement of quarks: a large class of particles called hadrons (such as protons and neutrons inside atomic nuclei) are known to be bound states of more elementary objects called quarks, which interact among each other via the so-called strong nuclear force. A special feature of these particles is the fact that they cannot be isolated: they are always "confined" into bound-states (the hadrons mentioned above) and these are the particles seen in accelerators such as the LHC.

This peculiar property of quarks seems to be a fundamental law of nature but, despite the overwhelming experimental evidence, we still do not have a clear explanation of this phenomenon. The reason is that we are currently unable to solve exactly the field theory describing quark interactions (QCD) and none of the known approximations can reliably explain the physical mechanism underlying confinement.

The solution to this problem then requires a better understanding of field theory and the approach I use to tackle this problem is to study a class of field theories similar to QCD but which are simpler to understand. These are the so-called supersymmetric gauge theories, in which the symmetries of the model powerfully constrain the structure of the theory and this considerably simplifies their analysis. A remarkable result of the 1990s in this sense is the proof of confinement in a special class of supersymmetric gauge theories (models with broken N=2 supersymmetry), which was achieved by recognizing that these models admit a rather simple algebraic description called Seiberg-Witten solution.

The purpose of my research so far has been to further develop this algebraic description of supersymmetric theories and elucidate the dynamical mechanisms underlying confinement in these models. The main tool I use in my investigations is string theory: in the last few years it proved particularly helpful to look for string theory realizations of supersymmetric theories, since string theory naturally leads to a simple geometric interpretation of their physical properties and suggests a mathematical framework for studying them.

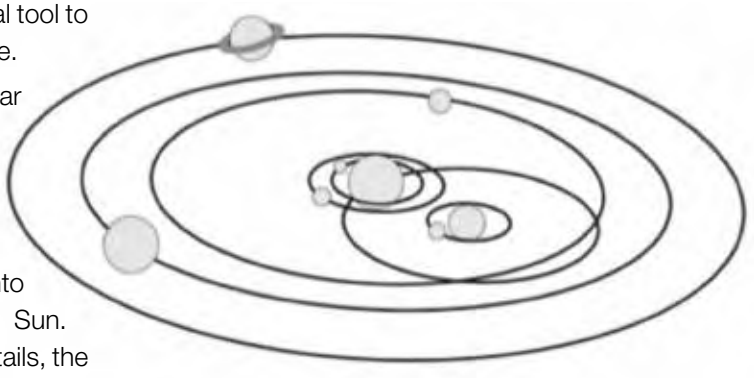
This interplay between field theory and string theory is actually helpful also to better understand string theory itself: the study of the vast landscape of string theory vacua involves solving geometric problems of overwhelming complexity, and in many cases the properties of these vacua remain elusive. A key aspect of the theory is the presence of extended objects called branes, which support on their worldvolume (the region of space they occupy) a field theory. The structure of the field theory depends on the specific string theory vacuum one is considering and by studying them, one can indirectly extract several information about the vacuum itself. I am currently exploring a class of string theory vacua from this perspective in collaboration with other members of the group at ULB.

Saskia **Demulder**

PhD Student VUB - Laureate of the 2015 Robert Brout Prize VUB

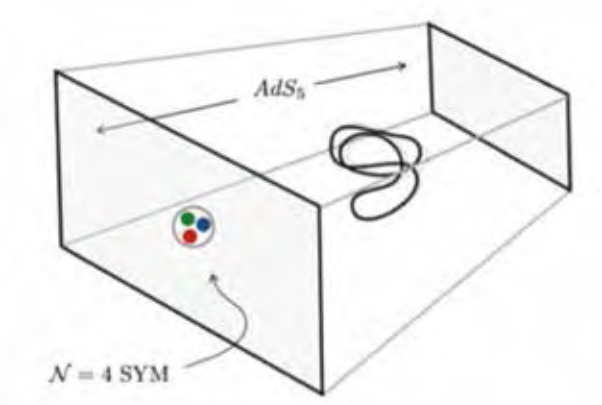
Symmetries are a guiding principle in physics, as they provide a tool to simplify complex problems. In some very particular cases, when the system is called integrable, one can even determine any physical quantity (e.g. the energy, masses of the particles, interaction amplitudes, etc.)! In general, however, physical systems are extremely complex and display far too little symmetry to be integrable. Fortunately, many physical system can be approximated by or build from integrable models. Understanding integrable systems and how they behave offers a crucial tool to understand the complexity of nature.

Maybe one of the most familiar examples is our own Solar System. The Solar System is populated by a realm of planets, asteroids, wandering satellites, etc., whose many-body interaction leads into a complicated dance around the Sun. Though extremely complex in its details, the motion of planets around the Sun follows regular patterns that can be predicted very accurately. The structure behind this choreography is a consequence of the integrability of the Kepler two-body problem.



The motion of two object orbiting each other is integrable and can be solved exactly. The two-body problem describes the motion of two point particles, interacting only with one another. The motions of planets can then be puzzled together as the gravitational pull can be neglected.

A cornerstone in modern theoretical physics is the so-called AdS/CFT correspondence. This correspondence relates a theory with gravity to one without gravity. In physics, it is not unusual that a physical system admits different, so-called dual, descriptions. A duality is a very useful tool as some solutions might be more accessible in one formulation than it is in the other. It gives a powerful connection between two fundamental frameworks of modern physics: string theory and gauge theory. How complex both theories might look, recently, signs of integrability were discovered within the so-called AdS/CFT correspondence. This discovery opened a complete new window to tackle and understand the AdS/CFT duality.



The AdS/CFT correspondence states a theory of gravity in five-dimensional anti-de Sitter space is dual a particular gauge theory define onto the boundary of AdS. The gauge theory, encodes exactly the same information: it is a "hologram" of the gravity theory in the higher dimensional bulk.

Integrable systems have been investigated since a long time in classical mechanics. However, understand when and how a quantum system — and contrast to a classical system — is integrable remains a challenge in theoretical physics. A rule of thumb when thinking about an integrable system is as a system with a very large number of symmetries. In fact, in systems with an infinite number of degrees of freedom, like a field theory or string theory, these symmetries form unfamiliar infinite-dimensional symmetry structures called quantum groups. The mathematical relations that are satisfied by this structure can be interpreted in very physical terms: any scattering in an integrable system — how complicated it might look— boils down to a successive scattering of two particles colliding together. For an integrable system the knowledge of a single object — the scattering matrix— is enough to understand how its particles collide!

A natural question is, given an integrable system, how much of its symmetry properties can we give up, while still retaining the property of integrability. Indeed the theories in the AdS/CFT correspondence are highly symmetrical. Unfortunately their symmetries (supersymmetry, conformal symmetry, …) are not seen directly in nature. Can we then deform the duality, giving up some of its symmetries, while preserving integrability?

A first approach, applied to the string theory side of the duality, is to deform the target space geometry in which the strings propagate. The second approach is by looking at the quantum group structure of the two-body scattering matrix, a.k.a. the S-matrix. The idea in this method is to 'twist' the symmetries respected by the S-matrix.

Together with Dan Thompson and Kostas Sfetsos, we looked at a distinguished deformation of an integrable string model and applied the deformation to the string side of the famous AdS/CFT correspondence. We provided evidence that the deformation can be realised at low energy. In the future we would like to understand how the deformation translates in the language of quantum group symmetries of the scattering matrix and ultimately complete the dictionary, unraveling how the deformation change the dual gauge theory.

Jonathan **Lindgren**
PhD student ULB-VUB

Strongly coupled physical systems, especially strongly coupled quantum field theories, are very difficult to study, and time dependence is especially difficult if not impossible to study using conventional methods. However, due to recent developments in string theory, it has been conjectured that some strongly coupled quantum field theories can be described by a gravitational theory in one higher dimension, thus reducing the quantum mechanical problem to solving classical equations. Since I joined the theoretical physics group at the VUB in 2013 as a PhD student, my research has been focused on using this conjecture to study time dynamics in strongly coupled field theories by looking at the corresponding gravitational system.

Holographic **thermalization**

The AdS/CFT correspondence, or holographic duality, has drastically changed how we think about quantum field theories and quantum gravity. According to this duality, (quantum) gravity in anti-de Sitter space could be dual to a conformal field theory living on the boundary of this spacetime. This is particularly useful since it is a so called strong/weak duality, meaning that weak coupling on the gravity side is dual to strong coupling on the field theory side, and vice versa. Although we can in principle try to learn something about non-perturbative quantum gravity by studying the dual conformal field theory, the duality has been mostly used in the opposite direction, namely using weakly coupled string theory to study strongly coupled conformal field theories. This is a very powerful technique since under certain circumstances, weakly coupled string theory reduces to classical gravity, and we can thus address the difficult problem of strongly coupled quantum field theories, by just studying classical gravity. This is often much simpler than doing non- perturbative calculations in strongly coupled systems.

In particular, black hole solutions on the gravity side are dual to quantum field theories at equilibrium at finite temperature. This allows us to relate questions about black holes to questions about thermal states in a quantum field theory. What I have been focusing on in my research is the process of thermalization, namely the dynamical process when a quantum field theory equilibrates into thermal equilibrium. For example, one can imagine starting with a field theory at zero temperature, and then perturb it with some short time perturbation. The system will then be thrown out of equilibrium, and then through some time dependent process it will typically equilibrate into a static state to which we can associate a temperature.

The dual picture on the gravity side is the formation of a black hole in anti-de Sitter space after a perturbation at the boundary. This is significantly more complicated than the static case, since it involves the time dependent Einstein equations, which is a system of non-linear partial differential equations and analytic solutions are scarce. In my research I have used various numerical and analytical tools to study such processes.

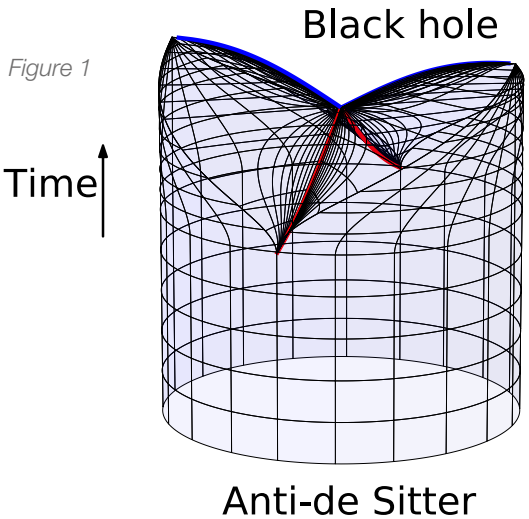
Confining field theories

Some quantum field theories enjoy a property called confinement. The most well known example is quantum chromodynamics (QCD), the theory of the strong interaction, where quarks can not be individually isolated, or in other words it is impossible to separate a quark-antiquark pair. According to the AdS/CFT correspondence, this property can be implemented in the gravity dual by a spacetime that is in some sense finite, and ends at some finite distance from the boundary. Together with my collaborators, we have used numerical methods to study time dependent perturbations in various confining holographic models, with the ultimate aim to say something about time dynamics in strongly coupled QCD. We found that if the energy of the perturbation is large enough, a black hole will form, and the field theory thermalizes. However, if the energy of the perturbation is small, a black hole does not form and the matter content just bounces around in the bulk spacetime. This is interesting from the field theory point of view, since it is dual to a system that never thermalizes but instead remains dynamic forever, which is not what one would usually expect after perturbing a quantum field theory. What these solutions really mean physically, and if they can be related to phenomena in real world systems such as the quark-gluon plasma, remains an interesting open question.

Gravity in **three dimensions**

The AdS3/CFT2 correspondence is one of the most successful examples of this duality, and relates gravity in three-dimensional anti de-Sitter space to physics in two-dimensional conformal field theories. Gravity in three dimensions is very special as it has no gravitational waves and the dynamics is thus much simpler, and the theory is locally trivial. However, there still exist solutions with interesting and non-trivial global properties, especially if some additional matter content is added. This property of three-dimensional gravity also allows us to use special techniques when constructing solutions, which do not work in higher dimensions. For instance, it is very easy to couple pointlike particles to three-dimensional gravity, as they can be defined as simple conical singularities. During 2015, I studied what can happen when massless pointlike particles, created at the boundary of anti-de Sitter space, collide with each other. It turns out that if the energy is large enough, a black hole can be formed. This had already been found earlier for the case of two particles *(Figure 1)* and I generalized this to an arbitrary number of particles. Via the AdS/CFT correspondence, this can be interpreted as a thermalization process in a two-dimensional conformal field theory after some localized perturbations. I also explored the possibility of constructing solutions of continuous matter that collapse into a black hole, by building the matter content using an infinite number of pointlike particles.

Figure 1



Appraisals and Prizes | Thesis defended in 2015

Appraisals and **Prizes**

Saskia Demulder (VUB) obtained an FWO "aspirant" fellowship, she was ranked first in the physics commission.

Saskia Demulder was awarded the 2015 Brout Prize by the Master of Physics and Astronomy Jury of the VUB and the International Solvay Institutes.

Professor Marc Henneaux (ULB) was awarded the 2015 F.R.S.-FNRS Quinquennial Prize (Prix Dr A. De Leeuw-Damry-Bourlart - Sciences exactes fondamentales).

Jonathan Lindgren, who is doing a joint VUB-ULB PhD, obtained an FWO "aspirant" fellowship.

Massimo Taronna (ULB) was awarded a prestigious "Chargé de Recherches" FNRS fellowship.

Thesis defended in **2015**

Sergio Hörtner (ULB) – "Investigations on electric-magnetic duality in gravity and higher spin theories" - 1 October 2015 (thesis advisor: Prof. Marc Henneaux).

Patricio Salgado Rebolledo (ULB) "Symplectic Structure of Constrained Systems: Gribov Ambiguity and Classical Duals for 3D Gravity" - 29 October 2015 (thesis advisor: Prof. Glenn Barnich).

Joris Vanhoof (VUB) "Holographic models of out-of-equilibrium systems" - 2 July 2015 (thesis advisor: Prof. Ben Craps).

Institutional Collaborations

Cooperation with Chile

The international collaboration with the Centro de Estudios Científicos (CECs, Valdivia, Chile), based on a collaboration agreement between the Institutes and the Center in Chile, was active in 2015.

Visits of Belgian Scientists to Chile

Prof. Glenn Barnich
7-18 December 2015

Prof. Marc Henneaux
30 March - 10 April 2015

Visits of Chilean Scientists to Belgium

Oscar Fuentealba
4 - 17 March 2015

Prof. Andrés Gomberoff
4 - 8 March 2015

Dr. Hernan Gonzalez Leiva (postdoctoral researcher)
1 January - 31 December 2015

Prof. Cristián Martínez
4 - 8 March 2015

Pablo Pais (PhD student)
1 January - 31 December 2015

Dr. Alfredo Pérez
31 January - 8 February 2015
16 September - 30 September 2015

Arash Ranjbar (PhD student)
1 January - 31 December 2015

Patricio Salgado Rebolledo (PhD student)
1 January - 30 September 2015

Dr. David Tempo (postdoctoral researcher)
1 January - 31 December 2015

Prof. Ricardo Troncoso
4 - 17 March 2015
10 September - 4 October 2015

Prof. Jorge Zanelli
4 - 8 March 2015

Joint Publications and preprints

G. Barnich, H. A. Gonzalez, A. Maloney and B. Oblak, "One-loop partition function of three-dimensional flat gravity," JHEP **1504** (2015) 178 - doi:10.1007/JHEP04(2015)178 [arXiv:1502.06185 [hep-th]].

G. Barnich, C. Troessaert, D. Tempo and R. Troncoso, "Asymptotically locally flat spacetimes and dynamical black flowers in three dimensions," arXiv:1512.05410 [hep-th].

G. Barnich, L. Donnay, J. Matulich and R. Troncoso, "Super-BMS3 invariant boundary theory from three-dimensional flat supergravity," arXiv:1510.08824 [hep-th].

M. Henneaux, A. Pérez, D. Tempo and R. Troncoso, "Hypersymmetry bounds and three-dimensional higher-spin black holes," JHEP **1508** (2015) 021 doi:10.1007/JHEP08(2015)021 [arXiv:1506.01847 [hep-th]].

M. Henneaux, A. Pérez, D. Tempo and R. Troncoso, "Extended anti-de Sitter Hypergravity in 2 + 1 Dimensions and Hypersymmetry Bounds," arXiv:1512.08603 [hep-th].

Cooperation with Russia

The international collaboration with the Lebedev Institute (Moscow, Russia), also based on a collaboration agreement, was active in 2015.

Joint publication

G. Barnich, X. Bekaert and M. Grigoriev,
"Notes on conformal invariance of gauge fields,"
J. Phys. **A 48** (2015) 50, 505402
doi:10.1088/1751-8113/48/50/505402
[arXiv:1506.00595 [hep-th]].

Talks at conferences, seminars and schools

January 28
Glenn Barnich
Holographic aspects of gravity in 4 and 3 dimensions
University of Milano I, Italy.

January 30
Geoffrey Compère
3d gravity and dual (warped) CFTs
Cambridge University, UK.

January 30
Karen De Causmaecker
Non minimal flavour violation in the squark sector
Vrije Universiteit Brussel, Belgium.

February 1- 6
Glenn Barnich
6 hours lecture course: Symmetries in gauge field theories
IPM School of Physics, Tehran, Iran.

February 3
Glenn Barnich
Holographic aspects of gravity in 4 and 3 dimensions
IPM School of Physics, Tehran, Iran.

February 9
Geoffrey Compère
Black holes of N=8 supergravity
Max Planck Institute, Potsdam-Golm, Germany.

February 10
Ben Craps
Analytic results on AdS (in)stability: conservation laws and missing secular terms
Oxford University, UK.

February 13
Kentarou Mawatari
Higgs characterisation: NLO+PS effects
Toyama University, Japan.

February 19
Christoffer Petersson
Neutron-antineutron oscillations as a probe of new physics
Workshop “NNbar at ESS”
Lund University, Sweden.

February 20
Marc Henneaux
Renormalization of Gauge Theories : a Fruitful Interplay between Physics and Mathematics
Joint Institute for Nuclear Research
Dubna, Russia.

February 24 - 26
Marc Henneaux
Topics in three-dimensional anti-de Sitter gravity
Verão Quântico 2015, João Pessoa
Brazil.

February 25
Glenn Barnich
Classical and quantum aspects of three-dimensional asymptotically flat gravity
Verão Quântico 2015, João Pessoa
Brazil.

March 5
Kentarou Mawatari
Simulation tools as a communication language among TH-PH-EXP
Ochanomizu University, Tokyo, Japan.

March 6
Blagoje Oblak
BMS Symmetry in Three Dimensions
ULB, Brussels, Belgium.

March 11
Blagoje Oblak
BMS Symmetry in Three Dimensions
ETH Zürich, Switzerland.

March 25
Kentarou Mawatari
Signals of a superlight gravitino at colliders
Kavli IPMU, Kashiwa, Japan.

March 27
Kentarou Mawatari
The Higgs characterisation project
Kavli IPMU, Kashiwa, Japan.

April 8
Riccardo Argurio
Holography and the dynamical breaking of supersymmetry
Galileo Galilei Institute, Firenze, Italy.

April 10
Hongbao Zhang
Holographic vortex pair annihilation in superfluid turbulence
Utrecht University, The Netherlands.

April 14
Jelle Hartong
Horava-Lifshitz Gravity from Dynamical Newton-Cartan Geometry
Florence, Italy.

April 15
Eduardo Conde Pena
Looking for an on-shell regulator
GGI, Florence, Italy.

April 15
Geoffrey Compère
Extension of Virasoro symmetries near extremal black hole horizons
Harvard, Cambridge, USA.

April 16
Geoffrey Compère
Extremal near-horizon symmetries and phase space
Harvard, Cambridge, USA.

April 16
Waldemar Schulgin
Liouville theory beyond the cosmological horizon
École Normale Supérieure, Paris, France.

April 16
Ben Craps
Holographic thermalization and AdS (in)stability
Gauge/Gravity Duality 2015
Galileo Galilei Institute, Firenze, Italy.

May 4
Kentarou Mawatari
Higgs characterisation at NLO in QCD
University of Pittsburgh, USA.

May 4
Marc Henneaux
Cosmological billiards, E(10) and hidden symmetries of gravity
Simons Center for Geometry and Physics, Stony Brook, USA.

May 7
Blagoje Oblak
BMS Symmetry inThree Dimensions
TUWien, Austria.

May 7- 8
Andrea Campoleoni
Higher-spin gauge theories in three dimensions
Introductory School on String Field Theory and Higher Spin Theory
Sichuan University, Chengdu, China.

May 11
Laura Donnay
Holographic entropy for warped AdS3 black holes
Max Planck Institute (Albert Einstein Institute), Potsdam, Germany.

May 11
Jelle Hartong
Life on the Boundary of a Lifshitz Space-Time
Lisbon, Portugal.

May 13
Alberto Mariotti
The state of SUSY after LHC8
Belgian Physical Society Meeting
University of Liège, Belgium.

May 15
Andrea Campoleoni
Asymptotic symmetries of higher-spin gauge theories: the metric approach
VII International Conference on String Field Theory and Related Aspects
Sichuan University, Chengdu, China.

May 19
Frank Ferrari
Holography, Probe Branes and Isoperimetric Inequalities
University of Crete, Heraklion, Greece.

May 20
Laura Lopez Honorez
Dark Matter & Cosmology
Cospa meeting, Mons, Belgium.

May 21
Jelle Hartong
Life on the Boundary of a Lifshitz Space-Time
Gothenburg, Sweden.

May 21
Tim De Jonckheere
Renormalization group and weak field collapse in planar AdS
Oostende, Belgium.

May 21
Saskia Demulder
Deformations and integrability
Oostende, Belgium.

May 22
Alberto Mariotti
Signs of tops from highly mixed stops
Theory@Sea meeting 2015, Ostende, Belgium.

May 26
Jelle Hartong
The Many Uses of Newton-Cartan Geometry
Copenhagen, Denmark.

May 27
Alberto Mariotti
Signs of tops from highly mixed stops
Planck 2015 Conference, Ioannina, Greece.

May 28
Eduardo Conde Pena
Double soft limits from asymptotic symmetries
University of Salamanca, Spain.

May 28
Ben Craps
Holographic thermalization and AdS (in) stability
International Workshop on Condensed Matter Physics and AdS/CFT
Kavli IPMU, Kashiwa, Japan.

June 1
Kentarou Mawatari
DM simplified models at NLO
CERN, Geneva, Switzerland.

June 2
Hongbao Zhang
Holographic vortex pair annihilation in superfluid turbulence
Kavli IPMU, Tokyo, Japan.

June 4
Glenn Barnich
The quantum Coulomb solution. A physical toy model for black hole microstates
University of Mons, Belgium.

June 4
Marc Henneaux
From the BKL analysis to hyperbolic Coxeter groups
University of Mons, Belgium.

June 4
Alexander Sevrin
Physics in low dimensions
University of Mons, Belgium.

June 11
Andrès Collinucci
Probing T-branes with 3d mirror symmetry
Universidad Autónoma de Madrid, Spain.

June 12
Frank Ferrari
Holography, Probe Branes and Isoperimetric Inequalities
Simons Center for Geometry and Physics, Stony Brook, USA.

June 18
Frank Ferrari
Bose-Einstein Condensation, Irreversibility, Large N and Quantum Black Holes
Simons Center for Geometry and Physics, Stony Brook, USA.

June 22
Daniel Thompson
On two parameter deformations
"η and λ Deformations in Integrable Systems and Supergravity" Meeting
Bern, Switzerland.

June 23
Laura Lopez Honorez
Scalar DM from minimal to composite scenarios
Invisibles 2015 workshop, Madrid, Spain.

June 24
Andrea Campoleoni
Higher-spin gauge theories in three dimensions
Utrecht University, The Netherlands.

July 3
Hernán González
Boundary Gravitons in Three Dimensional Flat Gravity
8th Aegean Summer School in Gravitational waves
Rethymno, Greece.

July 13
Geoffrey Compère
Generalized Virasoro symmetries near extremal black hole horizons
Marcel Grossman Meeting Sapienza, Rome, Italy.

July 14
Alberto Mariotti
On Neutral Naturalness
IPPP Durham University, UK.

July 14
Eduardo Conde Pena
Gossip session on 5d gauge theories
ICTP, Trieste, Italy.

July 23
Christoffer Petersson
Proposing a new LHC search for light compressed stop squarks
Conference "EPS-HEP 2015"
Vienna University, Austria.

July 24
Jonathan Lindgren
Holographic thermalization in the AdS soliton
KITPC at the Chinese Academy of Sciences, Beijing, China.

July 31
Hongbao Zhang
Numerical Holography
KISTI and KAIST(International School on Numerical Relativity and Gravitational Waves), Daejeon, Korea.

August 7
Jonathan Lindgren
Holographic thermalization in confining holographic models
Fudan University, Shanghai, China.

August 12
Glenn Barnich
Classical and quantum aspects of 3d asymptotically flat gravity at null infinity
ICISE, Quy Nhon, Vietnam.

August 20
Marc Henneaux
Constrained Hamiltonian Systems and BRST Symmetry
International Max Planck Research School, Potsdam, Germany.

August 29
Andrea Campoleoni
Higher spin charges in any space-time dimension
Workshop on Higher Spin Theories
Penn State University, USA.

September 3
Alberto Mariotti
Goldstini and the Z-peaked ATLAS excess
GGI - Gearing up for LHC13 workshop
Florence, Italy.

September 4
Marc Henneaux
Hamiltonian formalism for gauge systems and manifestly duality symmetric actions
Universitat de Barcelona, Spain.

September 7
Ben Craps
AdS (in)stability: an analytic approach
The String Theory Universe,
21st European String Workshop
and 3rd COST MP1210 Meeting
KU Leuven, Belgium.

September 8
Daniel Thompson
Generalised T-duality and Integrable deformations
The String Theory Universe,
21st European string workshop
and 3rd COST MP1210 meeting
KU Leuven, Belgium.

September 9 - 12
Frank Ferrari
4D N=1 Super Yang-Mills Theories
Asia Pacific Center for Theoretical
Physics, Pohang, South Korea.

September 10
Andrea Campoleoni
Higher spins in three dimensions
21st European Workshop
on String Theory
KU Leuven, Belgium.

September 11
Marco Fazzi
Supersymmetric AdS5 solutions of massive IIA
KU Leuven, Belgium.

September 12
Frank Ferrari
Black Hole Horizons and Bose-Einstein Condensation
Asia Pacific Center for Theoretical
Physics, Pohang, South Korea.

September 15
Glenn Barnich
Holographic aspects of gravity in 4 and 3 dimensions
University of Southampton, UK.

September 15
Pablo Pais
Some properties of strained graphene
Charles University, Prague, Czech
Republic.

September 23
Jelle Hartong
Holographic Reconstruction of 3D Flat Space-Time from Null Infinity
Stony Brook, USA.

September 23
Karen De Causmaecker
General squark flavour mixing: constraints, phenomenology and benchmarks
Vrije Universiteit Brussel, Belgium.

September 23
Matthias Vereecken
Z-peaked excess
Vrije Universiteit Brussel, Belgium.

September 24
Geoffrey Compère
Symmetries of extremal black holes
Institut Louis Pasteur, Paris, France.

September 24
Alberto Mariotti
SUSY after LHC8 and the Z-peaked ATLAS excess
University of Milano, Italy.

October 5
Geoffrey Compère
Wiggles of Extremal Black Holes
Nordita, Stockholm, Sweden.

October 10
Alberto Mariotti
Goldstini and the Z-peaked ATLAS excess
CERN, Geneva, Switzerland.

October 14
Ben Craps
Snaartheorie
Quetelet lecture (honors program)
Ghent University, Belgium.

October 21
Stephane Detournay
Bekenstein-Hawking Entropy from Non-Conformal Field Theories
Milan University, Italy.

October 22
Laura Donnay
Supersymmetric extension of the BMS algebra
University of Mons (PandA Doctoral School Day), Belgium.

October 23
Jelle Hartong
Holographic Reconstruction of 3D Flat Space-Time from Null Infinity
Gothenburg, Sweden.

October 23
Laura Lopez Honorez
Scalar DM with t-channel fermionic mediator
IPMU, Kashiwanoha, Japan.

October 26
Laura Lopez Honorez
Scalar DM with t-channel fermionic mediator
TeVPa 2015 conference, Kashiwanoha Japan.

October 30
Karen De Causmaecker
The Pheno Group
Vrije Universiteit Brussel, Belgium.

November 4
Alberto Mariotti
Goldstini and the Z-peaked ATLAS excess
SISSA, Trieste, Italy.

November 5
Andrea Campoleoni
Partition functions of higher spin fields in flat space
Workshop on Higher Spin Gauge Theories
Nanyang Technological University
Singapore.

November 6
Blagoje Oblak
BMS Symmetry in Three Dimensions
University of Cambridge, UK.

November 6
Marc Henneaux
Hypersymmetry bounds and three-dimensional higher spin black holes
Institute for Advanced Studies
Singapore.

November 10
Geoffrey Compère
Wiggles of Extremal Black Holes
UvA, Amsterdam, The Netherlands.

November 15
Marc Henneaux
Hypersymmetric black holes in 2+1 gravity
ETH Zürich, Switzerland.

November 18
Glenn Barnich
Holographic aspects of gravity in 4 and 3 dimensions
University of Bourgogne, Dijon, France.

November 18
Simone Giacomelli
Superconformal theories from M5 branes
University of Uppsala, Sweden.

November 20
Andrea Campoleoni
Higher spin gauge theories: a glimpse into quantum gravity?
Renato Musto Award presentation ceremony
U. Federico II of Naples, Italy.

November 20
Kentarou Mawatari
Dark matter search at the LHC
CFHEP/CAS, Beijing, China.

November 24
Marco Fazzi
Supersymmetric AdS5 solutions of massive IIA
UCSB, Santa Barbara, USA.

November 26
Christoffer Petersson
An exotic Higgs decay and a diboson excess
Lund University, Sweden.

November 27
Stephane Detournay
Asymptotic Symmetries, Bekenstein-Hawking Entropy and Two-Dimensional Field Theories
11th Vienna Central European Seminar on Particle Physics and Quantum Field Theory, Vienna, Austria.

November 30
Christoffer Petersson
Explaining the ATLAS diboson excess with supersymmetry
Conference “Partikeldagarna 2015”
Uppsala University, Sweden.

December 1
Ben Craps
Snaartheorie, zwarte gaten en kosmologie
Elcker-ik, Antwerp, Belgium.

December 3
Glenn Barnich
Finite BMS transformations
Université Libre de Bruxelles, Belgium.

December 3
Andrea Marzolla
On holographic Goldstone bosons
Université Libre de Bruxelles, Belgium.

December 3
Amaury Leonard
Higher spin conformal geometry and prepotentials
Université Libre de Bruxelles, Belgium.

December 4
Marc Henneaux
The power of cohomology: the role of the antifields in BRST theory
CERN, Geneva, Switzerland.

December 7 - 18
Glenn Barnich
3d gravity as group theory
Universidad Andrés Bello, Quintay, Chile.

December 7 - 18
Glenn Barnich
Finite BMS transformations
Universidad Andrés Bello, Quintay, Chile.

December 8
Blagoje Oblak
BMS Symmetry in Three Dimensions
Perimeter Institute for theoretical physics, Waterloo, Canada.

December 10
Geoffrey Compère
Wiggles of Extremal Black Holes
Queen Mary, London, UK.

December 15
Marco Fazzi
Supersymmetric AdS5 solutions of massive IIA
Columbia University, New York City USA.

December 15
Ben Craps
AdS (in)stability: an analytic approach
University of Amsterdam
The Netherlands.

December 17
Alberto Mariotti
SUSY after LHC8
University of Groningen
The Netherlands.

December 17
Marc Henneaux
SO(2) electric-magnetic duality for higher spin gauge fields
Meeting "Miami 2015 ", Fort Lauderdale USA.

December 18
Sergio Hörtner
Electric-magnetic duality in gravity and higher spin theory
UNAB, Quintay, Chile.

December 18
Kentarou Mawatari
Dark matter study in the FeynRules/ MadGraph5_aMC@NLO framework
Yukawa Institute, Kyoto, Japan.

List of Publications

[1] H. Afshar, A. Bagchi, S. Detournay, D. Grumiller, S. Prohazka and M. Riegler, "Holographic Chern-Simons Theories," Lect. Notes Phys. 892 (2015) 311 [arXiv:1404.1919 [hep-th]].

[2] P. D. Alvarez, P. Pais, E. Rodrguez, P. Salgado-Rebolledo and J. Zanelli, "Supersymmetric 3D model for gravity with S U (2) gauge symmetry, mass generation and effective cosmological constant," Class. Quant. Grav. 32 (2015) 17, 175014 doi:10.1088/0264-9381/32/17/175014 [arXiv:1505.03834 [hep-th]].

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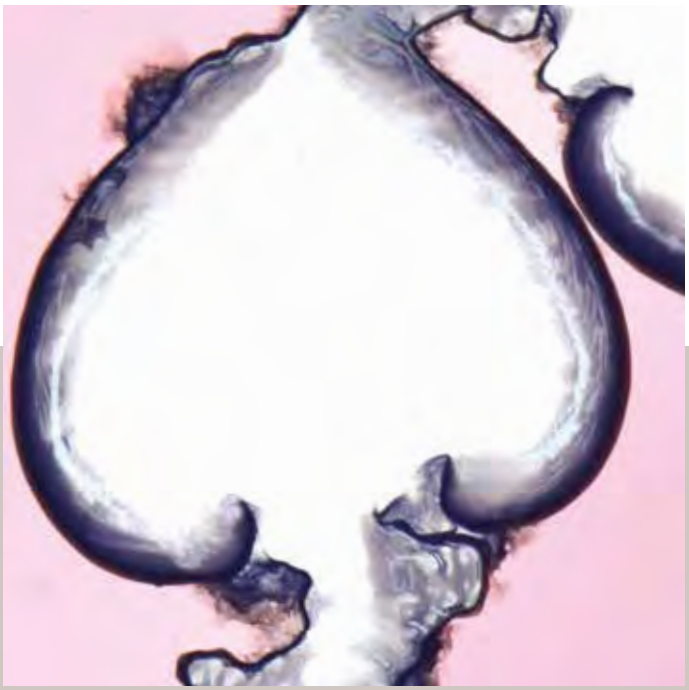


Research in **Chemistry** carried out in the group of

Professor Anne De Wit (ULB)

Researchers

Permanent members

Anne De Wit
Yannick De Decker
Laurence Rongy

Postdoctoral members

Igal Berenstein
Fabian Brau
Jorge Carballido-Landeira
Shyam Gopalakrishnan
Patrick Grosfils
Ceri Middleton
Gabor Schuszter
Priyanka Shukla
Aurore Woller

PhD students

Domenico Bullara
Jean-François Derivaux
Alexis Grau Ribes
Lorena Lemaigre
Vanessa Loodts
Rachel Lucena
Carelle Thomas
Reda Tiani
Valérie Voorsluijs

Master students

Alexia Papageorgiou
Thea Gutmacher

Research summary Non linear Physical Chemistry Unit

The research activities in the NLPC unit focus on combined experimental and theoretical studies of spatio-temporal dynamics resulting from reactions coupled to transport processes (diffusion, convection), phase transitions or non idealities. Our interdisciplinary research is developed at the boundaries between Chemistry, Physics, Engineering and Environmental Sciences.

*Specifically, **Anne De Wit** and **Laurence Rongy**'s objective is to analyse and characterise the dynamics of chemical species, pattern formation and reaction-diffusion-convection instabilities in out-of-equilibrium systems. The 2015 highlights of our research have been obtained in various applications:*

Chemical fronts in **microgravity**

CDIC3 experiment on the Maser 13 sounding rocket flight of ESA.

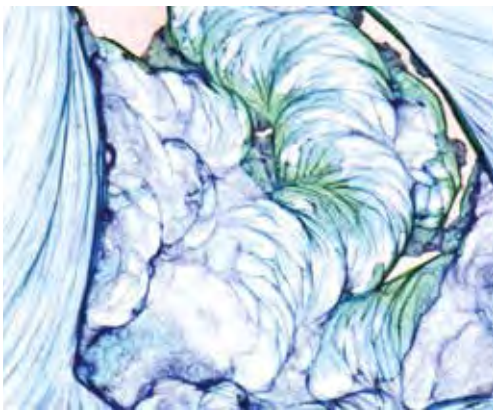
In the framework of a European Space Agency network focusing on chemo-hydrodynamic instabilities, we have been the Belgian partner modeling an experiment embarked on the Maser 13 Sounding Rocket Flight in December 2015. This experiment has shown that surface-tension effects can convectively deform traveling autocatalytic fronts in a different way than buoyancy does on earth.

Convective dissolution of CO_2

We have demonstrated both experimentally and theoretically that chemical reactions can either enhance or stabilize convective dissolution occurring when CO_2 dissolves in saline aquifers in CO_2 sequestration techniques.

Precipitation patterns

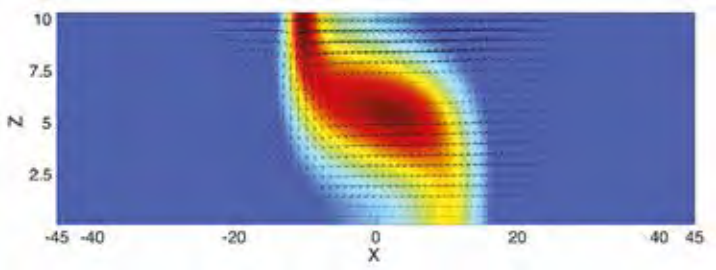
Beautiful precipitation structures can be obtained experimentally in flow conditions in a confined geometry when a solution of a reactant is injected into the solution of another one to yield a solid product. We have shown that a wealth of various patterns can be obtained depending on concentrations of reactants and injection flow rate. Applications range from CO_2 mineralisation to flow controlled material synthesis.



Precipitation patterns

Bimolecular reactions **A + B →C**

When the two reactants A and B are brought into contact, a reaction front is formed and the spatially localized zone where the reaction occurs evolves in time due to the interdiffusion of A and B. Due to changes in density or surface tension induced by the reaction, convective flows can be triggered. Their nature depends on whether they are driven by density changes (buoyancy-driven flows) or by surface tension (Marangoni flows). We have theoretically compared the characteristics of each flow induced around such reaction fronts.



Deformation of a reaction zone (red) by chemically-driven Marangoni flows. The product has a larger surface tension than both reactants inducing two counter-rotating vortices around the chemical front.

Modelling the **spatio-temporal dynamics** of extracellular microRNAs

Recent experimental investigations have shown that microRNAs (miRNAs) could play a role in cell-to-cell communication, through their functional delivery to neighbouring or distant cells via exosomes. We are currently developing models to study the impact of miRNAs highly expressed in a cell on the expression of target proteins in the neighbouring cells. Our models consider transport mechanisms coupled to the highly non linear kinetic terms describing biological regulations (positive and negative feedback loops).

***Yannick De Decker**'s research aims at developing a self-coherent, multiscale theoretical understanding of the dynamics of non-equilibrium chemical systems. To connect the complexity of the microscopic world to phenomena observed at larger scales, we rely among others on the theory of stochastic processes. This approach leads to an extension of the traditional thermodynamics and kinetics of reactive systems which, in their amended form, can be applied to model complex dynamical behaviors at very small scales. In 2015, we used it to analyze several important problems:*

Non-equilibrium **thermodynamics** of small systems

Thermodynamics is one of the founding pillars of macroscopic physics. Its stochastic extension to small scale systems would represent a major step for emerging technologies, such as nanochemistry. Last year, we proposed a new theory, the extended local equilibrium, whose objective is to bridge the macroscopic and the stochastic thermodynamics of non-equilibrium systems. Several important predictions have been made concerning the fluctuations of thermodynamic quantities of interest such as entropy production. Our next objective will be to confirm these results experimentally.

Non-linear processes in spatially constrained systems

When non-linear processes take place in small and spatially confined systems, specific fluctuation- or confinement-induced phenomena can arise. We showed that these effects can explain how biological cells self-organize on the skin of zebrafish to form regular colored patterns, despite the fact that they can barely move (*see Fig. 1*). We also investigated how fluctuations can affect the kinetics of the well-known oscillating chemical reaction, the Belousov-Zhabotinsky process, when such system is run in very small reactors like those found in microfluidics.

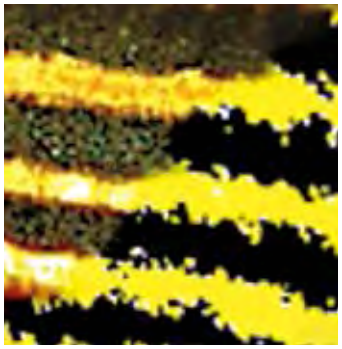


Fig 1: Real-life cellular pattern (left-hand side) and stochastic prediction (right-hand side) of stripes found on the skin of zebrafish.

Robustness of chemical nanodynamics

Regular temporal oscillations of a system's composition have been reported repeatedly for non-equilibrium reactions. They have been observed in systems as small as single biological cells or in atomic microscopy experiments. The theory of stochastic processes predicts that in such case, fluctuations strongly modify the period and the amplitude of oscillations. We analyzed the results of oscillations observed at the nanometer level during the NO_2+H_2 reaction on platinum to confirm that these effects indeed exist. These analyses provided the first experimental evidence of the validity of stochastic approaches to nanoscale chemical reactions. We showed among others that the fluctuation-induced changes of the period follow, as predicted, a universal scaling law.

Research Interests of some other members

Vanessa Loodts

PhD student, F.R.S.-FNRS Research Fellow

Carelle Thomas

PhD student, F.R.S.-FNRS PDR "FORECAST" contract

Our research objective is to understand the impact of the coupling between chemistry and hydrodynamics during the convective dissolution of carbon dioxide (CO_2) that occurs upon CO_2 injection in geological formations.

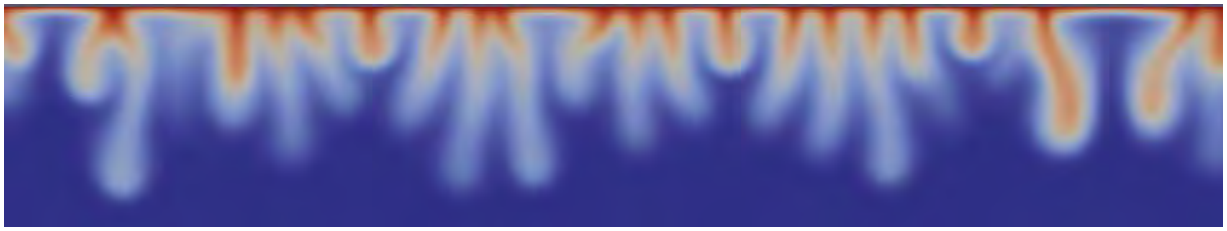
Within the global context of climate change, CO_2 sequestration into deep saline aquifers is one of the technologies developed to tackle the accumulation of anthropogenic CO_2 in the atmosphere. Upon injection of CO_2 into these porous geological formations, the less dense CO_2 rises above the aqueous phase, spreads laterally under an upper impermeable cap rock and starts to dissolve into the underlying brine. The dissolution of CO_2 into deep saline aquifers leads naturally to a buoyantly unstable stratification of denser CO_2-enriched brine on top of less dense pure brine, which can give rise to buoyancy-driven convective mixing in the brine. Less dense fluid tends to float up towards the surface while denser fluid sinks downwards in the form of fingers (*Fig.1*). This hydrodynamic instability is a favorable process for CO_2 sequestration as it accelerates the mixing of dissolved CO_2 into the aqueous phase and therefore enhances the safety of the storage in the saline aquifer (by reducing the risks of leaks of CO_2 to the atmosphere).

Vanessa Loodts

Carelle Thomas

Figure 1:

Simulation of the convective dissolution of CO_2 into brine: showing the density of the lower aqueous phase. CO_2 invades the host solution from the top boundary. The denser fluid, colored here in red, sinks into the less dense fluid in blue.



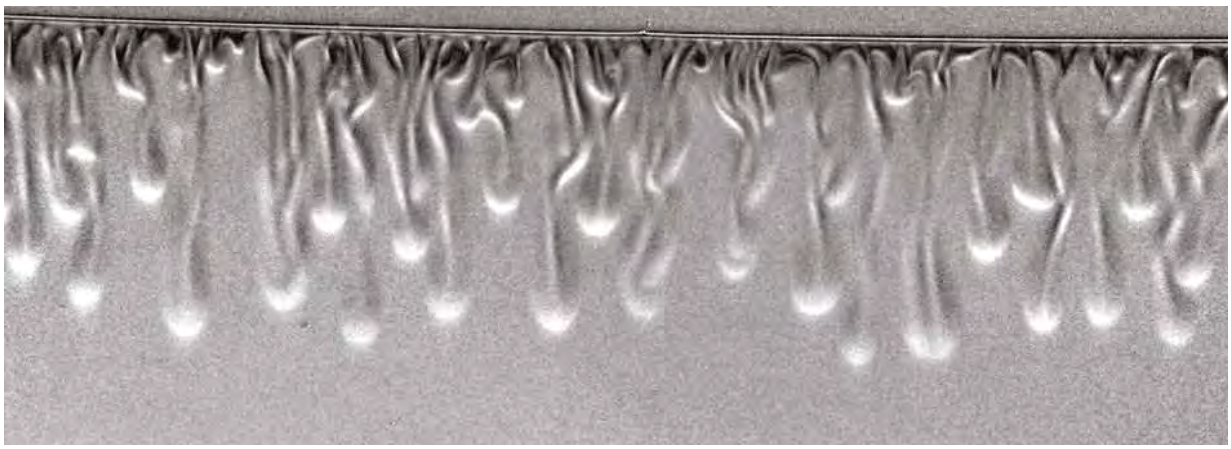


Figure 2 :

Experimental snapshot showing the fingering instability developing when gaseous CO_2 dissolves in a basic aqueous solution of KOH (0.05 M) in a vertical Hele-Shaw cell. The field of view is 11.9 cm × 4.5 cm.

A variety of geochemical reactions may occur between dissolved acidic CO_2 and the reactants dissolved in the brine. These reactions can modify the density profile in the aqueous phase, and thereby the unstable density gradient that triggers convective motions in the brine. The impact of these reactive processes on the transport of CO_2 in the reservoir is, however, poorly understood.

In this context, our goal is to investigate the influence of chemical reactions on the characteristics of the buoyancy-driven instability induced by CO_2 dissolution in reactive aqueous solutions, by means of combined experimental, theoretical and numerical approaches.

Experiments are performed by Carelle Thomas in quasi-bidimensional systems, typically in Hele-Shaw cells made of two transparent glass plates separated by a small gap. Pure gaseous CO_2 is injected through the top of the cell at atmospheric pressure and flows above aqueous solutions containing various chemical reactants. Dynamics occurring within the transparent fluids are visualized with the help of a schlieren technique, which tracks dynamical changes in refractive index related to density gradients in the solutions (*Fig.2*).

The reaction of CO_2 with alkali bases in aqueous solutions accelerates the growth of the fingering.

Theory and numerical simulations performed by Vanessa Loodts show that more generally reactions can accelerate or slow down the development of convection, depending on the parameters of the problem, and especially the relative contributions to density of the reactants and the product. Reactions can even be at the origin of buoyancy-driven convection in cases where the density stratification in the non reactive case is stable.

Domenico Bullara

PhD student at the ULB

Reactions can be imagined as sets of rules which dictate how the different units of a system can interact, combine and transform into different ones. Thermodynamics and kinetics very well define the nature of these rules for most classical chemical systems, but they hold on the idea that the reactive units are tiny atoms and molecules, whose internal volume can be neglected. When the reactive units consists of large macromolecules or even entire cells confined in limited spaces, this approximation does not hold true anymore, and one needs to develop a new set of theoretical tools.

My PhD studies at the ULB focused on a theoretical understanding of how spatial constraints can affect reactive processes in chemistry and cell biology. My studies showed that spatial constraints are sometimes able to produce unique phenomena, by promoting a struggle between the reactive units for the limited space. This can on one side facilitate or inhibit certain reactive pathways, and on the other side prevent an efficient mixing of the units or reduce their motion. These concepts proved central in solving one of the most debated questions in developmental biology of the last decade: the skin patterning of zebrafish.

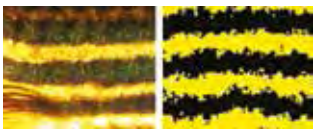


Figure 1: Comparison between a photo of the skin patterns on the zebrafish trunk (left) [Source: http://www.wikipedia.org] and a computational striped pattern generated through differential growth (right). The computational pattern has been generated through stochastic simulations of a minimal model, which has been deduced from the experimental observations on the zebrafish pattern reported in the literature.

The zebrafish is a small animal named after the striped pattern on its skin, constituted by a discrete assembly of black and yellow pigment cells. The wavelength of these patterns is intrinsic and it is recovered even after partial or full ablation (and subsequent re-formation) of the pattern. This is typical of Turing patterns generated by reaction-diffusion, but experimental evidences rule out such a mechanism for two reasons. First because the pigment cells constituting the pattern do not diffuse across the fish skin – they are practically motionless due to the spatial constraint represented by the skin tissue. And second because the reaction network among the cells differ from a typical chemical scheme in consisting of nonlocal contact-mediated interactions: these can affect the cellular growth rates, by promoting the birth or death of cells at each position in the skin depending on the near and far surrounding cells.

The combination of these two effects can – under certain conditions – induce a nontrivial redistribution of the cell populations in space, despite the single cells being immobile. This previously unknown mechanism – which I named differential growth – despite being qualitatively different from a reaction-diffusion mechanism, can nevertheless generate stationary patterns of intrinsic wavelength via a Turing instability, which closely resemble the experimental motifs (*Fig. 1*).

Appraisals and Prizes | Thesis defended in 2015

Appraisals and **Prizes**

Domenico Bullara was awarded the Prix Hector Lepouse for his PhD thesis.

Jean-François Derivaux received a FRIA PhD fellowship and the AScBr Prize for his Master thesis.

Anne De Wit

- Fellow of the American Physical Society "for pioneering contributions to our understanding of the coupling between chemical reaction, hydrodynamics, and pattern formation driven by coupled reacting-hydrodynamic systems.";
- Member of the Editorial Advisory Board of the Journal Physics of Fluids;
- has obtained a Prodex research grant as well as a BELSPO postdoctoral fellowship.

Laurence Rongy has obtained an ARC consolidator research grant as well as a MIS grant from FRS-FNRS.

Thesis defended in **2015**

Domenico Bullara

"Nonlinear reactive processes in constrained media"

27 March 2015

(Thesis advisor: Prof. Yannick De Decker).

Scientific stays

I. Berenstein, visit in the laboratory of Professor Carsten Beta, Institute for Physics and Astronomy, University of Potsdam (Germany), from May 29 to June 5, 2015.

J. Carballido-Landeira, Research stay at Basque Center of Applied Mathematics (Bilbao, Spain) from 18th to 22nd April 2015.

J. Carballido-Landeira, Research stay at the laboratory of Prof. AP Muñuzuri, Facultad de Fisica, Universidad de Santiago de Compostela (Spain) from 11th to 23rd May 2015.

J. Carballido-Landeira, Research stay at the laboratory of Prof. AP Muñuzuri, Facultad de Fisica, Universidad de Santiago de Compostela (Spain) from 1st to 15th September 2015.

J. Carballido-Landeira, Research stay at the laboratory of Prof. AP Muñuzuri, Facultad de Fisica, Universidad de Santiago de Compostela (Spain) from 15th December 2015 to 8th January 2016.

L. Lemaigre, visit in the laboratory of Prof. F. Rossi, Università di Salerno (Italy) 07-12 July 2015.

L. Lemaigre, visit in the laboratory of Prof. V. Pimienta, Université Paul Sabatier (Toulouse, France), 14-16 October 2015.

C. Middleton and C. Thomas, Visit to Dirk Notz and Leif Riemenschneider, Max Planck Institute for Meteorology, (Hamburg, Germany), 14-15 April 2015.

Conferences

A. De Wit: Chair of an e-session on “Chemical gardens”, CS-DC’15 World e-conference, e- satellite of CCS15 (Conference on Complex Systems), 30 September - 1 October 2015.

J. Carballido-Landeira, member of the organizing committee.

First BCAM Workshop on Nonlinear dynamics in Biological Systems, Bilbao, Spain, June 19-20 (2014)

Talks at Conferences, Seminars and Schools

Igal Berenstein

June 2015
Three different cases for spatiotemporal intermittency in reaction-diffusion systems
Seminar in Complex Nonlinear Processes in Chemistry and Biology, for Berlin Center for Studies of Complex Chemical Systems, Fritz-Haber-Institute, Germany.

Fabian Brau

March 30
Morphogenesis, self-organization and fracture in elastic thin sheets
Gulliver, ESPCI, Paris, France.

June 1
Chemical gardens in confined geometries
ESA topical team meeting, Alghero, Italy.

July 6 - 10
Silo collapse under granular discharge
9th European Solid Mechanics Conference, Madrid, Spain.

September 8 - 12
Spiral precipitation patterns in confined chemical gardens
Minisymposium The Dynamics of Chemical Gardens, XXXIV Dynamics Days Europe, Bayreuth, Germany.

December 18
Structures périodiques et hiérarchiques dans des plaques minces élastiques
PMMH, ESPCI, Paris, France.

Jorge Carballido-Landeira

May 26 - 29
Spatio-Temporal Dynamics Originated by Interacting Reaction Diffusion Systems
8th Chaotic Modeling and Simulation International Conference, Henri Poincaré Institute, Paris, France.

June 1 - 5
Sparkling waves as a dynamic transition from Turing patterns
Chaos, Complexity and Transport 2015 (CCT'15), Marseille, France.

July 15 - 17
Cross-diffusion driven buoyant instabilities Bifurcations and instabilities in fluid dynamics
Paris, France.

October 12 - 14
Emergence of mixed mode instabilities in miscible fluids induced by buoyancy and double-diffusion effects
Complex Fluid Flow in Porous Media, Bordeaux, France.

November 17 - 20
Mixed mode instabilities in miscible fluids undergoing density and diffusion driven instabilities Experimental Fluid Mechanics
Prague, Czech Republic.

Yannick De Decker

December
From classical to stochastic non-equilibrium thermodynamics
Symposium on dissipative non-equilibrium structures in chemistry, Université de Strasbourg, France.

Anne De Wit

June
Talk at the Workshop "chemo-hydrodynamic pattern formation at interfaces
Sassari, Sardinia.

July
Invited Chair at Gordon Research Conference on Oscillations and Dynamic Instabilities in Chemical Systems
Vermont, USA.

September
Invited talk at the international conference "Grand Challenges in Geological Fluid Mechanics", Santa Fe, USA.

October
Invited talk at Interpore Benelux Day, Antwerpen, Belgium.

November
Talk at the 68th Annual Meeting of the Division of Fluid Dynamics of the American Physical Society, Boston, USA.

December
Invited talk at Pacifichem, Session "Nonlinear Dynamics", Honolulu, USA.

December
Contributed talk at Pacifichem, Session "Dissolution Phenomena", Honolulu, USA.

Lorena Lemaigre

May 31 - June 03

Chemo-hydrodynamic instabilities around a partially miscible interface
ESA annual topical team network meeting on chemo-hydrodynamic patterns, Alghero, Italy.

Vanessa Loodts

March 18

Dissolution réactive et convective: classification des effets des réactions chimiques
18ème Rencontre du Non-Linéaire, Paris, France.

May 13

Chemical reactions can accelerate the development of dissolution-driven convection
Annual meeting FNRS Graduate School "COMPLEX" & "Science of the Cities", Namur, Belgium.

September

Effect of reactions on buoyancy-driven convection due to CO_2 dissolution in fluids
Géosciences Rennes, Université de Rennes1, France.

Ceri Middleton

November

Experimental observations of the transport of brine and dissolved gases in sea ice
Belgian geography days, Brussels, Belgium.

Laurence Rongy

June 1

Modeling convective dissolution in reactive partially miscible systems
ESA annual topical team network meeting on chemo-hydrodynamic patterns, Alghero, Italy.

September 3

Control of dissolution-driven convection by chemical reactions
Grand Challenges in Geological Fluid Mechanics, Center for Nonlinear Studies and Los Alamos National Laboratory, Santa Fe, New Mexico, USA.

November 22

Convective dissolution in partially miscible systems: classification of the effect of reactions
American Physical Society Division of Fluid Dynamics 68th Annual Meeting, Boston, Massachusetts, USA.

November 23

Influence of Marangoni-driven flows on $A + B \rightarrow C$ reaction fronts
American Physical Society Division of Fluid Dynamics 68th Annual Meeting, Boston, Massachusetts, USA.

Gabor Schuszter

Influence of pattern formation on carbon dioxide mineralization
ESA TT Meeting on Chemo-hydrodynamic Patterns and Instabilities, Alghero, Italy.

October 2

Experimental study of pattern formation during carbon dioxide mineralization
Interpore Benelux day, Antwerpen, Belgium.

November

Experimental study of pattern formation during carbon dioxide mineralization
APS Division of fluid dynamics, 68th Annual Meeting, Boston, USA.

Reda Tiani

August 24

Influence of Marangoni flows on the dynamics of a chemical front: a theoretical approach
Ecole d'été du non-linéaire, Peyresq, France

Press releases

January 2015
Cover of Physics Today, Publication of the American Physical Society.

Findings

R.M. Wilson, ”Chemical gardens grown in flatland”, Physics Today 68, 14-17 (2015).

La Recherche: numéro 495 January 2015 (p. 9)

Modeling Amazonian transitional forest micrometeorology (EurekAlert)
http://www.eurekalert.org/pub_releases/2015-12/aiop-mat122815.php

Brasil:
bosque de transición, útil para estudiar clima (Science & Development)
http://www.scidev.net/america-latina/biodiversidad/noticias/brasil-bosque-de-transicion-util-para-estudiar-clima.htm?utm_source=link&utm_ medium=rss&utm

“Eppur (non) si muove”: why cellular movements may not be essential to the formation of Turing patterns in biology (The Node)
http://thenode.biologists.com/eppur-non-si-muove-why-cellular-movements-may-not-be-essential-to-the-formation-of-turing-patterns-in-biology/research/

Les rayures (mathématiques) du poisson-zèbre (Daily Science)
http://dailyscience.be/2015/05/17/les-yeux-et-les-oreilles-de-daily-science-41/

Publications

- L.M. Barge, S.S.S. Cardoso, J.H.E. Cartwright, G.J.T. Cooper, L. Cronin, A. De Wit, I.J. Doloboff, B. Escribano, R.E.Goldstein, F. Haudin, D.E.H. Jones, A.L. Mackay, J. Maselko, J.J. Pagano, J. Pantaleone, M.J. Russell, C. Ignacio Sainz-diaz, O. Steinbock, D.A. Stone, Y. Tanimoto and N.L. Thomas, From chemical gardens to chemobrionics, *Chem. Rev.* ***115***, 8652-8703 (2015).
- C. Barroo, Y. De Decker, T. Visart de Bocarmé and N. Kruse, NO_2 Hydrogenation over Pt and Rh Catalysts: a Study at The Atomic Level by Field Emission Microscopy, *Microsc. Microanal*. ***21***, 1587 (2015).
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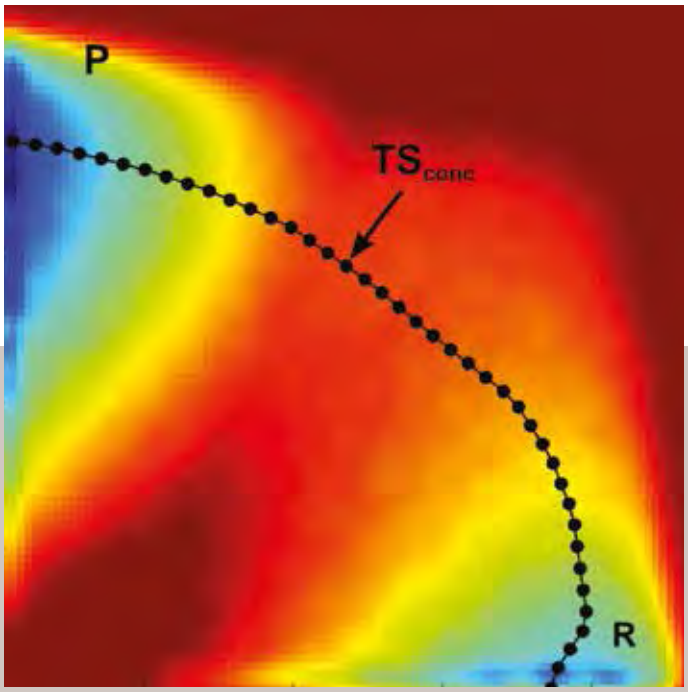
- I. Berenstein and Y. De Decker, Spatiotemporal chaos from bursting dynamics, *J. Chem. Phys.* ***143***, 064105 (2015).
- I. Berenstein, Standing wave-like patterns in the Gray-Scott model, *Chaos* ***25***, 064301 (2015).
- M.A. Budroni, J. Carballido-Landeira, A. Intiso, A. De Wit and F. Rossi, Interfacial hydrodynamic instabilities driven by cross-diffusion in reverse microemulsions, *Chaos* ***25***, 064502 (2015).
- M.A. Budroni, L. Lemaigre, A. De Wit and F. Rossi, Cross-diffusion induced convective patterns in microemulsion systems, *Phys. Chem. Chem. Phys.* ***17***, 1593-1600 (2015).
- D. Bullara and Y. De Decker, Chemical Equilibrium on Low Dimensional Supports: Connecting the Microscopic Mechanism to the Macroscopic Observations, *J. Stat. Phys.* ***161***, 210-226 (2015).
- D. Bullara and Y. De Decker, Pigment cell movement is not required for generation of Turing patterns in zebrafish skin, *Nature Communications* ***6***, 6971 (2015).
- J. Carballido-Landeira, A.P. Muñuzuri, Accelerated dynamics in active media: from Turing patterns to Sparkling waves, Langmuir ***31***, 3021-3026 (2015).
- Y. De Decker, D. Bullara, C. Barroo and T. Visart de Bocarmé, Nonlinear Dynamics of Reactive Nanosystems: Theory and Experiments. In S. C. Müller & J. Parisi (Eds.), Bottom-Up Self-Organization in Supramolecular Soft Matter: Principles and Prototypical Examples of Recent Advances (pp. 127-150), Springer International Publishing AG. (Springer Series in Materials Science, 217) (2015).
- Y. De Decker, A. Garcia Cantu Ros and G. Nicolis, Extended local equilibrium approach to stochastic thermodynamics, *The Eur. Phys. J. Special Topics* ***224***, 947-968 (2015).
- Y. De Decker, On the stochastic thermodynamics of reactive systems, *Phys. A* ***428***, 178-193 (2015).
- S.R. de Paulo, I.J.C. de Paulo and Y. De Decker, Reconstructing the micrometeorological dynamics of the southern Amazonian transitional forest, *Chaos* ***25***, 123123 (2015).

- G. Gutiérrez, C. Colonnello, P. Boltenhagen, J. R. Darias, R. Peralta-Fabi, F. Brau & E. Clément, *"Silo collapse under granular discharge"*, Phys. Rev. Lett. ***114***, 018001 (2015).
- F. Haudin and A. De Wit, Patterns due to an interplay between viscous and precipitation-driven fingering, *Phys. Fluids* ***27***, 113101 (2015).
- F. Haudin, V. Brasiliense, J.H.E. Cartwright, F. Brau and A. De Wit, Genericity of confined chemical garden patterns with regard to changes in the reactants, *Phys. Chem. Chem. Phys.* ***17***, 12804-12811 (2015).
- F. Haudin, J.H.E. Cartwright and A. De Wit, Direct and reverse chemical garden patterns grown upon injection in confined geometries, *J. Phys. Chem. C* ***119,*** 15067-15076 (2015).
- V. Loodts, L. Rongy and A. De Wit, Chemical control of dissolution-driven convection in partially miscible systems: Theoretical classification, *Phys. Chem. Chem. Phys.* ***17***, 29814-29823 (2015).
- C.A. Middleton, C. Thomas, D. Escala, J.-L. Tison, and A. De Wit, Imaging the evolution of brine transport in experimentally grown quasi-two-dimensional sea ice, *Procedia IUTAM* ***15***, 95-100 (2015).
- O. Oshri, F. Brau & H. Diamant, *"Wrinkles and folds in a fluid-supported sheet of finite size"*, Phys. Rev. E ***91***, 052408 (2015).
- S. Pramanik, A. De Wit, M. Mishra, Viscous fingering and deformation of a miscible circular blob in a rectilinear displacement in porous media, *J. Fluid Mech. Rapids* ***782***, R2, (2015).
- C. Thomas, L. Lemaigre, A. Zalts, A. D'Onofrio, A. De Wit, Experimental study of CO_2 convective dissolution: The effect of color indicators, *Int. J. Greenhouse Gas and Control* ***42***, 525-533 (2015).
- P.M.J. Trevelyan, C. Almarcha and A. De Wit, Buoyancy-driven instabilities around miscible A+B→C reaction fronts: A general classification, *Phys. Rev. E* ***91***, 023001 (2015).
- Z. Zheng, L. Rongy, and H.A. Stone, Viscous fluid injection into a confined channel, Phys. Fluids ***27***, 062105 (2015)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Research **highlights** of other **scientists** connected with the **Institutes**

Research highlight from the Applied Physics research group - VUB

Transforming two-dimensional guided light using metamaterials

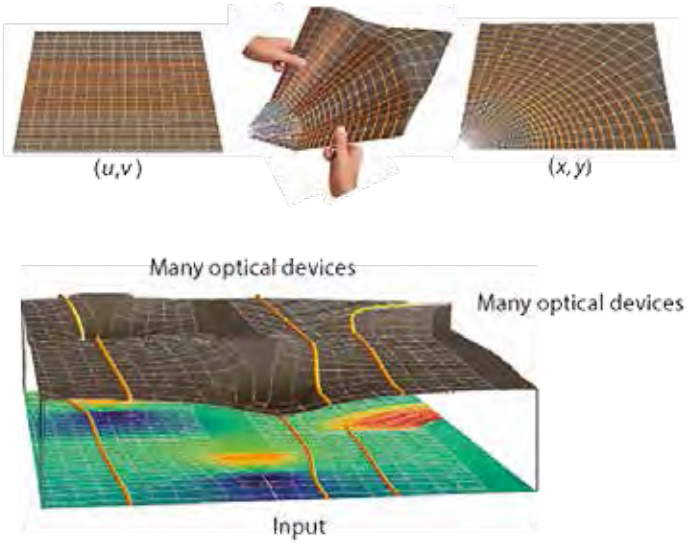
A century ago, Albert Einstein revolutionized our understanding of the universe introducing a powerful geometrical description of gravity. In his theory of general relativity, Einstein proposed that massive objects deform the fabric of space and time. As a result of space-time deformations, not only other massive objects but also light will therefore follow a curved trajectory instead of a straight line.

Ten years ago, scientists developed an impressive tool —transformation optics— for the design of artificial metamaterials that emulate the effects of a deformed space-time on light, leading to exciting photonic applications such as invisibility cloaks. In transformation optics, one first designs the desired trajectories of light with a coordinate-based space-time deformation. Subsequently, one determines the optical metamaterial properties that reproduce the Maxwell equations of that space-time. In practice, transformation optics makes use of “equivalence relations” to define the appropriate metamaterial properties for arbitrary coordinate transformations.

Unfortunately, the application of transformation optics to two-dimensional structures or devices, e.g. light that propagates on a photonic integrated circuit, does not lead to practical metamaterial designs. Indeed, the flow of light along the surface is designed by making use of a two-dimensional coordinate transformation, which is insensitive to the transverse coordinate. In principle, the required metamaterial properties should therefore extend to infinity outside of the layer, resulting in bulky metamaterial designs.

Research highlight from the Applied Physics research group - VUB

We developed alternative two-dimensional equivalence relations that restrict metamaterial implementations to the material layer itself. In particular, the application of a coordinate-based thickness variation to the interfaces of the material layer ensures that metamaterial implementations are excluded from the outer regions without disrupting the continuous profile of the incident guided mode. Moreover, since the metamaterial waveguides are nonmagnetic and low-loss, guided light modes may now transform consistently and efficiently inside metamaterial waveguide components such as beam benders, beam splitters and lenses (see figure).



Two-dimensional transformation optics may seamlessly manipulate light flows along thin material layers. The application of a two-dimensional coordinate transformation leads to the desired blueprint for a photonic integrated circuit or waveguide component, as illustrated for a beam bender (top). The implementation requires a thickness variation (shown for the upper interface by the grey floating surface) and a nonmagnetic uniaxial metamaterial layer with moderate anisotropy (indicated by the surface coloring on the symmetry plane (high = red, low = blue) (bottom).

S. Viaene, V. Ginis, J. Danckaert & P. Tassin,
Transforming two-dimensional guided light using nonmagnetic metamaterial waveguides,
Physical Review **B 93** (8), 085429 (2016).

Sophie Viaene is a PhD Student at VUB and laureate of the 2014 Robert Brout Prize of the VUB & of the 2015 Solvay Award for her master thesis.

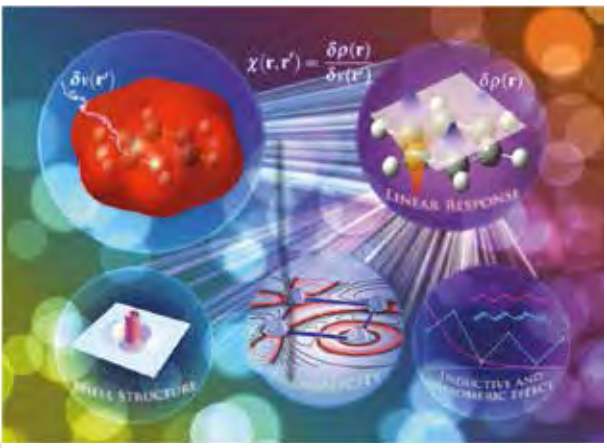
Vincent Ginis is FWO postdoctoral researcher at VUB and Laureate of the 2015 Solvay Award for his PhD dissertation.

Philippe Tassin is professor at VUB and at Chalmers University (Sweden), and the recipient of the 2013 BAEF Alumni Award in Exact Sciences.

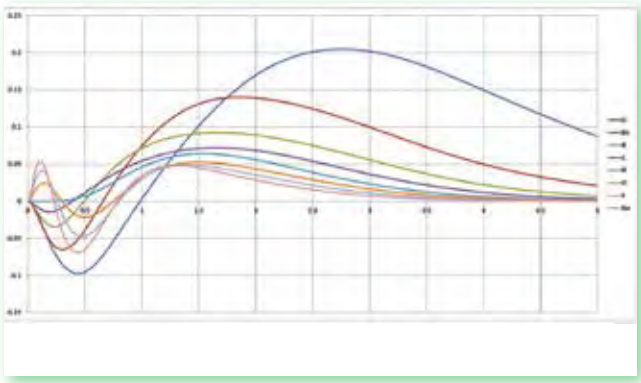
Jan Danckaert is professor at VUB and leading the Applied Physics research group.

Three main research lines can be discerned in the ALGC group (Prof. P. Geerlings and Prof. De Proft) in 2015: continuing and extending the long standing research on Conceptual Density Functional Theory, strengthening the line of design of molecules with well defined and optimized properties, and applications, mostly in collaboration with experimentalists, of concepts and principles in a variety of problems in organic, inorganic, bio and materials-chemistry.

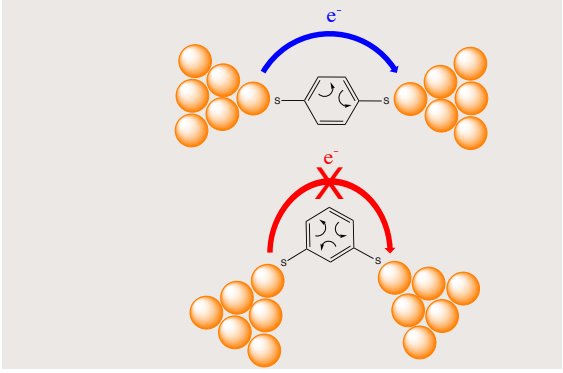
In Conceptual Density Functional Theory precision is given to often well known but sometimes vaguely defined chemical concepts enabling their evaluation and quantitative use (e.g. electronegativity). Being the core business of ALGC for many years (1) important steps were taken in 2015 by extending the time independent framework to a time dependent one in the study of the Linear Response Function (LRF) (2) $\chi(\underline{r},\underline{r}')$ telling us how sensitive the density $\rho(\underline{r})$ will be to a perturbation $\delta v(r')$ in the external potential: $\delta\rho(\underline{r})/\ \delta v(\underline{r}')$.



Z.Boisdenghien and Dr. S.Fias compared the two approaches leading among others to a straightforward evaluation of the local polarizability of atoms (3).

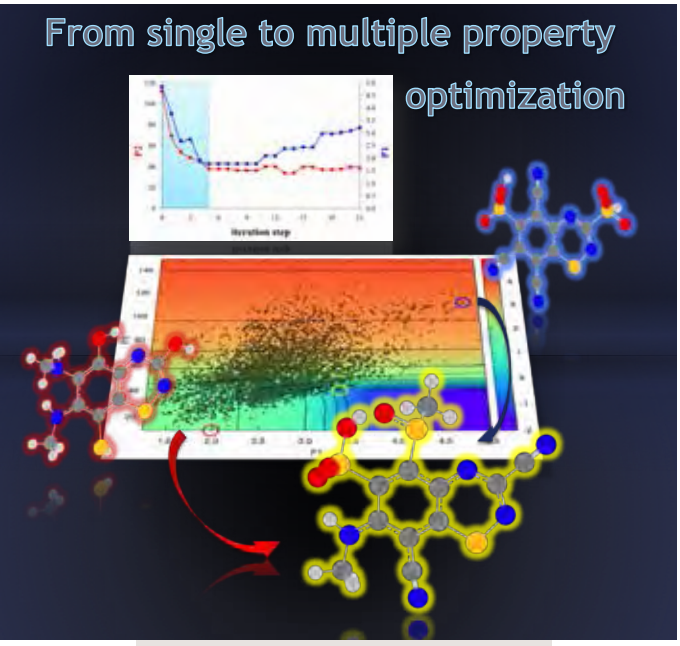


A new line was started in 2014 in Thijs Stuyver's Master thesis on the basis of analogies between the forerunner of the LRF, the atom-atom polarizability, and the molecular transmission coefficient in Molecular Electronic Devices (MED). In a tight binding or Hückel approach Thijs and Dr. Fias were able to derive selection rules for molecular conductivity and to link them with the curly arrow approach in mechanistic organic chemistry (4) (5).



Research highlight from the ALGC research group - VUB

In the rational design of compounds Dr. Freija Devleeschouwer developed so called Inverse Design techniques affording to investigate Chemical Compound Space for designing molecules with two or more optimized properties, e.g. radicals with both high stability and high electrophilicity or nucleophilicity (6) (7). Exploring techniques for efficiently investigating the gigantesque Compound Space will be one of the main topics that will be addressed by the new-hired Professor Anatole Von Lilienfeld (at the occasion of P.Geerlings' retirement) who took up his position in the ALGC group on January 1st 2016 and whose first collaborative work with ALGC is in press(8).



The work by Dr. Mercedes Alsonso and Tatjana Woller on the electronic structure of extended porhyrines, molecular switches showing topological changes from Hückel to Möbius type structures under the influence of changes in their redox state, metallation, temperature, pH…, can also be seen as part of this research line (9) (10). The link between this remarkable topological inversion and molecular conductivity (vide supra) is presently investigated.

In the "application line" the ALGC group has passed in recent years from mainly organic to a mixed organic/inorganic portfolio bewildered by the richness and e.g. conceptual evolutions in the latter field.

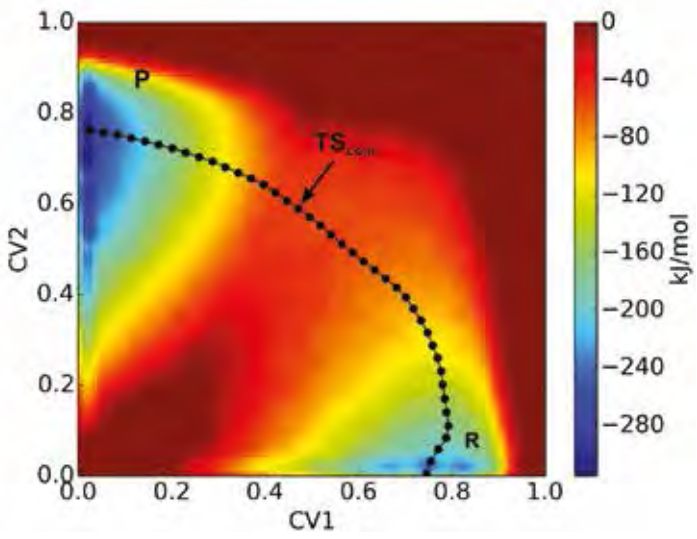
Concepts studied before at length also in the ALGC group, such as redoxreactions and generalized Lewis acid –base interactions, were transferred to new environments showing remarkable peculiarities and new insights. Dr. Balazs Pinter and Gabi Skara scrutinized the role of so called redox innocent ligands in redox processes at a central transition metal atom, whereby not only the metal atom but also the ligands are active or "non innocent", in the redox process, and were able to design new ligands showing optimal redox behaviour (11) (12).

In the same vein the particular situation was studied of interacting Lewis pairs decorated with voluminous substituents preventing them (and so frustrating them...) to associate as they would like and offering the possibility for insertion of a H2 molecule, which can undergo cleavage leading to metal free, environmental friendly, catalysts (13) (14).

Both in the work on extended porhyrins and the frustrated Lewis pairs the bulkiness of the structures leads to the use of advanced techniques for the investigation of non covalent interactions, e.g. the NCI-approach, in collaboration with colleagues from Paris VI (15).

In the applications on organic systems an important step has been taken by inserting Dynamics in the methodology through Dr. Moors' vast experience. He successfully analysed nucleophilic and electrophilic substitutions with results often far from what is taught in basic organic chemistry courses… (16).

Finally in Bio applications Laura van Bergen, in collaboration with Dr. Joris Messens (VIB-Department of Structural Biology), obtained a detailed scrutiny of the hydrogen bonding network in the enzyme alkyl hydroperoxid reductase E (AhpE) using the above mentioned NCI index; this work will further be extended to other in-house obtained and characterized mutants of this enzyme in the Messens group and a detailed insight in the catalytic activity will be provided using hybrid QM/MM calculations.



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Research highlight from the Laboratory of Polymer Chemistry - ULB

A phase is a region of space, throughout which all physical properties of a substance are essentially uniform. Well-known examples of phases are gas, liquid, and solid. Solid and liquid phases differ by their density and not by their structure. The situation is radically different in the case of crystals for which a given compound can assume various crystal arrangements as function of pressure and temperature. Each crystal structure has different physical and chemical properties. Polymorphism, i.e. the occurrence of two or more crystal structures for a specific compound, is widely exploited in industrial applications such as pigments, food, explosives, fertilizers, organic semiconductors, and pharmaceutical compounds. Different phases can also form in the vicinity of a rigid substrate because the latter imposes new constrains on the packing of molecules.

Yves Geerts has coordinated a five-year project on this particular topic that remains rather unexplored, particularly for molecular crystals. The outcomes of this study have been summarized in a review paper that is the first publication that treats comprehensively the topic[1].

In a nutshell, it appears that substrate-induced phases occur frequently and have been largely overlooked despite their crucial importance on the formation of polymorphs. This is surprising since the ability to obtain reproducibly a specific polymorph is particularly important for the pharmaceutical industry because each polymorph of a pharmacologically active substance has a different solubility and hence a different bioavailability. The same holds true for other industrial processes.

The research conducted by the group of Yves Geerts, in collaboration with the group of Roland Resel, at the Graz University of Technology, Ingo Salzmann, at the Humbolt University of Berlin, Raffaele Guido Della Valle, at the University of Bologna, and Michele Sferrazza, at ULB, casts a new light on this particular case of polymorphism. An important contribution to the study has been made by Basab Chattopadhyay, former Marie Curie Fellow, and current postdoctoral researcher of the FNRS.

1. *"Substrate-Induced and Thin-Film Phases: Polymorphism of Organic Materials on Surfaces"* A. O. F. Jones, B. Chattopadhyay, Y. H. Geerts, R Resel, *Advanced Functional Materials,* 2016*, 26,* in press.

Research highlight from the Institute of Astronomy and Astrophysics - ULB

Researchers from the Université libre de Bruxelles and the Université de Montpellier have succeeded, for the first time, in measuring the temperature at the heart of certain stars, as well as dating them. Our understanding of the production of heavy elements inside stars has been greatly improved by this study, published in the 2015, 8th January issue of Nature.

The temperature and chronology of heavy-element synthesis in low-mass stars

P. Neyskens, S. Van Eck, A. Jorissen, S. Goriely, L. Siess & B. Plez

In 1926, astrophysicist Sir Arthur Eddington wrote in his work "The internal constitution of the stars": “At first sight it would seem that the deep interior of the Sun and stars is less accessible to scientific investigation than any other region of the universe. What appliance can pierce through the outer layers of a star and test the conditions within?”.

Nearly 90 years later, this question has now gained an answer, thanks to the work of a team of six astrophysicists from the ULB Faculty of Science’s Institute of Astronomy and Astrophysics and the Université de Montpellier’s Laboratory of the Universe and Particles who have managed to measure the temperature at the heart of specific stars and to estimate their age.

These measurements use isotopes of well-chosen chemical elements (such as ^{99}Tc and ^{93}Nb), which act as both a thermometer and a clock and which the researchers have found to be in abundant supply on the stars’ surfaces. To do this, they have used the HERMES spectrograph (mounted on the KU Leuven Mercator telescope located on La Palma in the Canary Islands), built in the context of collaboration whose main partners were the KULeuven, the ULB and the Royal Observatory of Belgium.

The temperatures measured by the astrophysicists are those of the deep layers within the stars where the synthesis of elements heavier than iron takes place. These heavy elements, after having been dredged-up to the star’s surface, are ejected into the interstellar medium at the end of the giant star’s life. They become part of large dust and gas clouds making up the interstellar medium and giving birth to new stars. This is the scenario under which the Sun came into existence four and a half billion years ago. The heavier-than-iron elements that we use today here on the Earth in a range of technological applications (such as niobium in permanent magnets or cerium in catalytic converters) have followed this same path.

The Orion constellation, well visible from the Northern hemisphere.

The temperature at the stellar surface can easily be determined from the colour of stars: for example, Betelgeuse (3600K) looks red while Bellatrix (21 000K) looks blue. However, measuring the temperature inside stars is a real challenge. Two of the red giant stars studied in the present Nature paper are located in the Orion constellation. One of them, V1261 Orionis, was used to measure the temperature of the heavy-element production in the stellar interiors (around 100 000K). It was demonstrated that the other star, o1 Orionis, has been producing such heavy elements for 1.3 million years (Image created thanks to Aladin, Centre de Données Astronomiques de Strasbourg).

Robert Brout & Ilya Prigogine Prizes

Adrien Devolder
(Ilya Prigogine Prize ULB)

Edith Oyen
(Ilya Prigogine Prize VUB)

Saskia Demulder
(Robert Brout Prize VUB)

Seth Moortgat
(Robert Brout Prize VUB)

The **Robert Brout** Prizes and the **Ilya Prigogine** Prizes

In order to commemorate the memory of two exceptional scientists from the University of Brussels, the juries of the masters in chemistry and in physics of the ULB and the VUB have created:

- the Ilya Prigogine Prizes, to be awarded to the best students finishing their master studies in chemistry, provided they have a brilliant curriculum (one prize at the ULB, one prize at the VUB).
- the Robert Brout Prizes, to be awarded to the best student finishing their master studies in physics, provided they have a brilliant curriculum (one prize at the ULB, one prize at the VUB).

Given the close ties of these two personalities with the Institutes, the International Solvay Institutes are associated with this initiative.

In 2015, the prizes have been awarded to:

- Adrien Devolder
  (Ilya Prigogine Prize ULB)
- Edith Oyen (Ilya Prigogine Prize VUB)
- Saskia Demulder et Seth Moortgat
  (Robert Brout Prize VUB)

Report of the International Advisory Committee

Report of the **International Advisory Committee**

Executive Summary

Many of the conclusions are identical to the ones from the previous meeting and are repeated here.

- The Solvay Institutes are run in a most impressive and competent way.
- Within the existing organization and budget we find that the activities have reached an optimal stationary level.
- The Solvay Conferences are the pearls in the activities. Every effort should be spent to uphold this level. We note that the planning for the chemistry centennial conference in 2022 is being started.
- The Solvay Workshops are held at a very high scientific level with excellent speakers and participants.
- The Solvay Chairs and the Solvay Colloquia play very important roles for the universities in Brussels to gain exposure to world-class scientists. We note that there are attempts to further include Belgian universities outside Brussels.
- The Solvay Public Lectures are of utmost importance to foster interest in the most modern science within the public mind. It is very impressive to gather some 900 people on a Sunday afternoon.
- The strong and steady support from the Solvay family and the Solvay group provide a solid basis for the institutes.
- The strong support from the two universities both economically and morally are also very important for the institutes.
- The Solvay Institutes build an important bridge between the two language groups in Belgium.

We would further like to emphasize that it is very rewarding for the Committee to see our recommendations being so seriously considered. We see very good progress in the attempts to even out the differences between physics and chemistry and also to engage scientists from outside the Brussels area.

The Committee has the following recommendations

- The newly established local chemistry committee must be more active and enlargement with chemists from the interface with biosciences at ULB should also be considered.
- The Solvay institutes should get engaged in the modern social media in order to spread information about the various activities especially as concerns the public lectures and the Colloquia.
- The Solvay institutes should consider the idea to introduce ”Solvay Lectures” by young outstanding scientists.
- The Solvay Institute should find ways to involve the students more actively in participation of the colloquia. One possible way would be to organize a lunch for graduate students with the colloquium speaker and give some of them the opportunity to meet and discuss with world leading scientists.
- The Solvay Institutes should continue to strive to broaden the funding base in order to reach an endowment large enough to ensure long-time planning stability.
- The Solvay Institutes should continue to take an active role in promoting new subjects to facilitate the entry of the universities into new modern areas.

Introduction

The Committee that consists of Prof:s Lars Brink (Göteborg), chair, Ben Feringa (Groningen), Karen Goldberg (Seattle), Gunnar von Heijne (Stockholm), Hermann Nicolai (Potsdam), Hirosi Ooguri (Pasadena and Tokyo) and Jacques Prost (Paris) met in Brussels on October 12 - 14, 2015. Unfortunately Prof. Leticia Cugliandolo (Paris) could not attend the meeting, since she had a commitment in Santa Barbara which had been planned since long in advance. In order to prepare ourselves we had obtained a report on the activities 2013/14/15 and the budget for 2014. We have also had the report from 2012 as a reference for the work.

On October 12 the Committee met with the Director and the Deputy Director Marc Henneaux and Alexander Sevrin together with the President of the Board of Directors Jean-Marie Solvay for an informal dinner. On October 13 the Committee had extensive interviews with Prof:s Henneaux and Sevrin and Lode Wyns and with various representatives from the local faculties, Prof:s Coheur, Van Eck, Geerts, de Wit, Danckaert, Gaspard, Barnich and Craps. The Committee furthermore interviewed the two assistants of the staff. The Committee also had a lunch meeting with Profs: Eddy Van Gelder (president of VUB), Patrick De Baetselier (Vice rector for research at VUB) and Paul Geerlings (Vice President of the ISI) together with Prof:s Henneaux, Sevrin and Wyns. The day was concluded with a visit to ING Bank Headquarters for a discussion with M. Boyer, the new member of the board of directors and with a discussion with Jean-Marie Solvay. On October 14 the Committee first met with Prof Serge Schiffmann (Vice rector for research at ULB) and then with Prof Eric De Keuleneer (president of ULB). Finally the Committee had a meeting with Baron Daniel Janssen. Between and after the interviews and at the dinners and finally in the afternoon of October 14 the Committee had its deliberations.

The Committee found that all interviewees were very enthusiastic about the Solvay Institutes like at previous times. They are all committed to the cause to run the various activities and to uphold the excellence stamp that the name Solvay carries. Apart from the secretariat, the work behind the activities is performed on a voluntary basis within the academic positions. The Committee very much appreciates that the two universities allow and support this. It puts, however, a limit as to how much work the staff can do for the Solvay Institutes. We will comment more on this fact later.

The Committee appreciates that the recommendations from previous reports have been given such strong considerations and are very pleased to see how well they have been implemented. We have previously commented on the very heavy workload of the Director. It is still heavy but our impression is that it is more reasonable now. We will comment on these points later in the report.

Scientific Activities

The Committee is again very pleased to see how well all activities are working. The two Solvay Conferences held since the last report have been huge successes giving strong imprints in their respective fields. The Committee commends the strong commitments here not only by the Director but also by the scientific secretaries of the two scientific committees as well as by the committees themselves.

Even though a lot of work was committed to the organization of the Conferences, the Institutes have continued to have an almost full program of Solvay workshops, Solvay colloquia, Solvay chairs as well as Solvay public lectures. On top of this the institutes have contributed to a European graduate school. We note that also Zürich has now joined in here as a fourth node. We find that all these programs have been excellent as in the past. Hence there is no reason for us to discuss the individual activities. The Committee notes though that there were less workshops in chemistry this year and urges the local chemistry committee to make sure that the program is filled up covering some of the rapidly emerging fields of chemistry.

The Committee found that the European graduate school in fundamental physics is a very unique and successful enterprise. We ask the local chemistry committee to consider the possibility to organize something similar in a suitable subfield of chemistry. This would give a chance to Belgian graduate students in chemistry to meet graduate students from neighboring countries and at the same time get advanced graduate courses in a very stimulating milieu.

The Committee finds that the activities of the Institutes are now at a fairly optimal level given the economic and personal resources. Neither program should be extended at the price of being diluted. We understood like last time that it could be difficult to get someone for a Solvay chair be present in Brussels for the whole month. This is what should be preferred but if it cannot be achieved, a recipient of such a chair could divide up the time. We find it advantageous if she/he could also extend the activity to visit and make contacts with other universities in the country,

The Committee wants to make a small new proposal by introducing ”Solvay lectures” by young outstanding scientists. Besides recognition, it fulfills two purposes; attracting some of the most bright young minds to Brussels and provides further exposure to frontier fields of chemistry and physics at minimal costs. We are aware that there are now many distinctions given to a very small group of young scientists, so a program like this should not necessarily reward the same people. There are many young excellent European scientists that could be taken into consideration. The local physics and chemistry committees could be given the task to find these people in a way which is not too big a burden.

The Committee is impressed that the Solvay Colloquia scheme is working so well. In many universities it is very difficult to motivate the graduate students but also older scientists to attend talks in fields which are distant from their own. One suggestion to further increase the interest among the graduate students would be organize a lunch for some graduate students with the speaker and to advertise the colloquia on Facebook and Twitter. This has proved to work very well at other institutions.

The Committee noticed that there are also a number of workshops that are not directly organized by the institutes but get contributions from the institutes and can hence carry the Solvay name. This is a way to increase the number of Solvay workshops which is to be recommended. We trust that the Director and the local committees make the selections according to the same principles as for the ordinary Solvay workshops.

Finally it was taken up the question if scientists engaged in the institutes can sign papers with the Solvay institute address together with their university address. We encourage this initiative as a way to honor those who work voluntarily for the institutes and to give further visibility to the activities of the institutes.

The balance between physics and chemistry

The optimal way to run the two institutes is to have a perfect balance between physics and chemistry.

Traditionally this was not the case and the Committee has previously urged the director and the board to find this balance. The Committee is pleased to see that there has been great progress over the years to get the activities in chemistry up to a more even level with physics. It has certainly been improved since the last report, but there are still things to be done. All interviewed chemists were very pleased with the work of the Director to implement this, so now the initiative resides with the local chemistry committee. We found that this committee is not yet working at an optimal level, and we urge its chairman to engage the members of the committee more actively. Since there are very interesting interfaces to biochemistry in other departments we strongly suggest to also involve members from those departments. This should be done while still having a strong focus on novel developments in the basic chemistry research.

It is very important that the local committees meet regularly and be active to propose new activities within the various programs, and it is the responsibility of the chairs of the two committees to oversee this.

The Committee is pleased to see that the organization now is very symmetric in regards to the two fields. This time we noticed no complaints about the organization structure. All persons interviewed were happy with it.

We have previously encouraged the institutes to use their positions to introduce new important fields in physics and chemistry to the universities. There is of course again a balance to be sought for, since in the end it is the departments and the universities that decide about future directions, but the activities of the Solvay Institutes should help them in these decisions. We notice that the new activity in biophysics will be followed up by a workshop. This is an excellent way to support new research directions.

There was a question from the local chemistry committee if they could contact the scientific committee for advice. We encourage this and since there is now also a full representation of chemists in the advisory committee we also encourage the chemistry committee to keep an open dialogue with the advisory committee. We note that such contacts already exist between the local physics committee and the scientific committee for physics and the advisory committee.

Broadening of the activities outside Brussels

The new local committees with participation of scientists from the rest of Belgium is a very promising attempt to engage the faculties outside the Brussels area in the activities.

These people bring in new expertise in subjects not strongly represented in the Brussels area but also strengthen further already strong subjects in the Brussels area. The Committee notices that the increased involvement of those outside of Brussels has resulted in proposals for workshops. The chairmen of the local committees should make sure that this will continue. As mentioned above the Committee encourages the Director to oversee that the Solvay chairs are present not only in the Brussels area. We are very pleased to see how well the two universities work together in matters related to the Solvay institutes. Already at the previous meeting we noticed how hard and successfully the staff and the Director work to consolidate the important bridge that the Solvay Institutes build between the two language groups in Belgium. The commitment to this cause is very strong and we heard appreciations for it from many corners. Also for this very difficult issue the Solvay Institutes have an important role to play.

Staff and Support for the Director

Like at the previous times the Committee has understood that the success of the Solvay Institutes rests heavily on the tireless and excellent work that the Director and the staff perform. The appreciation for them is remarkable from all persons interviewed and very well deserved. Also the enthusiasm of the other persons involved is necessary for the success. We realize that within the present set-up one is close to the limit for what can be achieved and the Committee only has put forward some small suggestions to increase the programs. The bulk of the new work should reside with the local committees.

In previous reports we have found the workload of the Director to be extremely heavy. Not only did he have to actively work for the funding of the Institutes and to oversee all the activities but also to take a very active role in the daily running of the Institutes. On top of that he is the professor of a world-class research group. Since some years he has a very prestigious ERC grant which has allowed him to run a huge and successful group. The grant has helped also the people from his group working actively for the Solvay institute since there has been ample funding for graduate students and post-docs. The problem with ERC grants is that they are huge but only for a certain period of time.

Once it is finished it is hard to maintain the high level of research. The Committee is very pleased to see that the Solvay family and Solvay group support the Director with the aim to have a full grant of the size of an ERC grant in the future. This helps the Director to have a long term planning of his research and his group. This will also make the position very attractive the day the Director decides to step down. Here the Committee wishes that he can stay as long as the rules allow.

The two assistants play a vital role for the success of all the activities. At times the work load is very high but we heard no complaints about it. On the contrary they were very happy with their duties. One question that came up during the discussion with them was if they have all the benefits of corresponding positions within the university. It is important that this is the case and we understand that the director is taking care of this.

A very important aspect of all the activities is the documentation on internet. We notice that the normal running of the web pages is performed very expertly by the staff. The web pages are very instructive and is continuously being upgraded with new material and new functions that streamline the activities.

This was discussed in the last report and the progress is quite good. The Committee would also urge the secretariat to set up a Facebook page and a Twitter account to promote information about the activities. It need not be a great burden and the idea is just to announce the activities, not to use them as discussion fora. To generate followers of the Facebook and Twitter feeds, the email lists of previous attendants at the public lecture, and of participants and colloquia, could be used to advertise the new communication channels.

We have also noted in previous reports that the Solvay archives contain material of utmost importance for the history of science. In some respects they are unique in the world containing correspondences between some of the most important figures in the history of science. We understand that the Director has a long term program for this. It should be financed outside the normal budget and there is already one person, Prof. Franklin Lambert, with very deep knowledge about the Institutes engaged in this matter. We are pleased to learn that also the board is active here. By opening the archives to some chosen graduate students of the history of science they could do the bulk of the work while at the same time getting unique material for their theses. Here some strategic cooperations could be set up with University departments or institutes. Also the lectures and discussions at the Solvay meetings are of course of utmost value. The proceedings from the old conferences exist in print and we understand that the process to put them on the web page in electronic form is well on its way.

Already in the previous reports the Committee noted one experience from recent Solvay Conferences and Workshops, that physicists want to have all the talks directly available on the internet, while chemists often want to have meetings between closed doors, being worried that intellectual property rights might otherwise become compromised or that important new ideas might be exploited by competing groups. The Institutes have to keep this in mind when making information available. There was now a proposal that workshops and perhaps also colloquia could be put on line in real time. That is working very well at some other institutes and the Committee urges the institutes to consider this idea. The public talks should be possible to make available online or as real time webcasts.

Finances

The Committee is very pleased to see that the economic situation for the institutes has been further strengthened. The director has since some time managed to pay off all debts and we see that the endowment is increasing. The budget is balanced and has even generated a surplus which has been the way to increase the endowment. We understand that it is difficult to attract contributions to the endowment from outside sources since the institutes are so intimately connected with the Solvay name and the Solvay group. It would be advantageous to double it since it will give the institutes more freedom and relieve the stress to apply for money from outside sources, but it can take some time. It should be emphasised that the contributions from the Solvay family and the Solvay group as well as from the two universities are stable. The Committee feels that this serves the Institutes very well in their long-term planning. We are very pleased to note the strong support from the Solvay group for some of the specific chemistry activities. As at the previous occasions we are very pleased to see the two universities so positive to the activities. They do carry costs which are not seen in the budget, apart from the direct contributions, such as salaries and rents, but they do get a lot back and being associated with the Solvay institutes give them worldwide recognition.

The Institutes also benefits from the support of the National Lottery and from the Regions. We hope that these essential contributions will continue at the present level. It is a wise policy to take measures to put the Institutes in a position where they are less dependent on these less stable sources of financing. In that respect, besides the growing of the endowment mentioned above, we also propose that the Director continue his careful handling of the budget, and further surpluses should be used to further increase the endowment.

With the prestigious Solvay name for the various activities there should be good opportunities to attract funding from outside sources to finance some specific activities. This could help to build up the endowment further. This has to be balanced though against the workload.

We have previously noted that the institutes are quite generous to pay for participants to the workshops. As long as it is not a burden to the finances it helps to attract a strong participation. Many scientists though have good resources for traveling and are willing to use it. By a careful wording in the invitations some funding can perhaps be saved to be used elsewhere.

Conclusions

The Committee is very pleased to see that the excellent quality of all the programs has been upheld during the last three years and notes the great success of the two conferences that have been held since our last report. The task for the Director, Board and the Management is to continue along the same lines as in recent years.

The Committee is also very pleased to see that the imbalance between physics and chemistry and also about the weak participation of Belgian scientists and institutions outside the Brussels area have been handled very efficiently. Important steps have been taken to even out these imbalances both in action by the Director and the Management and by the appointment of the two local committees, one for physics and one for chemistry with broad participations. The chemistry committee can be more active though and we understand that it will be in the future.

The overall impression that the Committee has obtained also this time is that the Solvay Institutes are run in a most impressive and competent way. It is due to the excellent job of the director but also of his associates in the organization. It is remarkable that the director and his staff have re-established the Institutes as world leading institutions so swiftly, and the Committee can only congratulate Belgium and the scientific communities in physics and chemistry to have these activities.

Göteborg | Groningen | Seattle
Stockholm | Pasadena | Potsdam | Paris

Lars Brink | Ben L. Feringa | Karen I. Goldberg

Gunnar von Heijne | Hirosi Ooguri | Hermann Nicolai | Jacques Prost

Appendix

Au Métropole, un « sabbat de sorcières »

10|12 CES HÔTELS QUI ONT CHANGÉ LE MONDE

Automne 1911, Bruxelles. Une réunion mythique, un casting phénoménal : Albert Einstein, Marie Curie, Henri Poincaré, Max Planck, Paul Langevin, Maurice de Broglie et d'autres réinventent la science lors du conseil Solvay, dans le plus beau palace de la ville

STÉPHANE FOUCART
BRUXELLES - *envoyé spécial*

« Voilà, c'est ici. » Patrick Wielemans pousse la porte du salon Einstein. Au premier étage du Métropole, à droite de l'escalier monumental qui traverse l'imposant bâtiment de la place de Brouckère, dans le centre historique de Bruxelles, la salle de réunion ne paie pas de mine. Une quarantaine de mètres carrés, un peu de marbre au mur, une longue table au milieu. Comparé à la splendeur du grand hôtel, rien de très spectaculaire. Le lieu fait pourtant la fierté de l'établissement et de son patron.

C'est dans cette salle, rappelle Patrick Wielemans, que fut écrite l'une des plus fameuses pages de l'histoire des sciences. Pendant quatre jours, entre le 30 octobre et le 3 novembre 1911, à l'invitation d'un industriel et philanthrope belge, Ernest Solvay, une vingtaine des plus brillants esprits du XX[e] siècle ont empli ces murs d'ésotériques réflexions sur la nature profonde de la matière et de l'énergie, ouvrant la voie à la physique moderne – celle qui a donné l'électronique, l'informatique, l'Internet, la fission de l'atome et tant d'autres choses qui, pour le meilleur et le pire, ont façonné notre époque et façonneront les suivantes. Cette réunion mythique, le premier conseil Solvay, n'a pas seulement mis sur sa rampe de lancement une nouvelle physique. *« Il a changé profondément la manière de faire de la science »*, dit le physicien et philosophe Etienne Klein (CEA).

Est-ce vraiment dans cette petite pièce que tout s'est joué ? En réalité, Patrick Wielemans n'en est pas complètement certain. Il tient l'information de son père qui la tenait lui-même de ses aïeuls, les fondateurs du Métropole, qui furent aussi les hôtes du fameux congrès. *« Disons qu'on peut en être sûr à 90 % »*, lance-t-il. En face, dans le même couloir, le salon Langevin est aussi un candidat possible.

L'unique image de ce conseil Solvay, qui sera le premier d'une longue série, est une célèbre photo de groupe. Elle ne permet pas de trancher avec certitude entre les deux salons : ce n'est pas le lieu qu'elle veut immortaliser, mais le casting phénoménal de l'événement. Vingt-quatre savants dont les noms fondent, un siècle plus tard, une bonne part des manuels de sciences : Albert Einstein, Marie Curie, Paul Langevin, Henri Poincaré, Max Planck, Hendrik Lorentz, Arnold Sommerfeld, Marcel Brillouin, Ernest Rutherford, Jean Perrin, James Jeans… Près de la moitié des participants ont, ou auront, un prix Nobel. Marie Curie en aura deux.

Que font les plus grands savants de leur temps dans un palace bruxellois ? Qui les a réunis et pourquoi ?

« JE PRENDS UN BAIN TOUS LES MATINS. NOUS SOMMES LES INVITÉS DE M. SOLVAY, Y COMPRIS AUX REPAS. PAS MOINS DE CINQ PLATS À CHAQUE DÉJEUNER ! C'EST FOU ! », ÉCRIT ARNOLD SOMMERFELD À SA FEMME

UN « ACTE DE DÉSESPOIR »

L'histoire commence en réalité onze ans plus tôt. En 1900, Max Planck élabore une théorie fondée sur une idée révolutionnaire : le rayonnement et la matière n'échangent d'énergie que sous forme de petits paquets indivisibles. L'idée des « quanta d'énergie » est née. Le physicien allemand n'a pas trouvé d'autre alternative pour décrire certaines expériences. Mais sa théorie, en totale rupture avec l'approche classique, lui semble si incongrue qu'il la décrira lui-même comme un *« acte de désespoir »*.

Elle passe d'abord relativement inaperçue. Mais cinq ans plus tard, un jeune ingénieur du Bureau des brevets de Berne, un certain Albert Einstein, reprend et radicalise encore l'idée de Planck : ce ne sont pas seulement les échanges d'énergie qui sont granulaires, mais la nature même du rayonnement. La lumière elle-même serait formée de petits grains d'énergie, les fameux quanta, qu'on ne commencera à appeler « photons » que bien plus tard…

Un troisième personnage, bien moins célèbre qu'Einstein et Planck, joue ensuite un rôle-clé dans la genèse du premier conseil Solvay. En 1906, un physicien et chimiste allemand, Walther Nernst, établit de son côté un « théorème de la chaleur » qu'il tente de valider par une série d'expériences ambitieuses. Très vite, Nernst réalise que son travail ne prend toute son importance que dans le cadre des quanta.

« Walther Nernst a une grande ambition, raconte Franklin Lambert (Vrije Universiteit Brussel, Instituts Solvay), physicien, historien des sciences et exégète passionné de ce moment-clé de la physique. *Il veut le prix Nobel. Mais il sait que, pour cela, la théorie des quanta, alors très controversée, doit être validée au plus haut niveau. »* Pour que son propre génie soit reconnu, il faut que les idées de Planck et d'Einstein le soient préalablement !

Organiser une conférence chez lui, dans son Institut de Berlin, pour faire accepter la théorie d'un autre Allemand et conforter ainsi ses propres travaux ? *« Nernst comprend bien que ce serait cousu de fil blanc*, dit Franklin Lambert. *Il sait qu'il lui faut une autre solution. »* Il cherche donc une personnalité neutre comme initiateur et organisateur du congrès.

La « solution » de Nernst s'appelle Ernest Solvay. Ce riche industriel de la chimie, patron social et humaniste, passionné de sciences, est l'un des grands mécènes de son temps. Autodidacte génial, il a découvert un procédé de synthèse de la soude et a fondé en 1863 la société qui porte son nom. Elle est toujours, un siècle et demi plus tard, l'un des plus beaux fleurons de la chimie européenne.

Solvay est surtout un savant dans l'âme, lui-même auteur de remarquables intuitions, comme l'idée de l'équivalence entre la matière et l'énergie, qu'il formulera en 1887, dix-huit ans avant qu'un certain Albert Einstein ne l'établisse, l'incarnant dans l'équation la plus célèbre de la physique ($E = mc^2$). Epris de connaissance, profondément désireux de faire avancer le savoir, il fonde un institut de physiologie à l'Université libre de Bruxelles en 1894, puis une école de commerce, un institut de sociologie…

TERRAIN NEUTRE

Walther Nernst va voir Ernest Solvay et lui propose d'aider à la résolution de la crise que vit la physique. La crise est réelle : la théorie classique ne permet plus d'expliquer certains phénomènes et la théorie des quanta n'emporte pas le consensus. *« Ernest Solvay ressent lui-même la réalité de cette crise et veut participer à sa résolution »*, explique Jean-Marie Solvay, son arrière-arrière-petit-fils et président des Instituts Solvay qui continuent d'organiser, jusqu'à aujourd'hui, ces réunions au sommet de la physique et de la chimie.

Solvay reprend donc avec enthousiasme l'idée de Nernst : réunir les plus grands savants, les laisser confronter leurs idées, et se mettre d'accord sur la réalité des fameux quanta. Mais il amende la liste des invités préparée par Nernst et ajoute plusieurs Français qui n'étaient pas prévus au programme : sur l'insistance du mécène, Marie Curie, Marcel Brillouin et surtout Henri Poincaré seront de la partie. Ce choix sera déterminant.

Quant au lieu, il s'impose de lui-même. Solvay est belge, la réunion se tiendra en Belgique, terrain neutre, carrefour de l'Europe, frontière entre les cultures germanique et latine. Bruxelles, capitale de l'internationalisme naissant, sera la ville de la rencontre. Et si Bruxelles est la ville de la rencontre, alors le Métropole est une évidence.

« A l'époque, il n'y a tout simplement pas d'autre palace à Bruxelles », glisse Patrick Wielemans. En 1911, l'établissement est déjà une institution. Fondé en 1894 par les Wielemans, une grande famille de brasseurs qui investit au tournant du siècle dans la restauration et l'hôtellerie, l'établissement est un joyau de l'Art nouveau. En 1891, les frères Wielemans rachètent le grand bâtiment à l'imposante fa-

Le Monde – 31 July 2015

Le premier congrès Solvay, a réuni, en novembre 1911, à l'Hôtel Métropole de Bruxelles, 24 savants. Assis, de gauche à droite : Walther Nernst, Marcel Brillouin, Ernest Solvay (l'organisateur du congrès), Hendrik Lorentz, Emil Warburg, Jean-Baptiste Perrin, Wilhelm Wien, Marie Curie et Henri Poincaré. Debout : Robert Goldschmidt, Max Planck, Heinrich Rubens, Arnold Sommerfeld, Frederick Lindemann, Maurice de Broglie, Martin Knudsen, Friedrich Hasenöhrl, Georges Hostelet, Édouard Herzen, James Jeans, Ernest Rutherford, Heike Kamerlingh Onnes, Albert Einstein et Paul Langevin. BENJAMIN COUPRIE/SOLVAY INSTITUTES

Ci-contre, l'hôtel aujourd'hui. DR

çade haussmannienne blanche du 31, place de Brouckère, qui héberge alors les bureaux de la Caisse générale d'épargne et de retraites. Ils confient à l'architecte Gédéon Bordiaux sa transformation en hôtel de luxe, et à l'ornemaniste Alban Chambon la décoration et l'aménagement intérieurs. Ils leur laissent toute liberté.

Le résultat est une cathédrale – mais une cathédrale éclairée à l'électricité et chauffée à la vapeur. Colonnes, arcades, vitraux, miroirs et dorures partout, plafonds à caissons, lustres gigantesques ; bronze, stuc, bois précieux, fer forgé, brèche de Numidie… Chambon s'inspire de la Renaissance française pour le vestibule, de l'italienne pour la grande salle des fêtes, de l'art hindou pour le salon de réception, du style anglais pour le bureau et son interminable comptoir de teck derrière lequel scintillent, aujourd'hui encore, des rangées de ces lourdes et belles clefs argentées que la direction de l'hôtel a décidé de conserver en dépit de la triste mode des cartes magnétiques…

Chaque mètre carré de mur, de plafond, chaque chapiteau de colonne témoigne du talent et des heures de travail de centaines d'artisans. *« Lorsqu'on voit la minutie des ornements, le soin apporté au plus petit élément de décoration, on sait que nous n'irons plus jamais aussi loin dans le souci du détail. C'est quelque chose que nous avons perdu,* estime l'architecte et designer Hervé Langlais, directeur artistique de la Galerie Negropontes. *Les coûts que cela engendre sont devenus presque impossibles à assumer. »* Ce syncrétisme, ce foisonnement pourraient être écrasants. Il n'en est rien. Jusqu'à entrer dans l'ascenseur – confectionné par l'entreprise française Edoux, qui fit aussi ceux de la tour Eiffel –, le visiteur a toujours au-dessus de lui cinq, six, parfois sept mètres de plafond.

« Lorsque vous rêvez, que vous imaginez de nouvelles théories de la physique, c'est peut-être quelque chose qui peut aider », suggère Patrick Wielemans. Il ne croit pas si bien dire. *« Au départ, les savants devaient loger à l'hôtel et tenir leurs conférences dans l'amphithéâtre de l'Institut de physiologie du parc Léopold, mais ils ont préféré rester sur place »*, raconte Franklin Lambert. Ce ne sont pas de purs esprits. Au deuxième jour de congrès, Arnold Sommerfeld écrit à sa femme que le lieu où il est logé est *« prodigieusement chic ». « Chacun de nous a une baignoire privée et des toilettes dans sa chambre*, précise-t-il. *Je prends un bain tous les matins. Nous sommes les invités de M. Solvay, y compris aux repas. Pas moins de cinq plats à chaque déjeuner ! C'est fou ! »*

Une autre réflexion du physicien allemand à son épouse en dit long sur la nouveauté du congrès : *« Hier soir, j'avais un Français à ma droite, un Anglais à ma gauche et je leur parlais tour à tour ! »* L'étonnement de Sommerfeld devant ce qui est aujourd'hui une banalité montre que Solvay invente là une nouvelle manière de faire de la science : internationale, conviviale et dégagée des considérations politiques. Car réunir autour d'une même table, en 1911, des savants allemands, français et britanniques n'est pas anodin.

« PERSONNE N'Y VOIT CLAIR »

Il y a d'autres problèmes : à l'époque, nulle langue, comme l'anglais aujourd'hui, ne fait office de *lingua franca* scientifique. Mais par chance, Hendrik Lorentz, qui préside le conseil, n'est pas seulement un immense physicien. Il est aussi un polyglotte talentueux. Il traduit à la volée et facilite les échanges, passant de l'allemand au français, de l'anglais au néerlandais…

La convivialité du premier conseil Solvay a certainement joué un rôle important dans son succès. *« Einstein n'a que 32 ans et ce congrès sera pour lui une façon de faire son entrée officielle dans la communauté scientifique*, raconte Franklin Lambert. *Il nouera des liens d'amitié, avec Marie Curie, par exemple, et recevra des lettres de recommandation de plusieurs participants pour obtenir le poste qu'il convoite à Zurich. »*

Ces lettres montrent d'ailleurs, précise l'historien des sciences, que le jeune et fougueux Einstein *« a fasciné les autres membres du conseil par l'étendue de ses connaissances et la profondeur de son analyse des problèmes ». « En réalité, on peut dire que sa carrière est lancée par le premier conseil Solvay »*, ajoute Franklin Lambert. Einstein sort pourtant déçu du congrès qu'il présentait, dans une lettre à son ami et confident Michele Besso, comme un *« sabbat de sorcières »*. A l'issue de la réunion, il écrit à Besso : *« Personne n'y voit clair. Il y aurait dans toute cette affaire de quoi ravir une compagnie de jésuites démoniaques. »*

Le jeune physicien suisse déplore que Planck persiste à rejeter l'idée des quanta de lumière, au prétexte qu'elle conduirait à réformer la théorie de l'électromagnétisme de Maxwell et Lorentz. Il est aussi déçu du scepticisme d'Henri Poincaré. Mais Einstein se trompait – être un grand physicien n'interdit pas d'être médiocre psychologue. De retour à Paris, ce qu'il a entendu au Métropole continue de tarauder le grand chercheur français. Et, en 1912, Poincaré publie un article appuyant la théorie de Planck. Or, son prestige est tel que sa conversion jouera un rôle majeur dans l'acceptation de la théorie des quanta par la majorité des savants.

Le congrès laisse ouvertes de nombreuses questions, mais il permet le basculement vers une nouvelle physique. *« Tous les historiens de la physique moderne soulignent l'importance décisive du premier conseil Solvay pour la prise de conscience collective de l'importance des quanta, et pour le progrès de la théorie »*, écrivent Pierre Marage et Grégoire Wallenborn dans *La Naissance de la physique moderne racontée au fil des conseils Solvay* (Ed. de l'Université libre de Bruxelles, 2009). Les quanta seront l'élément central d'une nouvelle théorie – bizarre et contre-intuitive –, la mécanique quantique, qui devra attendre encore une vingtaine d'années pour voir pleinement le jour.

A l'issue du premier conseil Solvay, un compte rendu formel de plus de 400 pages sera publié, en français, et n'est toujours pas intégralement traduit en anglais… Mais il ne dit rien de la manière dont les débats se sont déroulés. Quelles questions ont-elles été posées ? Par qui ? A quel moment ? Les réponses n'ont pas encore été vraiment apportées par les historiens des sciences. Elles existent pourtant.

Pendant les conférences, le physicien français Maurice de Broglie, qui fait office de secrétaire, récupère toutes les petites notes prises sur le vif par les savants pendant leurs débats,

QUI DORMAIT DANS QUELLE CHAMBRE ? ON NE LE SAURA PAS, LES ARCHIVES DE L'HÔTEL AYANT PROBABLEMENT ÉTÉ DÉTRUITES. CELA N'A GUÈRE D'IMPORTANCE, MAIS C'EST POURTANT LA SEULE QUESTION QUI, À L'ÉPOQUE, INTÉRESSE LA PRESSE

les rassemble et les colle dans un cahier avec ses propres commentaires – un témoignage unique de ce qui s'est dit au Métropole ces jours-là… Ce registre est aujourd'hui conservé à l'Institut de France. Il n'a pas livré tous ses secrets et les Instituts Solvay ne font pas mystère de leur désir d'en obtenir copie pour leurs archives.

LYNCHAGE MÉDIATIQUE

Quant à celles du Métropole, elles ont disparu, sans doute détruites pendant la seconde guerre mondiale. Qui dormait dans quelle chambre ? On ne le saura pas. Cela n'a guère d'importance, mais c'est pourtant la seule question qui, à l'époque, intéresse la presse. Et surtout la presse conservatrice.

Car le 4 novembre 1911, de retour de Bruxelles, Marie Curie trouve, massée devant sa maison de Sceaux, un petit attroupement. Une foule hostile lui crie des insultes. Le quotidien nationaliste *Le Journal*, l'un des plus gros tirages de l'époque, vient de révéler en « une » sa liaison avec Paul Langevin. Elle est veuve depuis cinq ans, et Paul Langevin est séparé de son épouse, mais Fernand Hauser, l'auteur de l'article, n'en a cure. Il met tout à l'encan. Il aurait bien fait réagir les deux scientifiques mais, écrit-il, *« Mme Curie est introuvable, et nul ne sait où se trouve M. Langevin »*. Alors qu'il peaufine son brûlot, les deux savants sont à Bruxelles, avec leurs pairs, à discuter des quanta.

Dans le lynchage qui se poursuit les semaines suivantes – en dépit de son second prix Nobel, annoncé le 7 novembre –, les lecteurs de journaux retiendront surtout que Marie Curie et Paul Langevin étaient, ensemble, dans un luxueux hôtel bruxellois…

Fernand Hauser finira par faire, publiquement, de sincères excuses à Marie Curie pour avoir allumé l'incendie. Trop tard. *L'Œuvre* et *L'Action française* alimentent le scandale et fustigent *« l'étrangère »*, la *« Polonaise »* (elle est née en Pologne), *« la veuve adultère »* et vont, flattant l'antisémitisme de leurs lecteurs, jusqu'à lui inventer des origines juives. L'affaire n'est pas précisément à la gloire de la profession. *« Aucun journal n'a parlé, à l'époque, du premier conseil Solvay pour ce qu'il signifiait réellement pour l'avenir de la physique*, rappelle Marina Solvay, arrière-arrière-petite-fille d'Ernest, et qui met la dernière main à un livre sur le sujet. *Tout ce qu'on y a vu c'est une femme entourée d'hommes. »*

Le 23 novembre, depuis Prague, Albert Einstein fait une belle lettre à la savante française, qui montre que le premier conseil Solvay fut aussi le creuset de solides amitiés. Il se dit *« furieux »* du tort qui lui est fait. *« Je me sens le besoin de vous dire combien j'ai appris à admirer votre intelligence, votre énergie et votre intégrité, et que je me considère chanceux d'avoir pu vous rencontrer personnellement à Bruxelles*, ajoute-t-il. *Si cette racaille s'occupe encore de vous, cessez simplement de lire ces sottises. Laissez-les aux vipères pour qui elles ont été fabriquées. »*

Des amitiés savantes qui enjambent le Rhin, une nouvelle physique : le conseil Solvay a tenu ses promesses. Quant à Walther Nernst, il aura en 1920 le prix Nobel de chimie qu'il convoitait. Deux ans après que le grand Planck eût reçu celui de physique, pour la paternité des quanta. ■

Prochain article : « Tempête diplomatique à l'Intercontinental de Genève »

Changer le monde : tel est le thème de l'édition 2015 du Monde Festival qui se tiendra les 25, 26 et 27 septembre à Paris. Retrouvez le programme sur Lemonde.fr/festival/

JOZEF ONGENA (KONINKLIJKE MILITAIRE SCHOOL) OVER HET EUROPESE ENERGIEBELEID

'Er is meer correcte informatie

Europa moet het goede voorbeeld blijven geven in het klimaatdebat, maar het beleid moet realistischer worden, vindt fysicus Jozef Ongena. *Luc I*

"Europa heeft een gemeenschappelijk energiebeleid nodig, dat met de cijfers in de hand lessen trekt uit het verleden en zijn aanpak corrigeert." Plasmafysicus Jozef Ongena, onderzoeksdirecteur aan de Koninklijke Militaire School en voorzitter van de Energy Group van de European Physical Society (EPS), weet zich in zijn uitspraken gesteund door de overgrote meerderheid van de ruim 130.000 EPS-leden.

In de aanloop naar de klimaattop in Parijs in december, verzamelt de EPS in Brussel (zie kader *'België is belangrijk voor fysica'*). "De beleidsmakers mikken op een globaal klimaatakkoord, maar de doelstellingen zouden wetenschappelijk beter onderbouwd moeten zijn. Er is een gebrek aan correcte informatie, ook bij het grote publiek."

De vereniging stuurde enkele weken geleden een rapport met haar grieven naar diverse Europese leiders en instellingen, inclusief de Europese Commissie, regeringsleiders en de paus, die zich tijdens zijn recente rondreis in de Verenigde Staten uitsprak over het thema. "De wereldbevolking groeit", schetst Ongena. "Er zal behoefte zijn aan meer energie. Tegelijk moet er iets gebeuren aan de pollutie. Steden als Peking en Chengdu in China hangen onder een permanente laag smog door de massale verbranding van steenkool."

Daar werkt Europa toch aan? Het klimaatplan wil de broeikasgasemissies in de elektriciteitssector tegen 2030 terugdringen met 60 procent, en tegen 2050 met 95 procent.

JOZEF ONGENA. "Nu halen we ongeveer de helft van onze elektriciteit uit fossiele brandstoffen: olie, gas, kolen. Ik betwijfel of we die tegen 2050 allemaal kunnen vervangen door hernieuwbare energie. En zelfs als we daarin slagen, dan is het risico op ontwrichting in de elektriciteitsvoorziening groot. De mensen moeten die consequenties kennen, en ze aanvaarden.

"Die omschakeling zal niet goedkoop zijn. Duitsland heeft vele miljarden geïnvesteerd in wind- en zonne-energie. Als het altijd waait en de zon altijd schijnt, dan zouden de molens en panelen het volledige elektriciteitsverbruik van onze oosterburen dekken. Maar wind was vorig jaar goed voor slechts 8,6 procent van de geproduceerde stroom, en zon voor 5,5 procent.

"Dat brengt een ander probleem met zich: wat als er geen zon of wind is? Dan heb je back-upsystemen nodig. Het meest klimaatvriendelijk zijn nucleaire reactoren en gascentrales, maar in Duitsland zijn de jongste jaren alleen kolencentrales gebouwd. En als er te veel wind of zon is, moeten de Duitsers zelfs hun buren betalen om hun stroom af te nemen."

Duitsland subsidieert nu massaal de aanschaf van batterijen voor de eigenaars van hernieuwbare-energieproductie.

ONGENA. "We hebben berekend hoeveel batterijen Duitsland nodig zou hebben om bij 100 procent groene energie genoeg opslag te hebben voor windstille en donkere periodes: meer dan 8000 autobatterijen per persoon. Wie gaat dat betalen? Iedereen hoopt op een doorbraak in opslagtechnologie, maar je mag er niet zomaar van uitgaan dat die er ook zal komen.

nodig'

Huysmans, fotografie Eny Elleboog

JOZEF ONGENA

Geboren in Sint-Niklaas (1958)

Doctoraat fysica aan de Universiteit Gent

Werkt samen met het Duitse Forschungszentrum Jülich en Max-Planck Institut, met JET (Joint European Torus, grootste kernfusielaboratorium ter wereld) in het Britse Culham, en met het in aanbouw zijnde ITER in Cadarache in Frankrijk.

Onderzoeksdirecteur Koninklijke Militaire School, voorzitter Energy Group European Physical Society

JOZEF ONGENA "Iedereen hoopt op een doorbraak in opslagtechnologie, maar je mag er niet zomaar van uitgaan dat die er zal komen."

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actua energie

"Een van de mogelijke oplossingen is elektriciteit niet op te slaan in batterijen, maar in waterstof, die kan worden gebruikt voor transport. Maar dat vraagt grote veranderingen aan het distributienet. Hetzelfde geldt voor de opslag van elektriciteit als gas.

"Momenteel halen we onze energie uit drie hoofdbronnen: fossiel, nucleair en hernieuwbaar. Je moet er rekening mee houden dat we met die drie bronnen moeten voortdoen. Tegelijk moet er veel meer worden ingezet op onderzoek naar hernieuwbare energie, opslag van elektriciteit, *carbon capture and storage* (opslag van CO2 in bijvoorbeeld oude koolmijnen, *nvdr*), enzovoort."

U gelooft niet in het Europese energiebeleid?

ONGENA. "Ik denk dat wat Europa heeft gedaan, zeer moedig en interessant was. Maar er moet een aantal zaken worden gecorrigeerd. Europa laat de landen vrij hun doelstellingen te halen, terwijl er net één globaal energiebeleid nodig is. En er is meer correcte informatie nodig, bij de beleidsmakers én het grote publiek. Dat is hét probleem.

"Om de bruinkoolcentrale van Weisweiler (tussen Aken en Keulen, *nvdr*), met een vermogen van 2200 megawatt, te vervangen moet je een volledige Belgische provincie volbouwen met windmolens van het grootste type dat nu commercieel verkrijgbaar is. Dus ja, hernieuwbare energie is absoluut een deel van de oplossing, maar de uitrol gebeurt nu veel te massief."

Nochtans streeft Europa in Parijs naar een wereldwijd akkoord.

ONGENA. "Er wordt van uitgegaan dat dat er ook komt, maar zeker ben ik daar niet van. Europa zou beter rekening houden met wat er in de andere landen gebeurt. De Europese Unie is goed voor 10 procent van de uitstoot van de broeikasgassen in de wereld, waarvan ongeveer een derde voor rekening van de elektriciteitssector is. Als die sector in Europa volledig groen is, heb je op wereldniveau 3 procent bespaard. Dat is zinvol, maar blijft marginaal, want intussen stijgen de emissies in China, India, Zuid-Korea en elders veel sneller. Europa stelt een voorbeeld, maar moet andere landen overtuigen dat zijn beleid zinvol is."

In uw redenering moet kernenergie een deel van de mix blijven. Tot nader order sluit de laatste kerncentrale in België in 2025.

ONGENA. "Ik denk dat het een van de drie hoofdbronnen moet blijven. Ik kijk vooral uit naar de mogelijkheden van kernfusie. Daarvoor is weinig brandstof nodig om veel energie te produceren. Het eindproduct is helium, een ongevaarlijk en niet-radioactief edelgas. Het enige afval zou de metalen structuur van de reactor zijn, en we streven nu naar een ontwerp dat recyclage na honderd jaar mogelijk zou maken. Wat we willen doen met ITER (de testreactor in het Franse Cadarache, *nvdr*), is de zon op kleine schaal reproduceren op aarde. Maar dat zal tijd vergen. De eerste resultaten verwachten we in 2030-2035. Daarna moeten we de data verzamelen en testen, en een reactor bouwen. Dan hebben we tegen 2065 misschien één commerciële kernfusie-centrale."

Tegen dan leven we misschien in een 100 procent hernieuwbare wereld.

ONGENA. "In de elektriciteitssector zitten we nu aan 23 procent. Met de huidige technologie kan je maximaal naar 30 tot 40 procent hernieuwbare energie gaan. Ga je daarboven, dan jaag je jezelf op kosten zonder dat het land daar voordeel bij heeft.

"De EPS is tegen geen enkele technologie, maar iedereen moet wel de cijfers kennen. Het stoort me dat veel mensen slecht of zeer eenzijdig zijn geïnformeerd. Dan voer je een discussie die op lucht is gebaseerd. Over energie heeft iedereen een zwarte of witte mening, terwijl het juist zeer grijze materie is. Het zou niet slecht zijn als iedereen in het laatste jaar middelbaar onderwijs les in energietechniek zou krijgen." ®

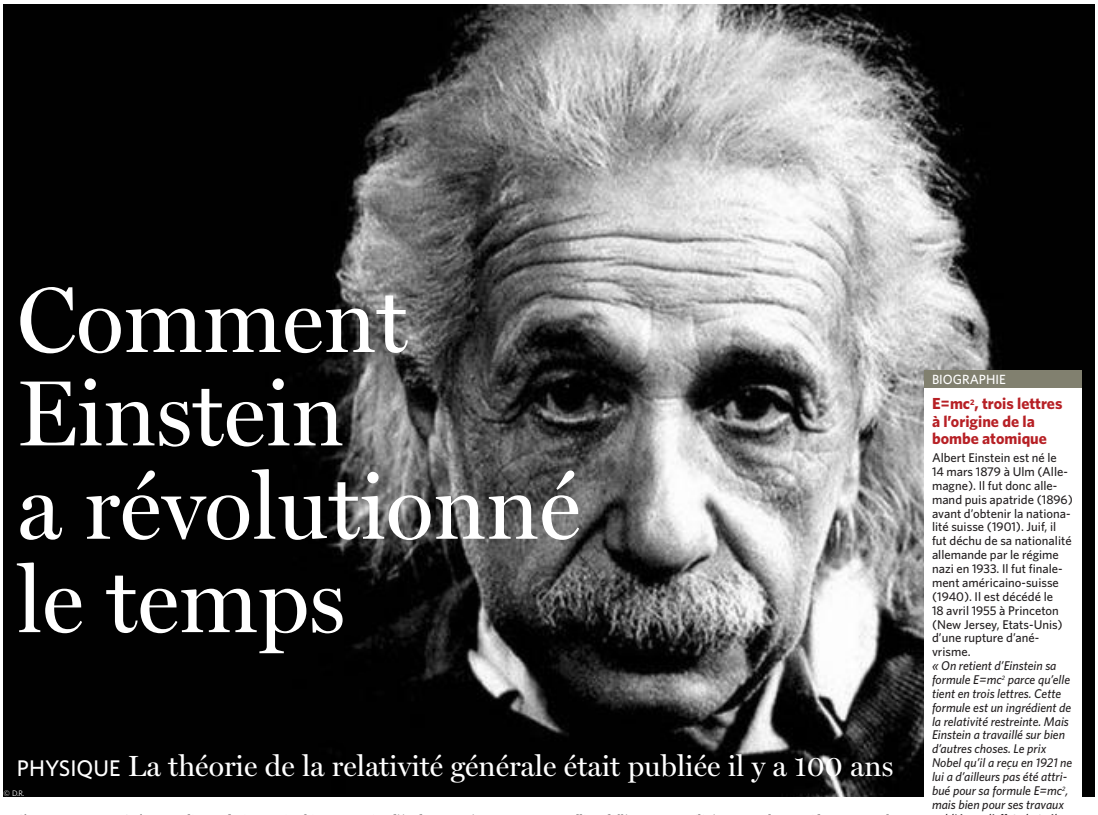
'BELGIË IS BELANGRIJK VOOR FYSICA'

De Belgische Natuurkundige Vereniging onthult, samen met de Internationale Solvay Instituten en de European Physical Society, op 24 oktober een herdenkingsplaat in het Brusselse Hotel Métropole. Daar werd in 1911 de eerste Solvay-conferentie gehouden. Onder de 24 briljante geesten die op uitnodiging van de industrieel Ernest Solvay bijeenkwamen om te discussiëren over fysica, waren er negen die later een Nobelprijs zouden winnen, onder wie Albert Einstein, Max Planck, Marie Curie en Hendrik Lorentz.

De Solvay-conferenties die daaruit volgden, legden de basis voor de kwantummechanica. "Daaruit zijn heel veel moderne toepassingen ontstaan", zegt Jozef Ongena. "Onder meer transistors, die leidden tot chips, en het internet, kernenergie, scanners, deeltjesfysica, de gps, ledlampen en uw smartphone."

Er worden nog altijd Solvay-conferenties rond fysica en scheikunde gehouden. "België is nog altijd een belangrijk land voor fysica. Denk maar aan François Englert, die in 2013 met de Nobelprijs won voor het Higgsdeeltje. Het blijft belangrijk dat onze jeugd zich aan de wetenschap wil wijden."

"Hernieuwbare energie is een deel van de oplossing, maar de uitrol gebeurt nu veel te massief"



Comment Einstein a révolutionné le temps

PHYSIQUE La théorie de la relativité générale était publiée il y a 100 ans

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▶ Il y a juste un siècle, Albert Einstein bouleversait la théorie de la gravitation énoncée par Isaac Newton en 1686.

▶ Sans sa théorie de la relativité générale, nos GPS se tromperaient d'une dizaine de kilomètres.

Tout est relatif. Enfin, en tout cas, le temps et l'espace. Il y a tout juste un siècle, Albert Einstein venait chambouler notre conception de ces deux notions fondamentales en publiant sa théorie de la gravitation appelée théorie de la relativité générale.

Jusqu'alors, il y avait une théorie de la gravitation : celle d'Isaac Newton, le chercheur à la pomme. C'est celle qu'on appelle la loi de la gravitation universelle. Mais en 1915, Einstein propose une nouvelle théorie de la gravitation et vient ainsi bouleverser la théorie de la gravitation de Newton énoncée en 1686.

Dans la théorie de Newton, le Soleil crée un champ de gravitation et la Terre, qui est dans son voisinage, se voit imprimer une force qui lui donne sa trajectoire elliptique. Selon la théorie d'Einstein, il n'y a plus de force de gravitation. Mais le Soleil, par sa masse, déforme l'espace-temps. La Terre, elle, est libre de ses mouvements. Elle devrait donc avoir une trajectoire rectiligne mais comme l'espace-temps est déformé par le Soleil, cette trajectoire n'est plus une ligne droite mais bien une courbe. Et c'est ainsi que la Terre tourne autour du Soleil. *« C'est comme si on mettait une pomme (le Soleil) sur une nappe (l'espace-temps) »*, illustre Stéphane Detournay, chercheur qualifié FNRS au sein du Service de physique mathématique des interactions fondamentales de l'ULB. La pomme irait s'enfoncer dans la nappe. Ensuite, si on met une bille (la Terre) dans cette nappe, cette dernière va tourner autour de la pomme.

Quelques anomalies

John Wheeler, un physicien américain, a résumé la théorie d'Einstein par cette phrase : *« Matter tells spacetime how to curve, and curved spacetime tells matter how to move »* (« La matière dit à l'espace-temps comment se courber, et l'espace-temps dit à la matière comment se déplacer. »)

« Lorsque Einstein est arrivé à cette formule en 1915, la théorie de Newton fonctionnait en général très bien. Pour expliquer le mouvement des planètes par exemple. Mais elle avait quelques anomalies. Ainsi, elle ne permettait pas d'expliquer pourquoi on se trompait chaque année au moment de prévoir le point où allait se trouver Mercure à son périhélie (lorsque Mercure se trouve au plus près du Soleil, NDLR). *Celui-ci se décalait en effet. Or, la théorie d'Einstein permet d'expliquer la trajectoire de Mercure. La théorie de la relativité générale a permis aussi de prédire l'existence des trous noirs dès 1916* (avant que ceux-ci ne deviennent un sujet d'étude, NDLR). *Mais pour vous et moi, ce n'est peut-être pas important de comprendre où se trouve le périhélie de Mercure d'année en année »*, reconnaît Stéphane Detournay.

Mais la théorie fournit d'autres enseignements. Ainsi, elle permet de démontrer que notre univers est en expansion. Mais cela allait à l'encontre de l'intuition d'Einstein qui estimait que l'univers était statique. Contrarié par le résultat de sa formule – selon laquelle soit l'univers s'effondre, soit il s'étend –, il décide d'apporter une petite modification pour coller au scénario d'un univers statique. Il utilise pour cela une variable qui, en fonction de la valeur qu'on lui attribue, permet d'avoir un univers qui s'effondre, qui est statique ou qui s'étend. Il reconnaîtra par la suite que cette modification, appelée la constante cosmologique, a été *« la plus grande erreur de* [s]*a vie »*.

C'est finalement le Belge Georges Lemaître qui démontra que l'univers était effectivement en expansion.

Et si l'expansion de l'univers ne vous concerne pas non plus de tout près, voici une autre conséquence très concrète de la théorie d'Einstein. *« Les GPS ! »*, s'exclame Stéphane Detournay.

Le GPS envoie un signal à des satellites. Ces derniers calculent notre position en se basant sur le temps que met le signal à leur parvenir. En sachant que la vitesse du signal est celle de la lumière et en prenant en compte le temps, ils peuvent alors calculer la distance qui les sépare de l'utilisateur. Pour corroborer la position du conducteur, deux à trois satellites différents sont utilisés.

Quel est le lien avec Einstein ? Si on ne prend pas en compte l'un des enseignements du chercheur, à savoir que le temps est relatif, on ne pourrait pas se fier aux GPS.

Pour comprendre cet enjeu, il faut revenir un instant sur ce postulat d'Einstein. Le savant a en effet formulé, dans sa théorie de la relativité restreinte, que le temps est modifié par la vitesse. Ainsi, il ne s'écoule pas de la même manière pour une personne immobile sur le quai d'une gare que pour quelqu'un qui se trouve à bord d'un train. Pour le passager du train, le temps s'écoulera plus lentement. A la vitesse d'un train, cette différence est infime mais elle peut être calculée.

Trois millisecondes plus jeune

Autre illustration : fin mars 2015, un astronaute américain a été envoyé dans la Station spatiale internationale pour 342 jours tandis que son frère jumeau, également astronaute, reste sur Terre pendant la même période. A la fin des 342 jours, celui qui a séjourné dans l'ISS reviendra plus jeune de quelque 3 millisecondes par rapport à son frère.

Dans la théorie de la relativité générale, Einstein intègre la gravité et montre que le temps est également influencé par ce facteur. Il ralentit lorsqu'il est à proximité d'un corps massif. Ainsi, au plus on s'éloigne du centre de la Terre, au plus le temps s'accélère. Le temps s'écoule donc plus rapidement en haute montagne qu'à la mer. Et plus rapidement en haut d'une tour qu'au rez-de-chaussée. Les variations peuvent être mesurées mais sont tellement infimes qu'elles ne sont bien sûr pas ressenties.

Si on ne prenait pas en compte le fait que le temps sur Terre diffère du temps là où se trouvent les satellites, les GPS se tromperaient de 10 kilomètres quant à notre position. *« Imaginez ce que cela représente pour un avion qui doit atterrir… »*, note Stéphane Detournay.

Et pourtant, *« comme tout chercheur théoricien, Einstein ne cherchait pas à ce que ses formules aient des implications sur le quotidien des gens »*, poursuit-il.

Mais peut-on imaginer qu'un jour la théorie d'Einstein soit remplacée par une autre ? Comme elle l'a fait avec la théorie de Newton ? *« La théorie d'Einstein n'a pas remplacé celle de Newton*, précise Stéphane Detournay. *La loi de gravitation universelle reste valable dans un certain nombre de domaines, comme le mouvement des planètes. Aujourd'hui, on sait que la loi d'Einstein a certaines limites. Ainsi, elle ne permet pas d'expliquer ce qu'il s'est passé au moment du Big Bang ou ce qu'il se passe au centre d'un trou noir. La théorie de la relativité générale ne se combine pas avec la théorie quantique des champs. Habituellement, on ne doit pas combiner ces deux théories sauf dans le cas des trous noirs par exemple. On cherche, pour ce type de domaines, d'autres théories comme la théorie des cordes. Mais les recherches n'annuleront pas la théorie d'Einstein. »* ■

VIOLAINE JADOUL

BIOGRAPHIE

E=mc², trois lettres à l'origine de la bombe atomique

Albert Einstein est né le 14 mars 1879 à Ulm (Allemagne). Il fut donc allemand puis apatride (1896) avant d'obtenir la nationalité suisse (1901). Juif, il fut déchu de sa nationalité allemande par le régime nazi en 1933. Il fut finalement américaino-suisse (1940). Il est décédé le 18 avril 1955 à Princeton (New Jersey, Etats-Unis) d'une rupture d'anévrisme.

« On retient d'Einstein sa formule E=mc² parce qu'elle tient en trois lettres. Cette formule est un ingrédient de la relativité restreinte. Mais Einstein a travaillé sur bien d'autres choses. Le prix Nobel qu'il a reçu en 1921 ne lui a d'ailleurs pas été attribué pour sa formule E=mc², mais bien pour ses travaux publiés sur l'effet photoélectrique. Or, ceux-ci ont été publiés dans la même revue et la même année que d'autres papiers sur le mouvement brownien ou la relativité restreinte », souligne Stéphane Detournay, chercheur qualifié FNRS à l'ULB. Le Comité Nobel n'a donc pas reconnu au savant le fait qu'il avait révolutionné la notion du temps et de l'espace.

Notons encore que c'est la formule E=mc² qui a permis la création des réacteurs nucléaires mais aussi des bombes. En 1939, Einstein signe une lettre, écrite par les physiciens Léo Szilard et Eugène Wigner, destinée au président américain Roosevelt. Il y est fait mention de la possibilité de créer des bombes extrêmement puissantes à partir des recherches des chercheurs. Cette lettre contribuera au lancement du projet Manhattan qui produisit la première bombe atomique durant la Seconde Guerre mondiale. En 1945, il écrit une nouvelle lettre au président pour lui demander de renoncer à cette arme. Il confessera à Linus Pauling (un chimiste et physicien américain qui reçut en 1962 le prix Nobel de la Paix pour sa campagne contre les essais nucléaires) peu avant sa mort, qu'il avait *« fait une grande erreur »* lorsqu'il a signé cette lettre de 1939.

V.J.A.

Le Soir – 19 September 2015

DAILY SCIENCE

dailyscience.be http://dailyscience.be/2015/12/01/dix-chercheurs-belges-recompenses-pour-lexcellence-de-leurs-travaux/

Dix chercheurs belges récompensés pour l'excellence de leurs travaux

Lundi à Bruxelles, le Fonds de la Recherche Scientifique (F.R.S-FNRS) et son pendant flamand, le Fonds Wetenschappelijk Onderzoek (FWO), ont remis leurs prix scientifiques quinquennaux à dix chercheurs belges à la carrière remarquable.

Ces Prix prestigieux, remis aux lauréats par le Roi Philippe, confirment la reconnaissance internationale de ces scientifiques dans toutes les disciplines scientifiques et marquent le couronnement de leur carrière. Tous ont été choisis par des jurys composés exclusivement d'experts étrangers.

L'ULB et l'UMONS à l'honneur

En Fédération Wallonie-Bruxelles, quatre chercheurs de l'Université Libre de Bruxelles, les Pr Marc Henneaux, Axel Cleeremans, Cédric Blanpain et le Dr Christos Sotiriou, ainsi qu'un chercheur de l'Université de Mons, le Pr Philippe Dubois, sont ainsi récompensés pour leurs travaux exceptionnels.

Des recherches fondamentales indispensables à la Société

Comme le rappelait Véronique Halloin, Secrétaire générale du F.R.S-FNRS, c'est la recherche fondamentale qui est ainsi récompensée et de son caractère indispensable en ce qui concerne les progrès de la Société.

« Les retombées directes de la recherche fondamentale sont nombreuses », a expliqué le Dr Halloin, lors de la cérémonie de remise des prix. « Il s'agit évidemment de nouvelles connaissances scientifiques, exposées dans les publications. Mais aussi de la formation de scientifiques de haut niveau dans tous les domaines et de la qualité de l'enseignement dans nos universités dont la spécificité est de se nourrir de la recherche ».

Daily Science – 1 December 2015

Overview of the **Institutes** through **selected data**

The Solvay Conferences on Physics

1911	Radiation theory and the quanta
1913	The structure of matter
1921	Atoms and electrons
1924	Electric conductivity of metals
1927	Electrons and photons
1930	Magnetism
1933	Structure and properties of the atomic nuclei
1948	Elementary particles
1951	Solid state
1954	Electrons in metals
1958	The structure and evolution of the universe
1961	Quantum Field Theory
1964	The structure and evolution of galaxies
1967	Fundamental problems in elementary particle physics
1970	Symmetry properties of nuclei
1973	Astrophysics and gravitation
1978	Order and fluctuations in equilibrium and nonequilibrium statistical mechanics
1982	Higher energy physics: What are the possibilities for extending our understanding of elementary particles and their interactions to much greater energies?
1987	Surface science
1991	Quantum optics
1998	Dynamical systems and irreversibility
2001	The physics of communication
2005	The quantum structure of space and time
2008	Quantum theory of condensed matter
2011	The theory of the quantum world
2014	Astrophysics and Cosmology

Chairs of the International Scientific Committee for Physics since the first Solvay Conference on Physics

1911 - 1928	Hendrik Lorentz, 1902 Nobel Laureate in Physics, Haarlem (The Netherlands)
1928 - 1946	Paul Langevin, Paris (France)
1946 - 1962	Sir Lawrence Bragg, 1915 Nobel Laureate in Physics, Cambridge (UK)
1962 - 1967	Robert Oppenheimer, Princeton (USA)
1967 - 1968	Christian Møller, Copenhagen (Denmark)
1969 - 1980	Edoardo Amaldi, Rome (Italy)
1980 - 1990	Léon Van Hove, Genève (Suisse)
1992 - 2006	Herbert Walther, Munich (Germany)
2006 - present	David Gross, 2004 Nobel Laureate in Physics, Santa Barbara (USA)

The Solvay Conferences on Chemistry

1922	Five topical questions in chemistry
1925	Chemical structure and activity
1928	Topical questions in chemistry
1931	Constitution and configuration of organic molecules
1934	Oxygen : chemical and biological reactions
1937	Vitamins and Hormons
1947	Isotops
1950	Oxidation mechanism
1953	Proteins
1956	Some problems in mineral chemistry
1959	Nucleoproteins
1962	Energy transfer in gases
1965	Reactivity of the Photoexited Organic Molecule
1969	Phase Transitions
1972	Electrostatic Interactions and Structure of Water
1976	Molecular Movements and Chemical Reactivity as conditioned by Membranes, Enzymes and other Molecules
1980	Aspects of Chemical Evolution
1983	Design and Synthesis of Organic Molecules Based on Molecular Recognition
1987	Surface Science
1995	Chemical Reactions and their Control on the Femtosecond Time Scale
2007	From Noncovalent Assemblies to Molecular Machines
2010	Quantum effects in chemistry and biology
2013	New Chemistry and New Opportunities from the Expanding Protein Universe

Chairs of the International Scientific Committee for Chemistry since the first Solvay Conference on Chemistry

1922 - 1939	Sir William Pope, Cambridge (UK)
1945 - 1958	Paul Karrer, 1937 Nobel Laureate in Chemistry, Zürich (Switzerland)
1958 - 1988	Alfred Ubbelohde, London (UK)
1989 - 2011	Stuart Rice, Chicago (USA)
2011 - present	Kurt Wüthrich, 2002 Nobel Laureate in Chemistry, Zürich (Switzerland) and La Jolla (USA)

The International Solvay Chairs in Physics and in Chemistry

Jacques Solvay Chair in Physics

2006 Ludwig Faddeev, Saint-Petersburg (Russia)

2007 Michael Berry, Bristol (UK)

2008 David Gross, Santa Barbara (USA)
2004 Nobel Laureate in Physics

2009 Valery Rubakov, Moscow (Russia)

2010 Serge Haroche, Paris (France)
2012 Nobel Laureate in Physics

2011 Nathan Seiberg, Princeton (USA)

2012 Jan Zaanen, Leiden (The Netherlands)

2013 Gian Giudice, CERN (Switzerland)

2014 Viatcheslav F. Mukhanov, LMU Munich (Germany)

2015 Peter Zoller, Innsbruck (Austria)

Solvay Chair in Chemistry

2008 Richard Saykally, Berkeley (USA)

2009 Alexander Mikhailov, Berlin (Germany)

2010 Weitao Yang, Durham (USA)

2011 Jean-Luc Brédas, Atlanta (USA)

2012 Viola Vogel, Zürich (Switzerland)

2013 Egbert Meijer, Eindhoven (The Netherlands)

2014 Richard Schrock, MIT (USA)
2005 Nobel Laureate in Chemistry

2015 Andreas Manz, KIST Europe, Saarbrücken (Germany)

2011 Solvay Centenary Chair

David Gross, Santa Barbara (USA)
2004 Nobel Laureate in Physics

Presidents and Directors

Ernest Solvay, his son Armand Solvay and his grand-son Ernest-John Solvay successively presided over the destiny of the International Solvay Institutes until 1958. In 1958, the Institutes were restructured with the creation of the positions of “President” and “Director”.

Presidents

1958 - 2010	Jacques Solvay
2010 - present	Jean-Marie Solvay

Directors

1958 - 2003	Ilya Prigogine (Professor ULB, 1977 Nobel Laureate in Chemistry)
2003 - 2004	André Jaumotte (Honorary Rector and Honorary President ULB)
2004 - present	Marc Henneaux (Professor ULB)

The Solvay Public Lectures

22 June 2005

"From Quarks to the Quantization of Gravitation: Challenges and Obstacles in our Search for the Fundamental Forces"
by Gerard 't Hooft (Utrecht), 1999 Nobel Laureate in Physics

"From Structural Biology to Structural Genomics: New Challenges for Physics and Chemistry in the Post-Genomic Era"
by Kurt Wüthrich (Zürich and La Jolla), 2002 Nobel Laureate in Chemistry

4 December 2005

"Strings, Black Holes and the End of Space and Time"
by Robbert Dijkgraaf (Amsterdam)

"The Fabric of the Cosmos, Space, Time and the Texture of Reality"
by Brian Greene (New York)

20 May 2007

"The Origin of the Universe"
by Stephen Hawking (Cambridge, UK)

"Architecture in Nanospace"
by Harold Kroto (Brighton), 1996 Nobel Laureate in Chemistry

2 December 2007

Chemistry? More than ever!

"De la Matière à la Vie: la Chimie? La Chimie!"
by Jean-Marie Lehn (Paris and Strasbourg), 1987 Nobel Laureate in Chemistry

12 October 2008

Images from the Quantum World

"New Forms of Quantum Matter near Absolute Zero Temperature"
by Wolfgang Ketterle (Cambridge, USA), 2001 Nobel Laureate in Physics

"Visualizing Complex Electronic Quantum Matter at Atomic Scale"
by J.C. Seamus Davis (Ithaca, USA)

4 October 2009

"VIH/SIDA, une aventure scientifique et humaine en réponse à une épidémie émergente"
by Françoise Barré-Sinoussi (Paris), 2008 Nobel Laureate in Medecine

17 October 2010

Chemistry: at the crossroads of Physics and Biology

"The magnetic compass of birds and its physical basis"
by Wolfgang Wiltschko (Frankfurt am Main)

"Experimental surprises and their solutions in theory"
by Rudolph Marcus (Pasadena), 1992 Nobel Laureate in Chemistry

23 October 2011

The Future of Physics

"Time and Einstein in the 21st century"
by William Phillips (College Park), 1997 Nobel Laureate in Physics

"Quantum Beauty"
by Frank Wilczek (Cambridge, USA), 2004 Nobel Laureate in Physics

21 October 2012

"The Science of Simplicity"
by George Whitesides (Cambridge, USA)

"Will our Thinking Become Quantum-Mechanical?"
by Michael Freedman (Santa Barbara), 1986 Recipient of the Fields Medal

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