INTERNATIONAL
SOLVAY
INSTITUTES
BRUSSELS

ANNUAL REPORT

2014

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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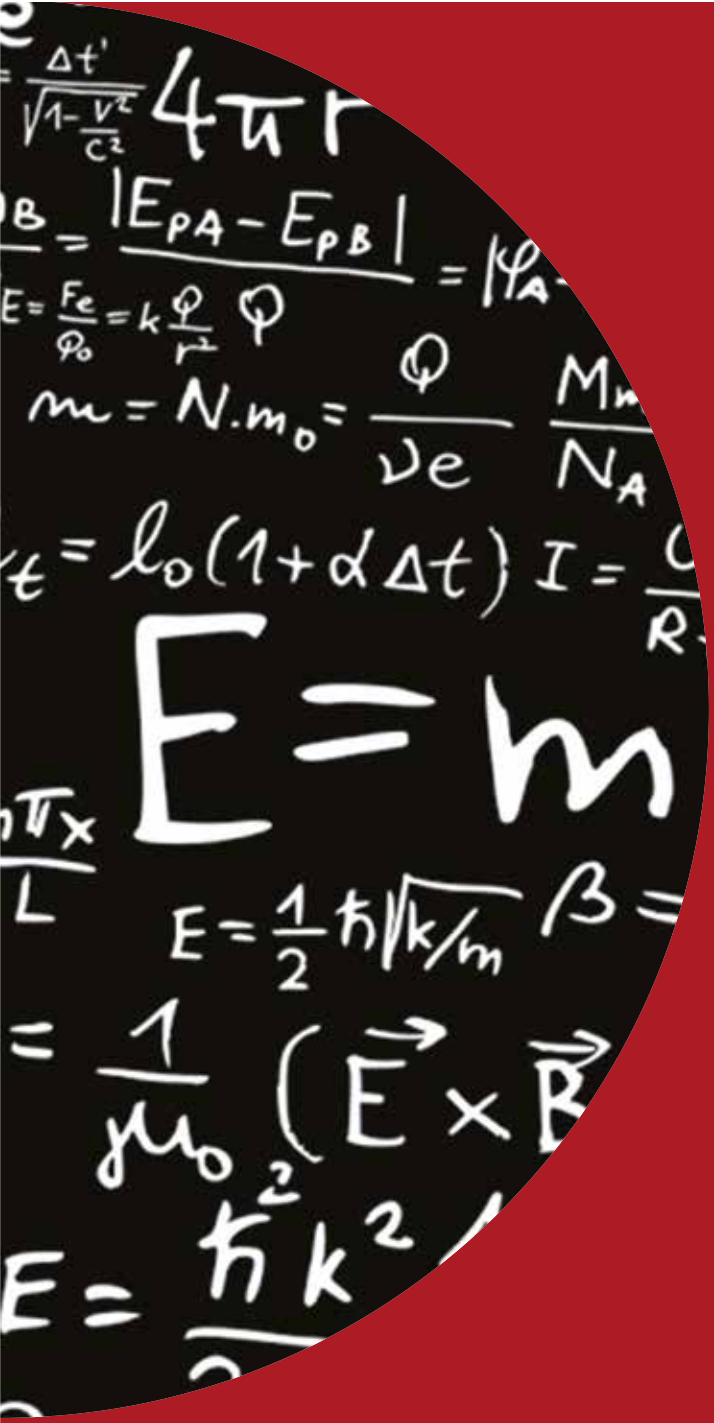

There are **no limits**
to what **science** can explore.

Ernest Solvay

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

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A **word** from the **President**

The 26th Solvay Conference on Physics stands out for me very strongly in remembering this last year 2014.

I am very pleased that after a 41 years interruption, the Solvay Institutes has again held a conference on Astrophysics and Cosmology. This very important topic in fundamental physics had not been debated since 1973. As children, astrophysics and cosmology held our imagination and provided us with a sense of wonder. For many of us, as adults, we remain mesmerized as we look up into the clear starry night. The universe beckons our intellect and our curiosity. Subjects such as the big bang, black holes and neutron stars challenge our intelligence and our sense of existence in this world.

This year, the 4th Solvay conference on cosmology and astronomy assembled again in Brussels.

The 11th Solvay Conference on Physics was wide reaching, bringing together astronomy and general relativity. It was named: "la structure et l'évolution de l'univers", (the second to last conference to be named in French). It was chaired by Sir Lawrence Bragg and attended by outstanding physicists and astronomers, among them Georges Lemaître, Robert Oppenheimer, John Wheeler and Wolfgang Pauli.

I was pleased to read in the conference proceedings, that Lemaître made a notable presentation during the 11th conference called "The primeval Atom Hypothesis", the theory that was later coined: "the big bang theory".

The 13th conference in 1964 under the chairmanship of Robert Oppenheimer focused on the structure and the evolution of galaxies. It was attended by Eduardo Amaldi, Werner Heisenberg and William Fowler to name only a few.

The 16th conference in 1973, was chaired by Eduardo Amaldi, its general theme was "Astrophysics and Gravitation".

With telescopes placed in orbits out of the earth's atmosphere, exceptionally accurate observations of the primordial radiation that filled the universe after the Big Bang stimulated giant leaps in our understanding of the early universe, confirming the theory on the origin of structure. Astrophysics became one of the most exciting fields in modern physics. Neutron stars, pulsars, super novae, black holes, dark matter and the early universe were discussed at length.

I am pleased to note that two participants to the 16th Solvay Conference on physics attended this year's 26th conference. These were Sir Martin Rees and Professor Edward van den Heuvel.

As an outsider to the study of astrophysics, I can only speculate about the incredible changes that have occurred in our understanding of the universe during these 41 years.

As an observer to the conference, I was struck by the warmth and friendship emanating from this community of physicists: it is as if these explorers of the universe were bound by a very special sense of humility and awareness in this world.

As the closing event of the 26th Solvay Conference, the Institutes brought together a full house of passionate students of cosmology for a public lecture at the Flagey Studio Brussels, on the 12th of October. The speakers Professor François Englert, 2013 Nobel Laureate in Physics, Professor Conny Aerts, 2012 Laureate of the Francqui Prize and Sir Martin Rees, 2005 Laureate of the Crafoord Prize, delighted us with their presentations. They were followed by a panel discussion on the importance of curiosity driven research in our society. I left Flagey with the stronger conviction that Science and the scientific spirit provide the rational methodology and the moral compass that our society needs to manage our existence on our little planet.

I would like to end by expressing my gratitude to our director, Professor Marc Henneaux, Professor Alex Sevrin, the deputy director for physics, Lode Wyns, the deputy director for Chemistry, Anne De Wit and Yves Geerts for organizing activities of outstanding scientific quality.

My thanks go also to the team, Dominique Bogaerts and Isabelle Van Geet who, in the spirit of the Institutes, by managing diligently every detail of our events make sure that participants only have to concern themselves with science. I also extend my deep gratitude to them for these beautiful annual reports!

Finally I wish to thank our board members for their continued support and all our sponsors without whom we could not exist.

Jean-Marie Solvay
President

A **word** from the **Director**

This report reviews the activities organized or supported by the International Solvay Institutes during the year 2014. These activities, to which hundreds of scientists took part, are detailed in the corresponding sections. Only the highlights of the year will be mentioned in this foreword.

The flagship activity has been the 26th Solvay Conference on Physics. Devoted to "Astrophysics and Cosmology", it took place in Brussels in October of 2014. It covered exciting topics in an area that has witnessed remarkable developments in the last years, both on the theoretical side and on the observational side. The world leaders in the field came to the Solvay Conference to exchange their views and ideas on neutron stars, black holes, the cosmic dawn, dark matter and the cosmological microwave background. We heartily thank the Chair of the Conference, Professor Roger Blandford from Stanford University, and the Chair of the Solvay Scientific Committee for Physics, Professor David Gross from the Kavli Institute of Theoretical Physics and the University of Santa Barbara, for their extremely careful scientific preparation of the 26th Solvay Conference that made it a remarkable success.

Following a well established tradition that started in 2005, the 26th Conference was followed by a public event where Professors Conny Aerts, Martin Rees and François Englert delivered beautiful lectures on captivating scientific questions at the frontiers of current knowledge. The event was attended by more than 800 people and was a notable success.

Another highlight of 2014 was the organization of the annual international Solvay Chairs in Physics and Chemistry, respectively created in 2006 and 2008. The 2014 Solvay Professor in Chemistry was Professor Richard Royce Schrock, 2005 Nobel Laureate in Chemistry, from the Massachusetts Institute of Technology (USA). The 2014 Jacques Solvay Chair in Physics was held by Professor Viatcheslav Mukhanov, from the Ludwig Maximilian University of Munich. Both chair holders gave brilliant opening lectures addressing the most pressing challenges in their respective fields of investigation. These were attended by many students and researchers from the ULB, the VUB and other Belgian universities.

The International Solvay Institutes have also organized or sponsored workshops and conferences on themes ranging from mathematics to cosmology and chemistry. We have also supported an international graduate school, as training through research is one of our goals. Finally, our colloquium series has been ongoing with the same vitality.

The present report describes also the research on gravitation theory and related topics pursued by scientists connected with the Institutes. The understanding of the force of gravity at a fundamental level is one of the most challenging issues faced by modern physics. This research receives a direct and extremely precious support from the Solvay family, which I heartily thank.

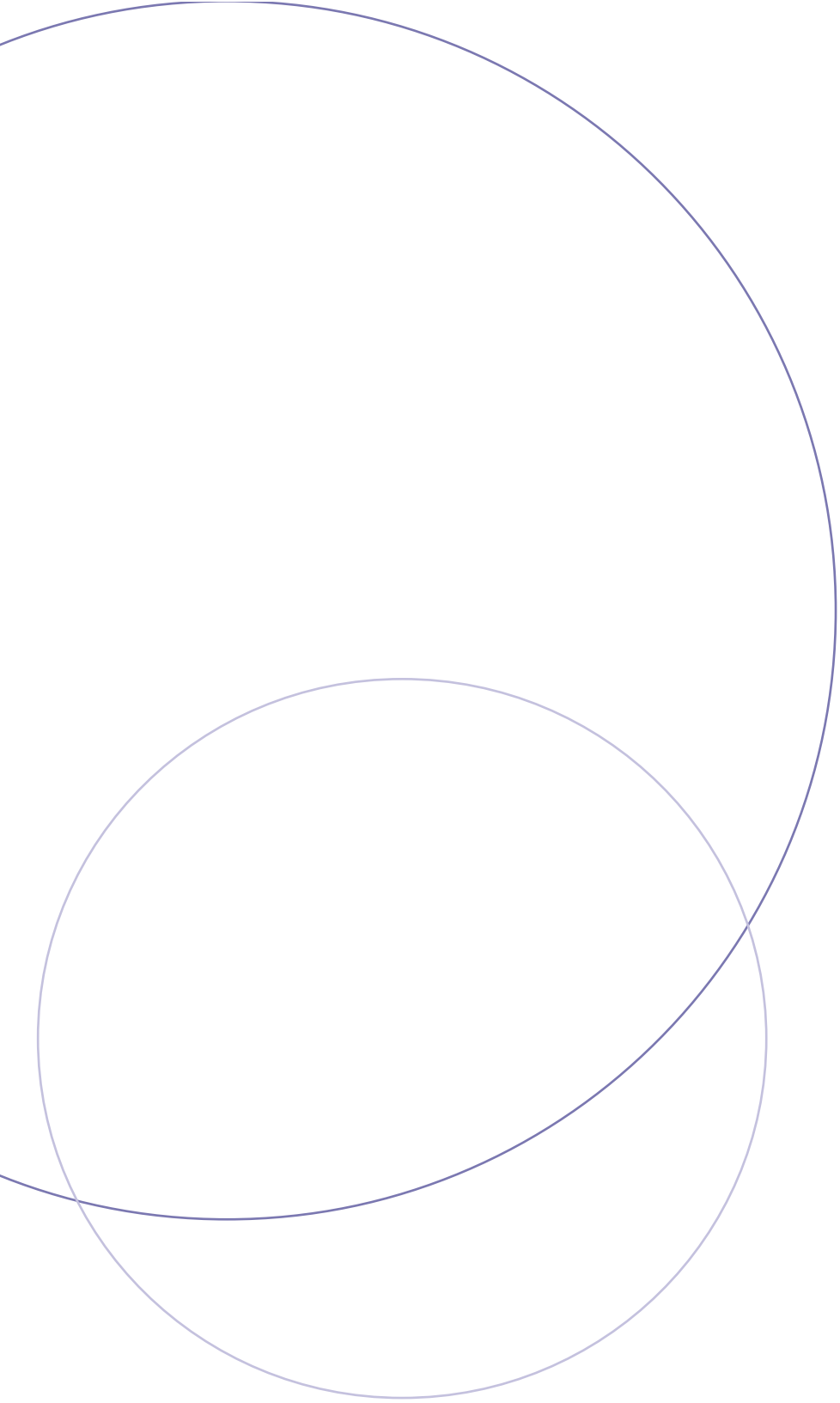
These activities and this research would not have been possible without the help of the sponsors of the International Solvay Institutes, to whom I would like to express our gratitude. These are the Université Libre de Bruxelles, the Vrije Universiteit Brussel, the Solvay Company, the Belgian National Lottery, the Brussels-Capital Region, the Fédération Wallonie-Bruxelles, the Vlaamse Regering, BNP-Paribas Fortis, Belspo, Belgacom, 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 extraordinary dedication and efficiency of the entire staff working at the Institutes is again gratefully acknowledged.

In particular, I would like to praise Dominique Bogaerts and Isabelle Van Geet for the new web site of the Institutes, launched in 2014, which they masterly designed and set up.

I also thank our treasurer, Professor Bingen, for his precious assistance in managing the finances.

Marc Henneaux
Director



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Logistic support researchers	Ms Marie-France Rogge
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How to **reach us**

Postal address

International Solvay Institutes
Campus Plaine ULB / CP 231
Bd du Triomphe
B-1050 Brussels | Belgium

Delivery and visiting address

International Solvay Institutes
Campus Plaine ULB / Access 2
Bd de la Plaine
Building N-O
5th Floor - Office 2N5 105A
B-1050 Brussels | Belgium

Ms Bogaerts: + 32 2 650 55 42 - dominique.bogaerts@ulb.ac.be
Ms Van Geet: + 32 2 650 54 23 - isabelle.vangeet@solvayinstitutes.be

Fax: + 32 2 650 50 28

Website: 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.

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MIT, Cambridge, USA

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Caltech, 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.

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

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26th Solvay Conference on Physics

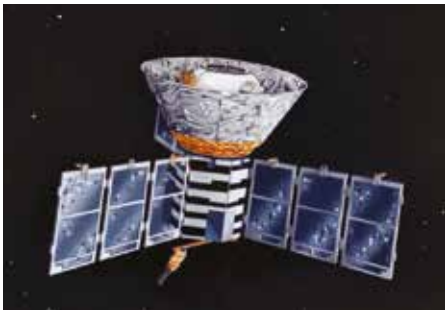
26th Solvay Conference on **Physics**

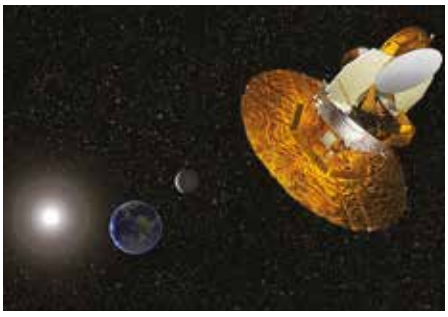
"**Astrophysics** and **Cosmology**"

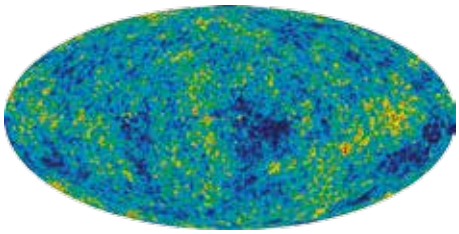
8 - 11 October 2014

With the remarkable observations made by the satellites COBE, WMAP and PLANCK of the properties of the cosmic microwave background (CMB) that fills the universe, cosmology has undergone dramatic developments. The CMB is the radiation created shortly after the big bang, which provides essential information about the early universe. Its observation has transformed cosmology from a highly speculative discipline into a well-established science, where predictions about the features of our universe and the origin of structure can be tested, and have been spectacularly confirmed. Similarly, astrophysics has witnessed a period of intense activity with unique insights being gained into black hole physics, or into the exquisite properties of neutron stars, to mention two of the hotter topics. The extraordinary number of experimental programmes currently underway investigating the field on so many fronts reflects its exceptional vigor and liveliness.

In this true "golden age" of astrophysics and cosmology, it was high time to organize a Solvay Conference devoted to the challenging questions raised by the understanding of the universe. This was the theme of the 26th Solvay Conference on Physics, which took place at the Metropole hotel in Brussels from October 9 through October 11, 2014.







Professor Roger Blandford (on the left)

The theme of the conference was chosen by the International Solvay Scientific Committee for Physics chaired by Nobel laureate Professor David Gross, from the Kavli Institute for Theoretical Physics and the University of Santa Barbara. The conference was masterly organized by Professor Roger Blandford, from Stanford University, who carried out with remarkable authority and efficiency this very demanding task. The International Solvay Institutes express their deepest thanks to the Committee and to Professors Gross and Blandford for the brilliant success of the 26th Solvay Conference on Physics.

A distinctive feature of the Solvay conferences is that they benefit from the benevolent support of the Royal Family. This has been true right from the start, for the very first Solvay Conference that took place in 1911. The International Solvay Institutes are fortunate that this interest in the Solvay Conferences and fundamental science has been kept intact over the years and acknowledge with respectful gratitude the continuation of this centenary tradition. The inaugural session of the 26th Solvay Conference was graced with the presence of His Majesty King Philippe, who met the participants during the coffee break that followed.

R. Blandford, L. Brink, D. Lambert, F. Englert, D. Gross, J-M Frère, His Majesty King Philippe, M. Henneaux, J-M Solvay, Mrs Solvay, A. Sevrin, T. Hertog.

Previous Solvay Conferences on astrophysics and cosmology

11th Solvay Conference on Physics (1958): "La structure et l'évolution de l'univers"
Chair: Sir Lawrence Bragg (Cambridge)

13th Solvay Conference on Physics (1964): "The Structure and Evolution of Galaxies"
Chair: Robert Oppenheimer (Princeton)

16th Solvay Conference on Physics (1973): "Astrophysics and Gravitation"
Chair: Edoardo Amaldi (Rome)

His Majesty King Philippe welcomed by profs. Marc Henneaux, David Gross and Roger Blandford.

Profs. Roger Blandford, Alexander Sevrin, François Englert and David Gross

Profs. George Efstathiou and Conny Aerts

The Excelsior conference room at the Metropole Hotel

A welcome reception took place on October 8, at the Brussels City Hall in presence of Mr. Freddy Thielemans, former Mayor of Brussels.

Scientific themes

The 26th Solvay Conference addressed at length the following scientific topics:

Neutron Stars

Densest and smallest stars in the universe that form by gravitational collapse of massive stars at the end of their evolution. Neutron stars can appear as remnants after violent supernova explosions. Their study and observation provide some of the finest tests of Einstein theory of gravity.

Black Holes

Objects so dense and massive that nothing, not event light, can escape from their gravitational attraction. Black holes constitute one of the most fascinating predictions of Einstein theory of gravity. Active supermassive black holes are thought to exist at the center of most galaxies. The black hole at the center of our galaxy has been indirectly observed through outstanding observational work.

Cosmic Dawn

Era between 100 million to 1 billion years after the big bang where the first stars and galaxies formed by gravitational collapse to light up the universe. Understanding the formation of the first galaxies and the "first light in the universe" raises many challenges.

Dark Matter

Kind of matter that does not emit visible light but has been hypothesized to account for most of the matter in the universe. Its existence has been inferred indirectly through its gravitational effects on visible matter. Understanding its nature is one of the greatest challenges of modern astrophysics and cosmology.

Microwave Background

Relic radiation left over from the big bang, created at the time of decoupling between matter and photons, when the universe became transparent (380,000 years after the Big Bang). Its tiny anisotropies provide unique information on the early universe and is studied through numerous observational collaborations, including COBE, WMAP and PLANCK.

Georges Lemaître

The inaugural session was partly dedicated to the exceptional figure of the Belgian cosmologist Georges Lemaître, scientific giant and father of the Big Bang. His revolutionary ideas were much ahead of their time. Initially regarded with (sometimes ironical) skepticism, they now form the basis of the modern understanding of the history of the universe. Georges Lemaître was close to the International Solvay Institutes and was "rapporteur" at the 11th Solvay Conference "La structure et l'évolution de l'univers" in 1958.

Programme

The Solvay conferences are very special. These are elitist conferences by invitation-only, with a limited number of participants. There are few presentations but a lot of discussions. The 26th Solvay Conference was no exception.

Thursday **9 October** 2014

Inaugural session in the presence of His Majesty The King

Welcome addresses by **Marc Henneaux** and by **David Gross**

Current challenges in astrophysics and cosmology
by Roger Blandford

Georges Lemaître: a visionary Belgian cosmologist
by Thomas Hertog

Coffee break with His Majesty The King

First Session: **Neutron Stars**

Chair: Ed van den Heuvel
Rapporteurs: Vicky Kaspi and Michael Kramer

Second Session: **Black Holes**

Chair: Scott Tremaine
Rapporteurs: Mitchell Begelman and Reinhard Genzel

Poster session

Friday **10 October** 2014

Third Session: **Cosmic Dawn**

Chair: Matias Zaldarriaga
Rapporteurs: Richard Ellis and Steven Furlanetto

Saturday **11 October** 2014

Fourth Session: **Dark Matter**

Chair: Simon White
Rapporteurs: Laura Baudis and Neil Weiner

Fifth Session: **Microwave Background**

Chair: George Efstathiou
Rapporteurs: John Carlstrom and David Spergel

Participants

Abel Tom (Stanford University, USA)
Aerts Conny (KU Leuven, Belgium)
Baudis Laura (Physik Institut UZH, Switzerland)
Begelman Mitchell (University of Colorado, USA)
Blandford Roger (Stanford University, USA)
Bond Dick (University of Toronto, USA)
Brink Lars (Chalmers University, Sweden)
Carlstrom John (University of Chicago, USA)
Damour Thibault (IHES, France)
De Bernardis Paolo (INFN, Italy)
de Bruyn Ger (ASTRON, The Netherlands)
Dijkgraaf Robbert (IAS, Princeton, USA)
Dunkley Jo (Oxford University, UK)
Efstathiou George (Cambridge University, UK)
Eisenstein Daniel (Harvard University, USA)
Ellis Richard (Caltech, USA)
Englert François (ULB, Belgium)
Fabian Andrew (Cambridge University, UK)
Frenk Carlos (Durham University, UK)
Furlanetto Steven (UCLA, USA)
Genzel Reinhard (Max Planck Institute, Germany)
Goldreich Peter (IAS, Princeton, USA)
Gross David (Kavli, UCSB, USA)
Guth Alan (MIT, USA)
Hawley John (University of Virginia, USA)
Henneaux Marc (ULB & Solvay Institutes, Belgium)
Hofmann Werner (Max Planck Institute, Germany)
Kamionkowski Marc (Johns Hopkins University, USA)
Kaspi Vicky (McGill University, Canada)
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Kouveliotou Chryssa (NASA, USA)
Kramer Michael (Manchester University, UK)
Kulkarni Shri (Caltech, USA)
Lattimer James (Stony Brook University, USA)
Mandolesi Nazzareno (INAF - IASF Bologna, Italy)
Madau Piero (UCSC, USA)
Mukhanov Viatcheslav (Arnold Sommerfeld Center, Germany)
Muruyama Hitoshi (University of California at Berkeley, USA)
Ostriker Jeremiah (Princeton University, USA)
Peebles P. James (Princeton University, USA)
Pen Ue-Li (CITA, Canada)
Phinney E. Sterl (Caltech, USA)
Piran Tsvi (Racah Institute of Physics, Israel)
Podsiadlowski Philipp (Oxford University, UK)
Pryke Clem (University of Minnesota, USA)
Puget Jean-Loup (IAS, France)
Raffelt Georg (Max Planck Institute, Germany)

Participants

Ramond Pierre (University of Florida, Gainesville, USA)
Rees Martin (Cambridge University, UK)
Romani Roger (Stanford University, USA)
Seljak Uros (University of California at Berkeley, USA)
Sevrin Alexander (VUB & Solvay Institutes, Belgium)
Silverstein Eva (Stanford University, USA)
Spergel David (Princeton University, USA)
Sunyaev Rashid (Max Planck Institute, Germany)
Tremaine Scott (IAS, Princeton, USA)
van den Heuvel Ed (UVA, Amsterdam, The Netherlands)
Weiner Neil (New York University, USA)
White Simon (Max-Planck-Institute, Germany)
Wijers Ralph (UVA, The Netherlands)
Zaldarriaga Matias (IAS, Princeton, USA)
Zaroubi Saleem (Kapteyn Astronomical Institute, The Netherlands)

Auditors

Baes Maarten (UGent, Belgium)
Barnich Glenn (ULB, Belgium)
Chamel Nicolas (ULB, Belgium)
Compère Geoffrey (ULB, Belgium)
Craps Ben (VUB, Belgium)
Decin Leen (KU Leuven, Belgium)
Detournay Stéphane (ULB, Belgium)
Ferrari Frank (ULB, Belgium)
Frère Jean-Marie (ULB, Belgium)
Gentile Gianfranco (UGent, Belgium)
Hambye Thomas (ULB, Belgium)
Hertog Thomas (KU Leuven, Belgium)
Lambert Dominique (Fundp, Belgium)
Sevrin Alexander (VUB, Belgium)
Spindel Philippe (UMons, Belgium)
Tytgat Michel (ULB, Belgium)
Van Beveren Danny (VUB, Belgium)
Van Winckel Hans (KU Leuven, Belgium)

26th Solvay Conference on Physics

Solvay Public Lectures

11th Solvay **Public Event**

"**Astrophysics** and **Cosmology**"

12 October 2014

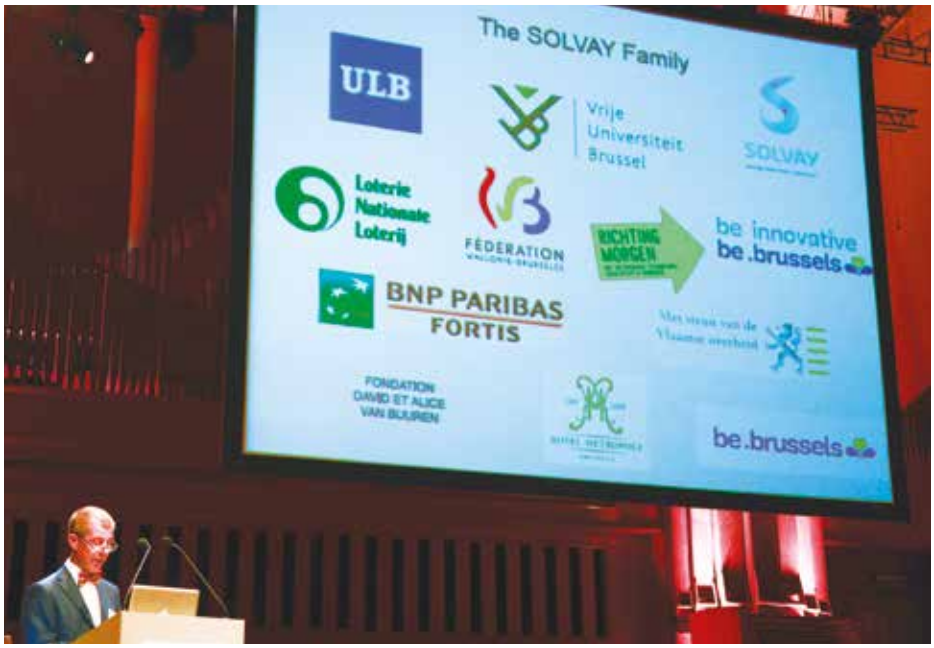
About ten years ago, the International Solvay Institutes initiated the tradition of organizing an annual public event during which distinguished scientists deliver lectures on the state-of-the-art in their field of research with an overview of the most pressing current issues. Organized jointly with 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 is free.

The 2014 annual Solvay public event took place at the Flagey building on October 12, 2014. The title of the event, "Astrophysics and Cosmology", was the same as the title of the 26th Solvay Conference on Physics that ended on the previous day. More than 800 participants (a full house!) listened to the brilliant lectures delivered by Professor Conny Aerts (KUL), Professor Lord Martin Rees (Cambridge University) and Professor François Englert (ULB and International Solvay Institutes). The three lecturers gave mind-challenging talks explaining some of the mechanisms underlying our description of nature at the most fundamental level, and opening a window on the wonders and mysteries of our universe.

The lectures were followed by a panel discussion on the current challenges in physics and cosmology. The panel was composed of distinguished scientists who had participated in the 26th Solvay Conference.

The event closed with a drink offered to all the participants, the speakers and the panel members, which allowed the public to interact more closely with the invited scientists.

The International Solvay Institutes warmly thank the three speakers who accepted to deliver a lecture, as well as all the panel members who participated in the discussion. They are very busy persons and the Institutes value very much the time that they spent to make their 11th public event a great success.



Professor Marc Henneaux

Mr. Nicolas Boël, CEO of the Solvay Group, Mr. Philippe Busquin, Minister of State, Mr. Christian Jourquin, former CEO of the Solvay Group

Speakers

Professor Conny Aerts
KULeuven, Belgium and Radboud University Nijmegen, The Netherlands

Professor Conny Aerts obtained her mathematics diploma from Antwerp University in 1988 and defended her PhD thesis in astrophysics at the Catholic University of Leuven in 1993. She was appointed as Full professor (2007) at Leuven University. Since 2004, she also occupies the Chair in Asteroseismology at the Radboud University Nijmegen in the Netherlands.

The research of professor Conny Aerts focuses on the unraveling of the internal structures of stars through stellar oscillations: asteroseismology. The basic principles of asteroseismology are very similar to those developed by earth seismologists. Stellar interiors can be probed from oscillations because different oscillation modes penetrate to different depths inside the star. Asteroseismology is the only available method to derive the internal structure of the stars with high precision. The structure and composition of the star imply that it oscillates at very specific frequencies. Just like after an earthquake, the oscillations function as a signal which gives us information about the internal stellar structure. In order to be able to detect those oscillations and deduce the physics of the stellar interior, we need photometric and spectroscopic observations of very high quality and long duration.

In her research, Conny Aerts and her team will make use of new high-precision observations gathered with the French-led European CoRoT satellite as well as the NASA Kepler mission, together with ground-based observations to be assembled with the Flemish Mercator Telescope at La Palma, Canary Islands and with the Very Large Telescope (VLT) of the European Southern Observatory located in Chile.

She was awarded the 2012 Francqui Prize and Honorary Fellowship of Royal Astronomical Society, UK.

Professor Lord Martin Rees
Cambridge University, UK

Professor Martin Rees is a Fellow of Trinity College and Emeritus Professor of Cosmology and Astrophysics at the University of Cambridge. After studying at the University of Cambridge, he held post-doctoral positions in the UK and the USA, before becoming a professor at Sussex University. In 1973, he became a fellow of King's College and Plumian Professor of Astronomy and Experimental Philosophy at Cambridge and served for ten years as director of Cambridge's Institute of Astronomy.
From 1992 to 2003 he was a Royal Society Research Professor, and then from 2004 to 2012, Master of Trinity College.
In 2005 he was appointed to the House of Lords, and he was President of the Royal Society for the period 2005-10.

He was awarded (among others) the Heineman Prize for Astrophysics, the Crafoord Prize, the Niels Bohr Medal and the Dirac Medal and Prize.

His main current research interests are:

(i) High energy astrophysics - especially gamma ray bursts, galactic nuclei, black hole formation and radiative processes (including gravitational waves).

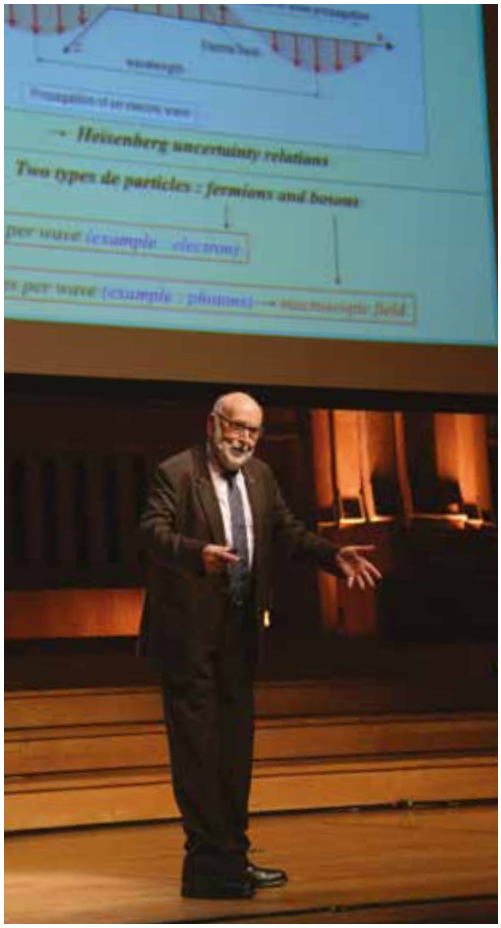
(ii) Cosmic structure formation - especially the early generation of stars and galaxies that formed at high redshifts at the end of the cosmic 'dark age'.

(iii) General cosmological issues.

Professor François Englert
ULB & Solvay Institutes, Belgium

Professor François Englert graduated as an electromechanical engineer in 1955 from the Université Libre de Bruxelles (ULB) where he received his PhD in physical sciences in 1959. From 1959 until 1961, he worked at Cornell University, first as a research associate of Robert Brout and then as assistant professor. He then returned to the ULB where he became a university professor and was joined there by Robert Brout. In 1984 Professor Englert was first appointed as a Sackler Professor by Special Appointment in the School of Physics and Astronomy at Tel-Aviv University. Professor Englert joined Chapman University's Institute for Quantum Studies in 2011, where he serves as a Distinguished Visiting Professor.

He was awarded the 1982 Francqui Prize, the 2010 J. J. Sakurai Prize, the Wolf Prize in Physics in 2004 (with Brout and Higgs). He is the recipient of the 2013 Prince of Asturias Award in technical and scientific research, together with Peter Higgs and the CERN.

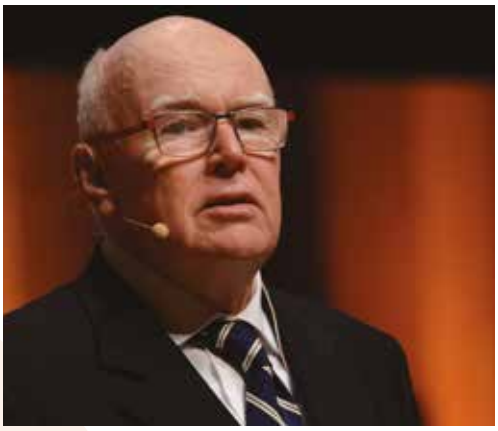


Professeur Englert was awarded the 2013 Nobel Prize in Physics, together with Peter Higgs "for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider".

Programme

Moderator

Prof. Franklin Lambert
VUB & International Solvay Institutes



15:00 - 15:05	Opening by **Professor Marc Henneaux** *(ULB & International Solvay Institutes)*
15:05 - 15:45	**Professor Conny Aerts** *(KU Leuven)* "Starquakes and exoplanets in our Milky Way galaxy"
15:45 - 16:25	**Professor Martin Rees** *(Cambridge)* "From a 'simple' big bang to our complex cosmos"
16:25 - 17:15	**Professor François Englert** *(ULB)* "The origin of mass and the Brout-Englert-Higgs boson"
17:15 - 18:05	Discussion with the participation of Professors Conny Aerts *(KU Leuven)*, Roger Blandford *(Stanford)*, François Englert *(ULB)*, David Gross *(Santa Barbara)*, James Peebles *(Princeton)*, Jean-Loup Puget *(Paris-Sud)*, Martin Rees *(Cambridge)*. Question session
18:05 - 18:10	Closing

The Panel

Professors Aerts, Englert and Rees were members of the panel. Here is a brief presentation of the other members.

Professor Roger Blandford
Stanford University, USA

Professor Roger Blandford was an undergraduate and research student at Cambridge University where he was supervised by Martin Rees. He had postdoctoral positions at Cambridge, Princeton and Berkeley before joining the Caltech faculty in 1976. In 2003, he moved to Stanford University to become the first Director of the Kavli Institute for Particle Astrophysics and Cosmology.

His research interests now cover many aspects of particle astrophysics and cosmology.

He was awarded the Dannie Heineman Prize and the Humboldt Research Award.

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

Professor David Gross received his bachelor's degree and master's degree from the Hebrew University of Jerusalem, Israel, in 1962. He received his Ph.D. in physics from the University of California, Berkeley in 1966 and joined Princeton University in 1969. He assumed the title Director and holder of the Frederick W. Gluck Chair in Theoretical Physics at the Kavli Institute for Theoretical Physics of the University of California, Santa Barbara in 1997.

In 2004, Gross was awarded the Nobel Prize in Physics for his discovery of asymptotic freedom, along with Frank Wilczek and David Politzer.

His main current research interests are:

- High Energy Physics
- Quantum Field Theory
- String Theory

Professor James Peebles
Princeton University, USA

Professor James Peebles is a Canadian-American physicist and theoretical cosmologist who is currently the Albert Einstein Professor Emeritus of Science at Princeton University. He completed his bachelor's degree at the University of Manitoba. He left Manitoba in the fall of 1958 to attend Princeton University, where he completed his doctorate.

Professor Peebles has made many important contributions to the big bang model. With Robert Dicke and others he predicted the cosmic microwave background radiation. Along with making major contributions to big bang nucleosynthesis, dark matter and dark energy, he has contributed to the theory of structure formation. Long before it was considered a serious, quantitative branch of physics, professor Peebles was studying physical cosmology and has done much to establish its respectability.

In 1987, he proposed the primordial isocurvature baryon model for the development of the early universe.

He was awarded (among others) the Heineman Prize (1982), the Gruber Prize in Cosmology (2000), the Dirac Medal (2013).

Professor Jean-Loup Puget
Université Paris-Sud, France

Professor Jean-Loup Puget is a French astrophysicist. His current research interests lie in the Cosmic Microwave Background. Professor Puget and his collaborators reported the first identification of the Cosmic infrared background using COBE data. He is also, along with Alain Léger, credited with the origin of the hypothesis that the series of infrared lines observed in numerous astrophysical objects are caused by emission from polycyclic aromatic hydrocarbons. He is currently principal investigator of the HFI module of the Planck space mission.

He served two terms as director of the Institut d'astrophysique spatiale from 1998 to 2005.

He has been a member of the Académie des sciences (France) since 2002 and was awarded the Prix Jean Ricard in 1989. He received the COSPAR Space Science Award in 2014.

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.

2014 Jacques Solvay **Chair in Physics**

Professor Viatcheslav Mukhanov
Ludwig Maximilian University, Munich
Germany

The ninth International Chair in Physics took place in October of 2014. It was held by Professor Viatcheslav Mukhanov (Ludwig Maximilian University, Munich, Germany), a world leader in cosmology, who has made profound contributions to the understanding of the origin of structure in the universe.

Professor Mukhanov made the outstanding prediction that quantum fluctuations, amplified during the stage of cosmic acceleration, are responsible for the large scale structure of the Universe and the formation of galaxies.

He discovered the form of the spectrum of inhomogeneities originating from initial quantum fluctuations.
The predicted spectrum has an unambiguous imprint in the fluctuations of the temperature of the Cosmic Microwave Background.
These fluctuations were observed by COBE, WMAP as well as many ground based and balloon experiments, and more recently by PLANCK.
All the observations provide brilliant experimental evidence for the validity of these remarkable predictions.

The inaugural lecture delivered by Professor Mukhanov was devoted to these exciting questions.

Programme

Inaugural Lecture: "**Quantum Universe**"

21 October 2014

Abstract:

Why are atoms stable? What caused galaxies, stars and planets to form? I will explain why quantum physics is crucial for explaining both. Finally, I will discuss the experimental evidence that assures us that everything in our universe originated from quantum fluctuations.

Professor Viatcheslav Mukhanov studied at the prestigious Moscow Institute of Physics and Technology, to which so many famous names are associated: Kapitsa, Landau, Ginzburg to name a few.

He received his doctorate in 1982. He then joined the Institute for Nuclear Research, also in Moscow. From 1982 to 1991 he served as a researcher there, and then spent a year as a professor.

After the fall of the Soviet Union, Mukhanov moved abroad. From 1992 to 1997 he was a lecturer at ETH Zurich. In December 1997 he joined the Ludwig-Maximilians-Universität in Munich as a full professor of physics as well as the head of the Astroparticle Physics Division, posts he holds to this day.

For this remarkable achievement, Professor Mukhanov received many awards. He was the first scientist from Germany to receive the Blaise Pascal Chair from the French government. He also received the Gold Medal of the Soviet Academy of Sciences, the Klein Medal of Stockholm University, the Tomalla Prize, the Amaldi Medal, the Gruber Prize in Cosmology and more recently the Planck Medal of the German Physical Society.

Professor François Englert and the Solvay family

Lectures on "Physics of the **Early Universe**"

22, 27, 29, 30 October 2014

The subsequent lectures given by Professor Mukhanov covered the "Physics of the Early Universe".

Professor Mukhanov developed the theory of cosmological pertubations and explained how to compute the evolution of quantum fluctuations in an inflationary phase of the universe that lasts a finite time. The lectures were included in the program of the International Doctoral School on "Quantum Field Theory, Strings and Gravity" co-organized with the University of Amsterdam, the Ecole Normale Supérieure in Paris, a consortium of Swiss universities led by ETH Zürich and the two Brussels Universities ULB and VUB.

2013 Solvay Chair in Chemistry

Professor Egbert Meijer
Eindhoven University of Technology, The Netherlands

The last lectures of the 2013 Solvay Chair in Chemistry, held by Professor Egbert Meijer, took place in 2014. They were the continuation of the lectures given in 2013 and were devoted to frontier subjects of supramolecular systems and chemical self-assembly, an area in which Professor Meijer made pioneering contributions.

Lecture on "About **supramolecular assemblies** of **π-conjugated** oligomers and polymers; **chirality as a muse**"

29 April 2014

Abstract:

Chemical self-assembly is an important tool in constructing functional nanoscopic materials. Knowledge about the presence and stability of multiple local supramolecular minima or substates in these synthetic self-assembled systems is crucial in order to drive the assembly towards the desired thermodynamic minimum. Both the existence and the factors that influence the formation of these substates have, however, barely been investigated. In the presentation, we show that the chemical self-assembly of chiral π-conjugated oligomers, sexithiophenes and oligo(phenylenevinylenes) operates via a nucleation – elongation pathway and hence is highly cooperative. As a result the solvent plays an essential role in the chemical self-assembly and strong evidence is found that the alkane solvents are co-organized with the oligomeric stack. These results are also of crucial importance for the discussion whether the chemical self-assembly creates the thermodynamically determined product or that is possible to form kinetically trapped structures as well. We will show that the self-assembly is strongly influenced by external stimuli. Impurities levels as low as 0.1% can direct the assembly, while only with cooling rates as low as 1 K/hr the assembly process occurs close to or under thermodynamic equilibrium. Multiple supramolecular substates have been probed, while stepwise cooling shows that annealing at different stages of the self-assembly influences the assembly process in different ways and indicates the changing energy landscape.

Lecture on "Folding of **single-chain macromolecules**; towards **synthetic enzymes**"

23 May 2014

Abstract:

The folding of proteins as well as the self-assembly of proteins into fibrillar and beta-amyloidal structures is the results of specific secondary interactions within a polymer chain or between polymer chains. The diversity in protein structures and the complexity of the processes involved make studies to folding and assembly of proteins challenging research objectives. In the lecture, a number of simple artificial structures will be introduced that are studied in great detail for their self-assembly processes in both organic solvents and water. In a particular example, meta-stable folded single-chain macromolecules will be used as a catalyst. An attempt will be made to elucidate the differences and similarities between these simple artificial structures and complex proteins to arrive at a few general statements on folding and assembly of (macro)molecules. Both kinetic and thermodynamic studies will be used to show some remarkable similarities in behavior of artificial structures in organic solvents and proteins in water.

2014 Solvay **Chair in Chemistry**

Professor Richard Schrock
Massachusetts Institute of Technology, USA

The seventh International Chair in Chemistry was held by Professor Richard Schrock from the Massachusetts Institute of Technology (USA), a renowned world expert in synthetic and mechanistic organotransition metal and inorganic chemistry, catalysis, and polymers.
In 2005, Professor Richard Schrock received the Nobel Prize in Chemistry for his work in the area of olefin metathesis, a fundamental organic synthesis technique.

His inaugural lecture, given on the 23rd of September 2014, explained the fascinating story behind the discovery that led to the 2005 Nobel Prize.

The rest of Professor Schrock's lectures will be given in 2015.

During his stay in Brussels, Professor Schrock is hosted in the group of Professor Yves Geerts (ULB).

After receiving his PhD degree at Harvard University, **Professor Richard Schrock** carried out postdoctoral studies at the University of Cambridge. In 1972, he was hired by DuPont, and in 1975, he joined the faculty of the Massachusetts Institute of Technology where he became full professor in 1980. He is currently the Frederick G. Keyes Professor of Chemistry at MIT, a post he has held since 1989.

Professor Schrock is a member of the American Academy of Arts and Sciences, the National Academy of Sciences and was elected to the Board of Overseers of Harvard University in 2007.

In 2005, Professor Richard Schrock received the Nobel Prize in Chemistry, with Robert H. Grubbs and Yves Chauvin, for his work in the area of olefin metathesis, an organic synthesis technique.

According to the Nobel Foundation, "Olefin metathesis is one of the most important organic chemical reactions, creating remarkable opportunities for producing many new molecules, including pharmaceuticals or advanced plastic materials. Richard Schrock was the first to produce an efficient metal-compound catalyst for metathesis, [...] which represents a great step forward for "green chemistry", reducing potentially hazardous waste through smarter production. Metathesis is an example of how important basic science has been applied for the benefit of man, society and the environment."

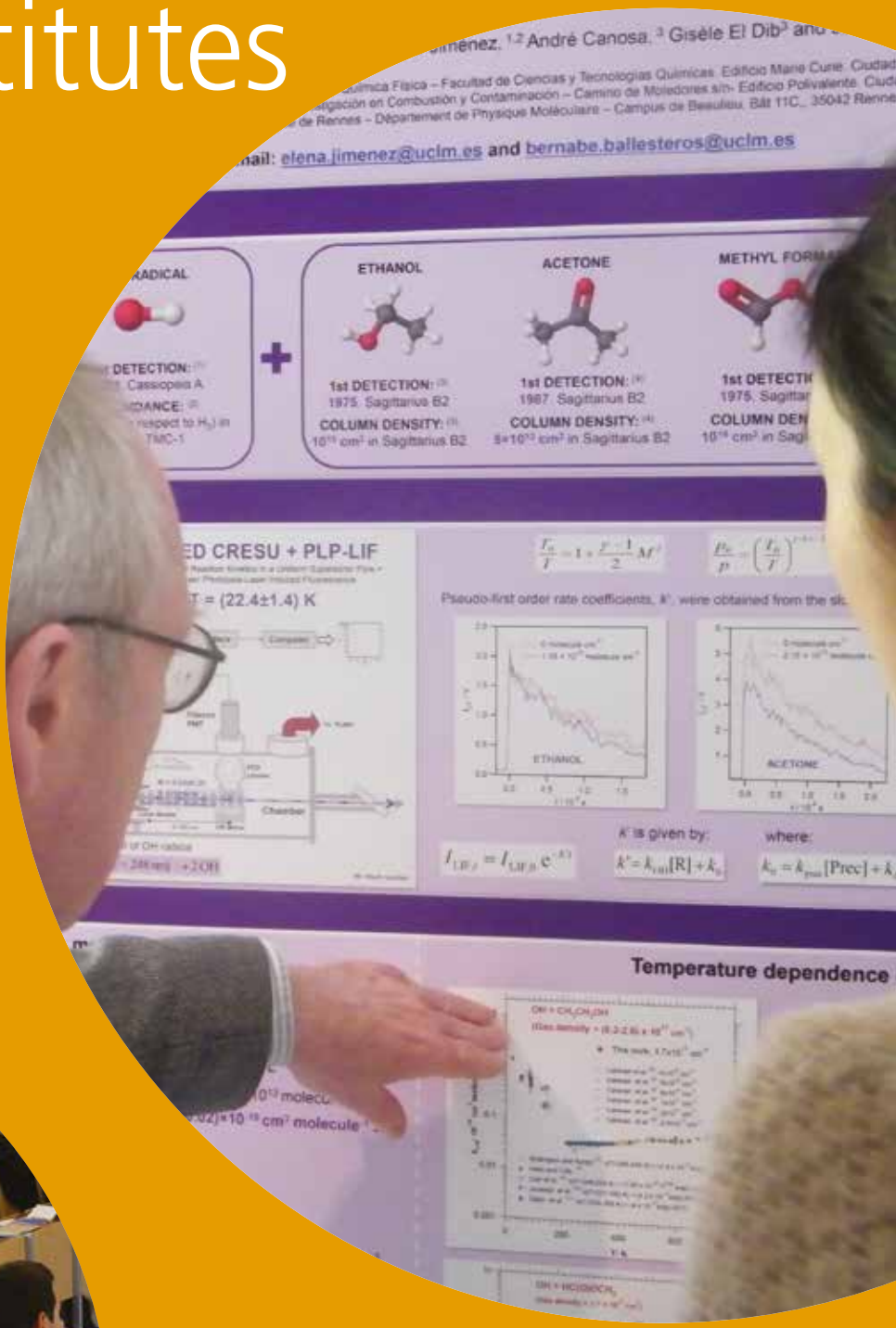
Inaugural Lecture: "The **Nobel Prize** in **2005**"

23 September 2014

Abstract:

Olefin metathesis was recognized by the Nobel Prize in Chemistry in 2005. It is a reaction in which C=C bonds are cleaved and "rearranged" to give new C=C bonds. I will present some of my own discoveries that led to over 30 years of progress and the Nobel Prize in 2005. That progress has depended upon the development of molecular catalysts that contain molybdenum, tungsten, or ruthenium. Olefin metathesis has had a major impact on the synthesis of organic molecules, polymers (from strained olefins), and chemicals from renewable feed stocks (e.g., seed oils), and could also impact pharmaceutical, fragrance, agro, and materials chemistries. I will give examples of several recent successes with recently prepared catalysts that are based on molybdenum or tungsten.

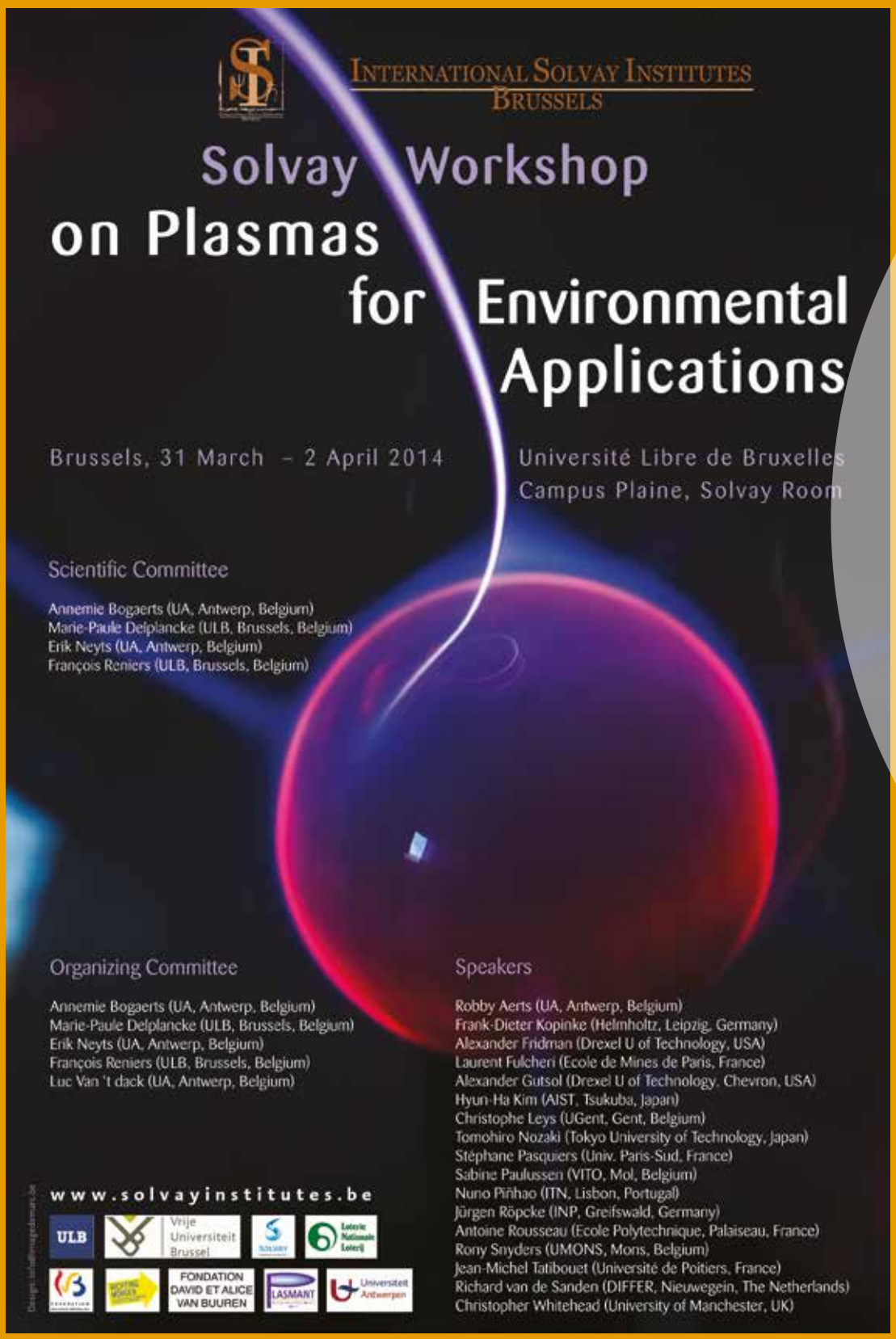
Workshops and School organised by the Institutes



Workshop on

"**Plasmas** for **Environmental** Applications"

31 March - 2 April 2014



Workshops and School
organised by the Institutes

Workshop on "**Plasmas** for **Environmental** Applications"

31 March - 2 April 2014

Scientific Committee

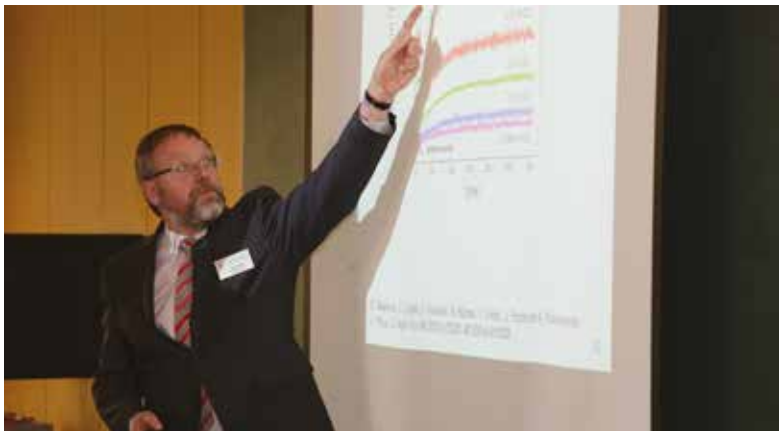
Annemie Bogaerts (UA, Antwerp, Belgium)
Marie-Paule Delplancke (ULB, Brussels, Belgium)
Erik Neyts (UA, Antwerp, Belgium)
François Reniers (ULB, Brussels, Belgium)

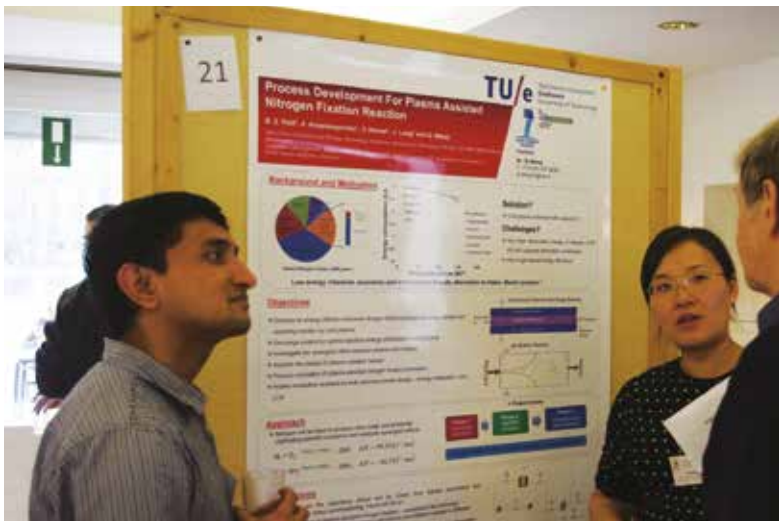
Organizing Committee

Annemie Bogaerts (UA, Antwerp, Belgium)
Marie-Paule Delplancke (ULB, Brussels, Belgium)
Erik Neyts (UA, Antwerp, Belgium)
François Reniers (ULB, Brussels, Belgium)
Luc Van't dack (UA, Antwerp, Belgium)

Speakers

Robby Aerts (UA, Antwerp, Belgium)
Frank-Dieter Kopinke (Helmholtz, Leipzig, Germany)
Alexander Fridman (Drexel U. of Technology, USA)
Laurent Fulcheri (Ecole des Mines de Paris, France)
Alexander Gutsol (Drexel U. of Technology, Chevron, USA)
Hyun-Ha Kim (AIST, Tsukuba, Japan)
Christophe Leys (UGent, Gent, Belgium)
Tomohiro Nozaki (Tokyo University of Technology, Japan)
Stéphane Pasquiers (Univ. Paris-Sud, France)
Sabine Paulussen (VITO, Mol, Belgium)
Nuno Piñhao (ITN, Lisbon, Portugal)
Jürgen Röpcke (INP, Greifswald, Germany)
Antoine Rousseau (Ecole Polytechnique, Palaiseau, France)
Rony Snyders (UMONS, Mons, Belgium)
Jean-Michel Tatibouet (Université de Poitiers, France)
Richard van de Sanden (DIFFER, Nieuwegein, The Netherlands)
Christopher Whitehead (University of Manchester, UK)





Workshops and School organised by the Institutes

Programme

Monday **31 March** 2014

Welcome and opening address

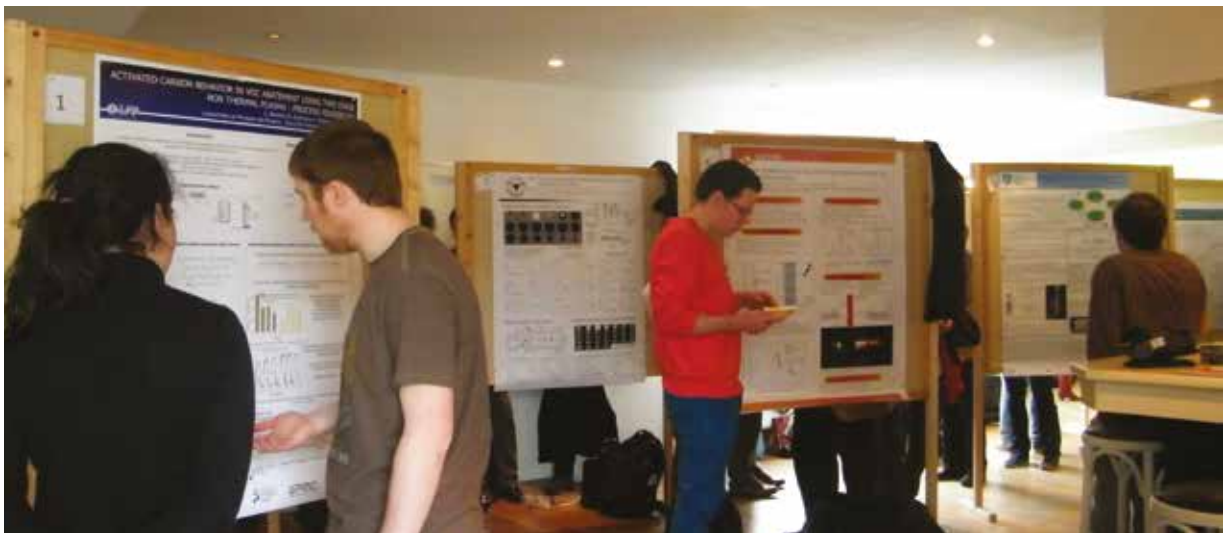
Morning session chaired by **Annemie Bogaerts**

Richard van de Sanden	Energy storage in CO^2 neutral fuels
Alexander Fridman	Dissociation of CO^2 and other plasma processes stimulated by vibrational excitation of molecules
Tomohiro Nozaki	Greenhouse gas conversion in catalytic packed-bed DBD reactor: methane dry reforming

Afternoon session chaired by **Marie-Paule Delplancke**

Rony Snyders	Microwave discharges as a potential solution for an efficient decomposition of CO^2
Robby Aerts	The role of plasmas in a sustainable society: a modelling point of view

Poster Session



Tuesday **1 April** 2014

Morning session chaired by **Erik Neyts**

Jean-Michel Tatibouet	Depolymerization of cellulose and related biopolymers by non-thermal plasma
Hyun-Ha Kim	Complementary combination of non-thermal plasma and catalyst for air pollution control
Jürgen Röpcke	On recent progress in studying chemical phenomena and surface interactions in plasmas using infrared absorption techniques

Afternoon session chaired by **François Reniers**

Laurent Fulcheri	Plasma assisted conversion of hydrocarbons for green and environmental friendly energy transition
Alexander Gutsol	Plasma for environment – look from industry
Christophe Leys	Diagnostics of active species in atmospheric pressure plasmas
Sabine Paulussen	Plasma-assisted synthesis of heterogeneous metallo-silicate catalysts for renewables conversion

Banquet

Wednesday **2 April** 2014

Morning session chaired by **Rony Snyders**

Antoine Rousseau	Oxydation of volatile organic compounds adsorbed onto catalytic surfaces using non thermal plasma
Frank Holzer	Plasma catalysis - fundamental aspects, limitations and challenges
Stéphane Pasquiers	Decomposition kinetics of volatile organic compounds in non-thermal plasmas of atmospheric gases

Afternoon session chaired by **Annemie Bogaerts**

Nuno Pinhão	Characteristics of the electron kinetics and modeling of discharges used for methane conversion
Christopher Whitehead	Plasma-catalysis for the treatment and conversion of waste gases

Closing address

Participants

Aerts Robby (UA, Antwerp, Belgium)
Aghaei Maryam (UA, Antwerp, Belgium)
Baguer Neyda (University of Namur, Belgium)
Barakat Christelle (LPP - Ecole Polytechnique, France)
Berthelot Antonin (UA, Antwerp, Belgium)
Blin Simiand Nicole (Université Paris Sud, France)
Bogaerts Annemie (UA, Antwerp, Belgium)
Bongers Waldo (FOM Institute DIFFER, The Netherlands)
El Ghoulbzouri Fikri (ULB, Brussels, Belgium)
Engeln Richard (Eindhoven University of Technology, The Netherlands)
Fridman Alexander (Drexel University, USA)
Fulcheri Laurent (Ecole des Mines de Paris, France)
Georgieva Violeta (ULB, Brussels, Belgium)
Gleeson Michael (DIFFER, Nieuwegein, The Netherlands)
Godfroid Thomas (MATERIANOVA, Mons, Belgium)

Bosmans Anouk (KU Leuven, Belgium)
Britun Nikolay (UMONS, Mons, Belgium)
Butterworth Tom (University of Sheffield, UK)
Caby Mathieu (ULB, Brussels, Belgium)
Chen Guoxing (ULB, Brussels, Belgium)
de Marneffe Jean-Francois (IMEC vzw, Belgium)
Delplancke Marie-Paule (ULB, Brussels, Belgium)
den Harder Nicolaas (FOM Institute DIFFER, The Netherlands)
Dufour Thierry (ULB, Brussels, Belgium)
Goede Adelbert (FOM Institute DIFFER, The Netherlands)
Goris Ken (Atlas Copco, Brussels, Belgium)
Groen Pieter Willem (FOM Institute DIFFER, The Netherlands)
Guaitella Olivier (LPP, Ecole Polytechnique, France)
Gutsol Alexander (Chevron, Energy Technology Company, USA)
Habibzadeh Pouya (ULB, Brussels, Belgium)
Hauchecorne Birger (UA, Antwerp, Belgium)
Heijkers Stijn (UA, Antwerp, Belgium)
Helsen Lieve (KU Leuven, Belgium)

Hoeben Wilfred (Eindhoven University of Technology, The Netherlands)

Holzer Frank (Helmholtz, Leipzig, Germany)

Houssiau Laurent (University of Namur, Belgium)

Huang Yifan (Zhejiang University, China)

Hubert Julie (ULB, Brussels, Belgium)

Huygh Stijn (UA, Antwerp, Belgium)

Kim Hyun-Ha (AIST, Tsukuba, Japan)

Kozak Tomas (UA, Antwerp, Belgium)

Kuvshinov Dmitriy (University of Sheffield, UK)

Lenaerts Silvia (UA, Antwerp, Belgium)

Leys Christophe (UGent, Belgium)

Liu Zhen (Zhejiang University, China)

Magne Lionel (Université Paris Sud (XI), France)

Meynen Vera (UA, Antwerp, Belgium)

Michielsen Inne (UA, Antwerp, Belgium)

Neyts Erik (UA, Antwerp, Belgium)

Nikiforov Anton (Ghent University, Belgium)

Nittler Laurent (University of Namur, Belgium)

Nordheden Karen (University of Kansas, USA)

Nozaki Tomohiro (Tokyo University of Technology, Japan)

Ozkan Alp (UA, Antwerp, Belgium)

Pasquiers Stéphane (Univ. Paris-Sud, France)

Patil Bhaskar (Eindhoven University of Technology, The Netherlands)

Paulussen Sabine (VITO, Mol, Belgium)

Pinhão Nuno (ITN, Lisbon, Portugal)

Ramakers Marleen (UA, Antwerp, Belgium)

Reniers François (ULB, Brussels, Belgium)

Röpcke Jürgen (INP, Greifswald, Germany)

Rousseau Antoine (Ecole Polytechnique, Palaiseau, France)

Shirazi Mahdi (UA, Antwerp, Belgium)

Silva Tiago (UMONS, Belgium)

Snoeckx Ramses (UA, Antwerp, Belgium)

Snyders Rony (UMONS, Belgium)

Somers Wesley (UA, Antwerp, Belgium)

Sultana Sharmin (Ghent University, Belgium)

Tatibouet Jean-Michel (Université de Poitiers, France)

Uytdenhouwen Yannick (UA, Antwerp, Belgium)

Van 't dack Luc (UA, Antwerp, Belgium)

Van Acker Frederik (Atlas Copco, Brussels, Belgium)

van de Sanden Richard (DIFFER, Nieuwegein, The Netherlands)

van den Bekerom Dirk (FOM Institute DIFFER, The Netherlands)

van den Daele Wim (UA, Antwerp, Belgium)

Van Gorp Carolien (UA, Antwerp, Belgium)

Van Laer Koen (UA, Antwerp, Belgium)

Van Loock Peter (UA, Antwerp, Belgium)

van Rooij Gerard (FOM Institute DIFFER, The Netherlands)

Van Wesenbeeck Karen (UA, Antwerp, Belgium)

Vandenbroucke Arne (Ghent University, Belgium)

Walsh Anton Institute (DIFFER, The Netherlands)

Wang Qi (Eindhoven University of Technology, The Netherlands)

Welzel Stefan (FOM Institute DIFFER, The Netherlands)

Whitehead Christopher (University of Manchester, UK)

Wouters Marieke (UA, Antwerp, Belgium)

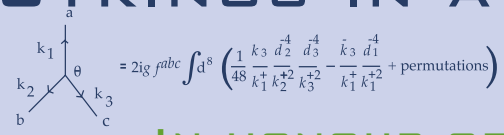
Workshop on

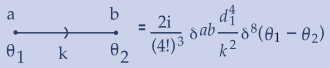
"**Fast is beautiful**: **supersymmetry** and **strings** in a null frame"

14 -15 May 2014

SOLVAY WORKSHOP ON

FAST IS BEAUTIFUL: SUPERSYMMETRY AND STRINGS IN A NULL FRAME





IN HONOUR OF LARS BRINK

CO-ORGANIZED WITH CECS (VALDIVIA) AND WITH SUPPORT FROM ASC (MUNICH)

BRUSSELS, 14 - 15 MAY 2014 - UNIVERSITÉ LIBRE DE BRUXELLES - CAMPUS PLAINE, SOLVAY ROOM

Invited Participants

Luis Alvarez Gaumé (CERN, Geneva, Switzerland)
Ignatios Antoniadis (CERN, Geneva, Switzerland)
Costas Bachas (LPTENS, Paris, France)
Anders Bengtsson (UB, Borås, Sweden)
Ingemar Bengtsson (Stockholm U, Sweden)
Zvi Bern (UCLA, Los Angeles, USA)
Roberto Casalbuoni (UniFI, Florence, Italy)
Martin Cederwall (Chalmers University, Sweden)
Eugene Cremmer (ENS, Paris, France)
Thomas Curtright (UM, Miami, USA)
Paolo Di Vecchia (Nordita, Stockholm, Sweden)
Louise Dolan (UNC at Chapel Hill, USA)
Georgi Dvali (CERN, Geneva, Switzerland)
François Englert (ULB, Brussels, Belgium)
Peter Goddard (IAS, Princeton, USA)
Cesar Gomez (IFT, Madrid, Spain)
Michael Green (Cambridge University, UK)
David Gross (Kavli Institute, UCSB, Santa Barbara, USA)
Hans Hansson (Stockholm U, Sweden)
Gerard 't Hooft (Utrecht U, The Netherlands)
Paul Howe (King's College, London, UK)
Bernard Julia (ENS, Paris, France)
Renata Kallosh (Stanford University, USA)
Sung-Soo Kim (KIAS, Seoul, Republic of Korea)
Costas Kounnas (LPTENS, Paris, France)
Dieter Luest (LMU, Munich, Germany)
Chiara Nappi (Princeton University, USA)
Hermann Nicolai (Max-Planck-Institut, Munich, Germany)
Yaron Oz (Tel Aviv University, Israel)
Alexander Polyakov (Princeton University, USA)
Eliezer Rabinovici (HUJI, Jerusalem, Israel)
Soo-Jong Rey (IAS, Princeton, USA)
John Schwarz (Caltech, Pasadena, USA)
Adam Schwimmer (Weizmann Institute, Rehovot, Israel)
Nathan Seiberg (IAS, Princeton, USA)
Mikhail Shifman (University of Minnesota, USA)
Kelly Stelle (Imperial College, London, UK)
Bo Sundborg (Stockholm U, Sweden)
Charles Thorn (UF, Gainesville, USA)
Arkady Vainshtein (University of Minnesota, USA)
Misha Vasiliev (LPI, Moscow, Russia)
Peter West (King's College, London, UK)

Scientific and Organizing Committee

Riccardo Argurio (ULB, Brussels, Belgium)
Claudio Bunster, (CECs, Valdivia, Chile)
Marc Henneaux (ULB & Solvay Institutes, Brussels, Belgium)
Måns Henningson (Chalmers University, Sweden)
Viatcheslav Mukhanov (LMU, Munich, Germany)
Bengt E.W. Nilsson (Chalmers University, Sweden)
Pierre Ramond (UF, Gainesville, USA)
Alexandre Sevrin (VUB, Brussels, Belgium)
Phillipe Spindel (Umons, Belgium)
Isabelle Van Geet (Solvay Institutes, Brussels, Belgium)
Antoine Van Proeyen (KU Leuven, Belgium)

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Arnold Sommerfeld Center for Theoretical Physics | ULB | Vrije Universiteit Brussel | Solvay | Loterie Nationale Loterij | fnrs | FONDATION DAVID ET ALICE VAN BUUREN

Design: info@eimagedesign.be

Workshops and School organised by the Institutes

Workshop on

"**Fast is beautiful**: **supersymmetry** and **strings** in a null frame"

14 -15 May 2014

A meeting held in honour of Professor Lars Brink, in scientific cooperation with the Centro de Estudios Científicos (CECs, Valdivia, Chile) and the Arnold Sommerfeld Center (University of Munich, Germany).

In addition to their practical usefulness, light cone gauge techniques, in which null frames play an essential role, provide a unique physical insight into many fundamental questions involving massless particles. In particular, finiteness of N=4 super Yang-Mills models was first established using light cone techniques by Lars Brink and his collaborators. These techniques are also central in important approaches to string theory, to higher spin gauge theories and their consistent interactions, as well as to the analysis of short supersymmetric multiplets containing massless particles (light-cone superspace).

The topics covered in the workshop were (i) extended supersymmetry, (ii) string theory, (iii) recent investigations on the renormalization of maximal supergravity, (iv) construction of consistent interactions for higher spin gauge theories. Light cone techniques were the common, unifying thread.

In addition to discussing advances in these frontiers topics, the workshop also provided opportunities to reflect on the future of theoretical physics, with some of the world leading figures in the field.

Organizing Committee

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Phillipe Spindel (Umons, Belgium)
Isabelle Van Geet (Solvay Institutes Brussels, Belgium)
Antoine Van Proeyen (KU Leuven, Belgium)

Programme

Wednesday **14 May** 2014

Welcome by Marc Henneaux (ULB & Solvay Institutes) and Claudio Bunster (CECs, Chile).

Panel 1 chaired by **François Englert** (ULB)

Luis Alvarez-Gaumé (CERN)

Alexander Polyakov (Princeton U.)

John Schwarz (Caltech)

Mikhail Shifman (U. of Minnesota)

Panel 2 chaired by **Pierre Ramond** (UF Gainsville)

Michael Green (Cambridge U.)

Viatcheslav Mukhanov (LMU, Munich)

Gerard 't Hooft (Utrecht U.)

Nathan Seiberg (IAS, Princeton)

Both panels were devoted to central questions of fundamental physics.

Thursday **15 May** 2014

Morning Session chaired by **Bengt Nilsson** (Göteborg)

Zvi Bern (UCLA)	UV surprises in N=4 Supergravity
Misha Vasiliev (Lebedev I., Moscow)	Higher-spin theory from classical works to recent developments
Kelly Stelle (Imperial College, London)	Localizing braneworlds in infinite transverse spaces

Afternoon Session chaired by **Måns Henningson** (Göteborg)

Hermann Nicolai (Max-Planck I., Potsdam)	Another look at quadratic divergences
Costas Bachas (ENS Paris)	(Inter)faces of maximal symmetry
Gia Dvali (Munich)	A Corpuscular Theory of Black Holes and Inflation

Participants

Luis Alvarez Gaumé (CERN, Geneva, Switzerland)
Ignatios Antoniadis (CERN, Geneva, Switzerland)
Costas Bachas (LPTENS, Paris, France)
Glenn Barnich (ULB, Brussels, Belgium)
Anders Bengtsson (UB, Borås, Sweden)
Ingemar Bengtsson (Stockholm U, Sweden)
Zvi Bern (UCLA, Los Angeles, USA)
Nicolas Boulanger (UMONS, Belgium)
Lars Brink (Chalmers University, Sweden)
Roberto Casalbuoni (UniFI, Florence, Italy)
Martin Cederwall (Chalmers University, Sweden)
David Chow (ULB, Brussels, Belgium)
Geoffrey Compère (ULB, Brussels, Belgium)
Eduardo Conde Pena (ULB, Brussels, Belgium)
Ignacio Cortese (ULB, Brussels, Belgium)
Eugène Cremmer (ENS, Paris, France)
Thomas Curtright (UM, Miami, USA)
Karen De Causmaecker (VUB, Brussels, Belgium)
Stéphane Detournay (ULB, Brussels, Belgium)
Paolo Di Vecchia (Nordita, Stockholm, Sweden)
Louise Dolan (UNC at Chapel Hill, USA)
Laura Donnay (ULB, Brussels, Belgium)
Georgi Dvali (CERN, Geneva, Switzerland)
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Marco Fazzi (ULB, Brussels, Belgium)
David Fairlie (Durham U., UK)
Frank Ferrari (ULB, Brussels, Belgium)
Peter Goddard (IAS, Princeton, USA)
Hernan Gonzalez (ULB, Brussels, Belgium)
Cesar Gomez (IFT, Madrid, Spain)
Michael Green (Cambridge University, UK)
Hans Hansson (Stockholm U, Sweden)
Gerard 't Hooft (Utrecht U., The Netherlands)
Sergio Hörtner (ULB, Brussels, Belgium)
Chris Hull (Imperial College, London, UK)
Bernard Julia (ENS, Paris, France)
Sung-Soo Kim (KIAS, Seoul, Republic of Korea)
Costas Kounnas (LPTENS, Paris, France)
Pierre-Henry Lambert (ULB, Brussels, Belgium)
Amaury Léonard (ULB, Brussels, Belgium)
Gustavo Lucena Gómez (ULB, Brussels, Belgium)
Andrea Marzolla (ULB, Brussels, Belgium)

Kentarou Mawatari (VUB, Brussels, Belgium)

Andrea Mezzalira (ULB, Brussels, Belgium)

Micha Moskovic (ULB, Brussels, Belgium)

Hermann Nicolai (Max Planck Institute, Germany)

Yaron Oz (Tel Aviv University, Israel)

Jakob Palmkvist (IHES, Bures-sur-Yvette, France)

Alexander Polyakov (Princeton University, USA)

Dmitry Ponomarev (LMU, Munich, Germany)

Eliezer Rabinovici (HUJI, Jerusalem, Israel)

Rakibur Rahman (ULB, Brussels, Belgium)

Soo-Jong Rey (Seoul National University, Korea)

Waldemar Schulgin (ULB, Brussels, Belgium)

John Schwarz (Caltech, Pasadena, USA)

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Misha Vasiliev (LPI, Moscow, Russia)

Gary Way (Trinity College, Dublin, Ireland)

Peter West (King's College, London, UK)

Hongbao Zhang (VUB, Brussels, Belgium)

Modave Summer School in **Mathematical Physics**

1 - 5 September 2014

Workshops and School organised by the Institutes

Modave Summer School in **Mathematical Physics**

1 - 5 September 2014

The tenth edition of the Modave Summer School in Mathematical Physics took place from the 1st to the 5th September 2014. 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.

Lectures

Cosmology

- Tarek Anous, "QFT on de Sitter space"
- Sébastien Clesse, "Analysis of Planck data"
- Ruben Monten, "Introduction to modern cosmology"

Exact results in **QFT**

- Curtis Asplund, "Matrix/vector models and large N limits"
- Simone Giacomelli, "N=2 SUSY"
- Claudius Klare, "SUSY on curved space"
- Jules Lamers, "Introduction to quantum integrability"

Organizing Committee

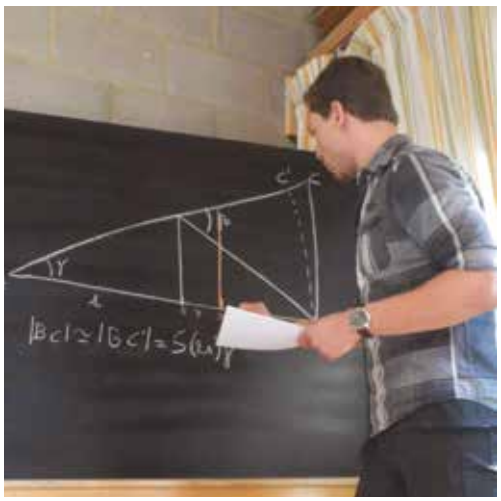
Gabriele Conti (KUL)
Laura Donnay (ULB)
Laure-Anne Douxchamps (ULB)
Marco Fazzi (ULB)
Amaury Léonard (ULB)
Jonathan Lindgren (VUB)
Pujian Mao (ULB)
Andrea Marzolla (ULB)
Thomas Mertens (UAntwerp)
Ruben Monten (KUL)
Blagoje Oblak (ULB)
Brecht Truijen (KUL)
Ellen Van der Woerd (KUL)
Joris Van Hoof (VUB)
Yannick Vreys (KUL)

Lectures

Quantum field theory in de **Sitter space**

Tarek Anous

In these lectures we provided an introduction to perturbative quantum field theory in de Sitter space, which is much more subtle than its flat space counterpart. In the first lecture, the geometry of de Sitter space was introduced, as well as many of the coordinate systems used to describe it, followed by an introduction to the various, inequivalent quantum vacua in de Sitter space. We then proved that geodesic observers in the Bunch-Davies vacuum observe a thermal bath of particles. The second lecture was more speculative and we discussed so called "natural" observables for quantum fields in de Sitter space. We highlighted the perspectives of two different observers: the static one, who follows a geodesic in de Sitter space, and the metaobserver, observing the late-time CMB of a past de Sitter era.



Introduction to **matrix models**

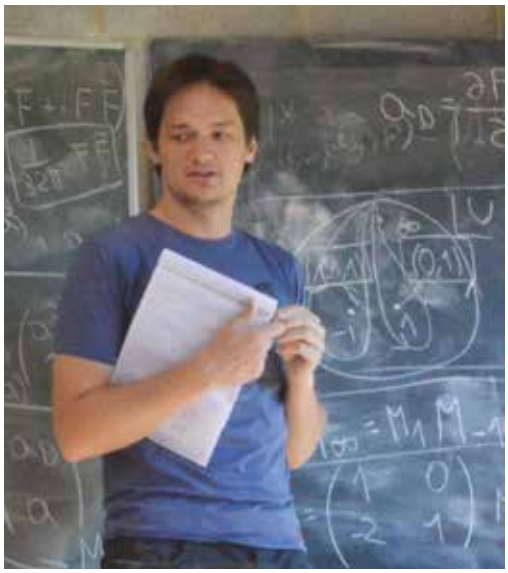
Curtis Asplund

Random matrices made their first significant appearance in physics with the work of Wigner, Dyson, Mehta, and others, in trying to model the complicated Hamiltonians of atomic nuclei. Since then, they have been applied to many other areas of physics. In these lectures, I first discussed Random matrices as general-purpose statistical models, based on recent theorems showing the universality of various eigenvalue statistics (e.g., Wigner-Dyson and Tracy-Widom statistics). I then explained the technique of orthogonal polynomials for calculating eigenvalue densities, correlation functions and partition functions, especially in the limit of large matrices. I showed how the perturbation theory for these calculations can be organized as an expansion in the genus of triangulated two-dimensional surfaces, which leads to a connection with two-dimensional quantum gravity and low-dimensional string theory. Finally, I turned to multi-matrix models, which are used as models of M-theory and in descriptions of D-branes.

An introduction to **inflation** after **Planck**: From **theory** to **observations**

Sébastien Clesse

This was a short introductory course on the status of inflation after Planck and BICEP2. The first objective was to give an overview of the theory of inflation: motivations, homogeneous scalar field dynamics, slow-roll approximation, linear theory of cosmological perturbations, classification of single field potentials and their observable predictions. This included a derivation of the primordial scalar and tensor power spectra for any effective single field potential. The second goal was to present the most recent results of Planck and BICEP2 and to discuss their implications for inflation. Bayesian statistical methods were introduced as a tool for model analysis and comparison. Based on the recent work of J. Martin et al., the best inflationary models after Planck and BICEP2 were presented. Finally a series of open questions and issues related to inflation were mentioned and briefly discussed.



N=2 SUSY and **Seiberg-Witten** duality

Simone Giacomelli

The dynamics of non-abelian gauge theories in four dimensions represents one of the main challenges of modern theoretical physics. The most famous example is QCD, the theory of strong interactions, which at low energy is expected to exhibit confinement and chiral symmetry breaking; currently we do not have a clear understanding of what is the physical mechanism underlying these phenomena. The situation improves drastically for supersymmetric gauge theories: for theories with N=2 supersymmetry Seiberg and Witten managed to obtain an exact description of the theory at low energy and described in detail the effects of quantum corrections. In these lectures I discussed the derivation of the Seiberg-Witten solution and described the theoretical tools involved which include magnetic monopoles, electric-magnetic duality and anomalies.

Localisation and **supersymmetry** on curved space

Claudius Klare

In this mini series of lectures I reviewed some of the recently obtained exact results in supersymmetric field theories. Defining supersymmetric theories on curved spaces (like spheres) sometimes allows for computing explicitly the partition function by localisation. The resulting matrix models give rise to new observables and many interesting results for theories in various dimensions. In the first lecture I presented an overview of the subject, including a brief summary of the technical tool of localisation. In lecture two I reviewed rigid supersymmetry on curved spaces. Finally in lectures three and four, I discussed some of the applications that have been realised in 2, 3 and 4 dimensions.

Introduction to **quantum integrability**

Jules Lamers

The goal of these lectures was to provide a pedagogical introduction to quantum integrability for PhD candidates and junior researchers in theoretical physics. As a motivation we started with a brief historical overview and mentioned several applications of quantum integrability in the context of theoretical high-energy physics.

Next we introduced spin chains and discussed the coordinate Bethe Ansatz (CBA) for a representative example: the Heisenberg XXZ model. Subsequently the transfer-matrix method was discussed for the six-vertex model, uncovering a relation between that model and the XXZ spin chain. Equipped with this background the quantum inverse-scattering method (QISM) and algebraic Bethe Ansatz (ABA) were treated, emphasizing the use of graphical notation for algebraic quantities as well as computations.

Introduction to **cosmology**

Ruben Monten

In this introductory lecture to cosmology, the students were guided through the evolutions of our theoretical understanding of the cosmos. Starting early in the twentieth century, from speculation based on Einstein's general theory of relativity and arriving at the very successful Λ-CDM model that stood the test of highly precise experiments. Apart from the theoretical framework that was developed, it was outlined which types of experimental data are available to constrain the parameters of our own universe.

Furthermore, in the final part of this course, we connected with ongoing (theoretical and experimental) research at the limits of the current well-established model. In particular, the students were introduced to some of the problems that arise when trying to explain the earliest moments of the universe, and to the theory of inflation, which aims at providing a solution.

The goal of this course was to prepare the students for the more advanced course on the Planck experiment by Sébastien Clesse and on quantum field theory in de Sitter space by Tarek Anous.

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.

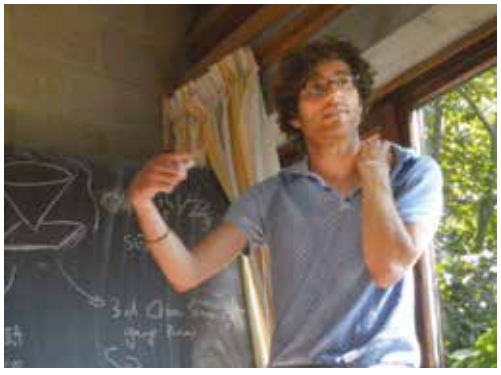
Participants

Anous, Tarek (MIT, USA)
Asplund, Curtis (Columbia University, USA)
Clesse, Sébastien (Université de Namur, Belgium)
Conti, Gabriele (KU Leuven, Belgium)
Coone, Dries (Groningen University, The Netherlands)
Corvilain, Pierre (ULB, Belgium)
Donnay, Laura (ULB, Belgium)
Douxchamps, Laure-Anne (ULB, Belgium)
Fazzi, Marco (ULB, Belgium)
Galante, Mariano (Groningen University, The Netherlands)
Giacomelli, Simone (ULB, Belgium)
Gonzalez, Hernan (ULB, Belgium)
Kabir, Laurens (UvAmsterdam, The Netherlands)
Klare, Claudius (Paris 6, France)
Lamers, Jules (Utrecht University, The Netherlands)
Lekeu, Victor (ULB, Belgium)
Léonard, Amaury (ULB, Belgium)
Linander, Hampus (Chalmers University, Sweden)
Lindgren, Jonathan (VUB, Belgium)
Mao, Pujian (ULB, Belgium)
Marzolla, Andrea (ULB, Belgium)
Matulich, Javier (CECs, Chile)
Mertens, Thomas (UAntwerp, Belgium)
Monten, Ruben (KU Leuven, Belgium)
Oblak, Blagoje (ULB, Belgium)
Salgado Rebolledo, Patricio (ULB, Belgium)
Truijen, Brecht (KU Leuven, Belgium)
Van der Woerd, Ellen (KU Leuven, Belgium)
Van Hoof, Joris (VUB, Belgium)
Vreys, Yannick (KU Leuven, Belgium)
Zojer, Thomas (Groningen University, The Netherlands)
Zwikel, Céline (ULB, Belgium)









Workshops and School organised by the Institutes

Workshop on

"**Beta-Decay** Weak Interaction Studies in the **Era** of the **LHC**"

3 - 5 September 2014

INTERNATIONAL SOLVAY INSTITUTES BRUSSELS

Brussels
3-5 September 2014
Université Libre de Bruxelles
Campus Plaine, Solvay Room

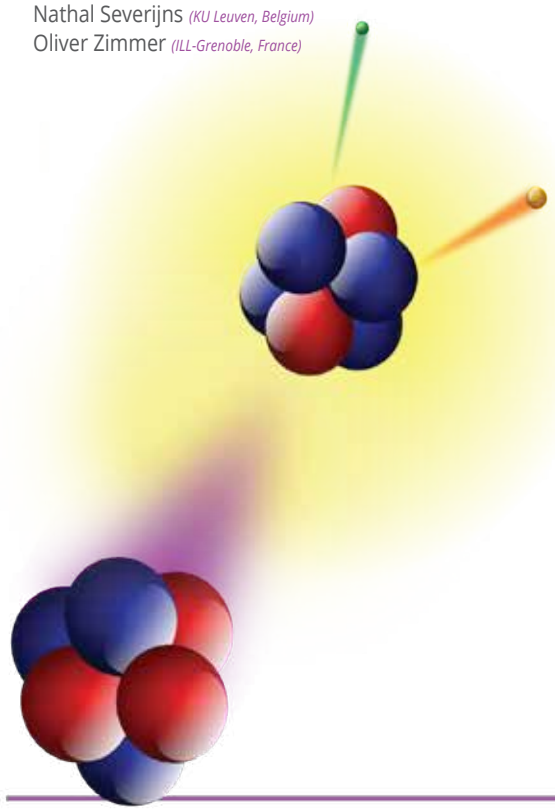
www.solvayinstitutes.be

Solvay Workshop on

Beta-Decay Weak Interaction Studies in the Era of the LHC

Scientific & Organizing Committee

Vincenzo Cirigliano *(Los Alamos National Laboratory, USA)*
Jean-Marie Frère *(ULB, Brussels, Belgium)*
Oscar Naviliat-Cuncic *(MSU, Michigan, USA)*
Dinko Pocanic *(University of Virginia, USA)*
Nathal Severijns *(KU Leuven, Belgium)*
Oliver Zimmer *(ILL-Grenoble, France)*



Speakers

Hartmut Abele *(TU Wien, Vienna, Austria)*
Marcus Beck *(JGU, Mainz, Germany)*
John Behr *(UBC & TRIUMF, Vancouver, Canada)*
Bertram Blank *(CENBG, Gradignan, France)*
Kazimierz Bodek *(Jagiellonian University, Krakow, Poland)*
Vincenzo Cirigliano *(Los Alamos National Laboratory, USA)*
Michael Scott Dewey *(NIST, Gaithersburg, USA)*
Jean-Marie Frère *(ULB, Brussels, Belgium)*
Susan Gardner *(University of Kentucky, USA)*
Ferenc Glück *(KIT, Karlsruhe , Germany)*
Martín González-Alonso *(IPNL, Lyon, France)*
Rajan Gupta *(Los Alamos National Laboratory, USA)*
John Hardy *(Texas A&M University, USA)*
Michael Hass *(Weizmann Institute of Science, Rehovot, Israel)*
Gertrud Konrad *(TU Wien, Vienna, Austria)*
Etienne Liénard *(Université de Caen Basse Normandie, France)*
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Michael Snow *(Indiana University, Bloomington, USA)*
Torsten Soldner *(Institut Laue-Langevin Grenoble, France)*
Carl Svensson *(University of Guelph, Ontario, Canada)*
Rob Timmermans *(KVI, Groningen, The Netherlands)*
Frederik Wauters *(UW, Seattle, USA)*
Albert Young *(NC Sate University, North Carolina, USA)*
Oliver Zimmer *(Institut Laue-Langevin Grenoble, France)*

Workshops and School organised by the Institutes

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Workshop on

"**Beta-Decay** Weak Interaction Studies in the **Era** of the **LHC**"

3 - 5 September 2014

Precision measurements in nuclear and neutron beta decay offer a sensitive window to probe details of the structure of the weak interaction and to test the underlying fundamental symmetries. Such measurements have turned into powerful tools to search for new physics beyond the standard electroweak model, like the signatures for right-handed weak currents, scalar and tensor type interactions and deviations from time reversal invariance. Over the years the precision reached in these experiments has steadily been improved owing to developments of new experimental techniques like the use of atom and ion traps.

At the large energy frontier, the Large Hadron Collider is running with remarkable stability and luminosity to explore new energy territories. Experiments at the LHC have already provided the discovery of the celebrated Brout-Englert-Higgs boson and allow also the search for new interactions through the direct production of new particles that could possibly also contribute to the weak interaction.

Some possible scenarios for new physics assume that the new bosons would only occur at significantly higher energies than those available at the LHC. It becomes then possible to build bridges between the high precision and the high energy frontiers in order to study the sensitivities and complementarities of the two frontiers in the search for new physics.

The aim of this workshop was to review the state of the art of beta-decay experiments and related precision measurements and to draw a sketch of what could become the main priorities of this research field in the coming years at the light of LHC results. This included the primary physics questions, the sensitivity of observables to be addressed, the suitable experimental instrumentation, beam and sources developments as well as the required theoretical calculations and models for new physics. The discussions were expected to shape a frame for continuing providing substantial contributions in the search for new physics beyond the standard model through measurements at the precision frontier.

Scientific and **Organizing** Committee

Vincenzo Cirigliano (LANL, USA)
Jean-Marie Frère (ULB, Brussels, Belgium)
Oscar Naviliat-Cuncic (MSU, Michigan, USA)
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Nathal Severijns (KU Leuven, Belgium)
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Torsten Soldner (ILL, Grenoble, France)
Carl Svensson (U. of Guelph, Ontario, Canada)
Rob Timmermans (U. of Groningen, The Netherlands)
Frederik Wauters (UW, Seattle, USA)
Albert Young (NC State U., North Carolina, USA)
Oliver Zimmer (ILL, Grenoble, France)

Programme

Wednesday **3 September** 2014

Welcome and opening address

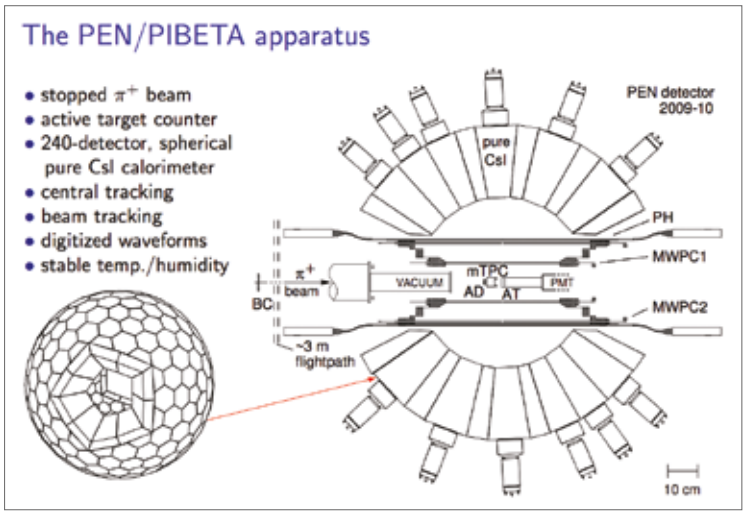
Hartmut Abele	A, B - Status and prospects
Gertrud Konrad	a, b - Status and prospects
Marcus Beck	Results from aSPECT
Maynard Scott Dewey	Neutron t1/2 from beam exps.
Anatoly Serebrov	Neutron t1/2 from trap exps.
Oliver Zimmer	New t1/2 exp. in trap
Albert Young	New t1/2 exp. in trap + SNS
Michael Snow	NPDG experiment at SNS
Susan Gardner	TRV in radiative neutron decay
Torsten Soldner	Fundamental physics at ESS
Jiro Murata	The MTV TRV exp. with 8Li
Rob Timmermans	Lorentz Invar. Viol. – theory
Kazimierz Bodek	Lorentz Invar. Viol. in n decay

Thursday **4 September** 2014

Frederik Wauters	Tensor current limits
Martín González-Alonso	Effective field theory - limits
Ferenc Glück	Radiative corrections
Rajan Gupta	gA, gS, gT
Dinko Pocanic	Results from pion and muon decay
Jean-Marie Frère	Challenges to Nucl. Phys.
John Behr	Beta decay correl. with TRINAT
Etienne Liénard	Results from LPCTRAP
Peter Mueller	a-6He at Seattle
Guy Ron	a-6He with electrost. Trap
Nicholas Scielzo	a-8Li at Argonne
Dan Melconian	TAMUTRAP

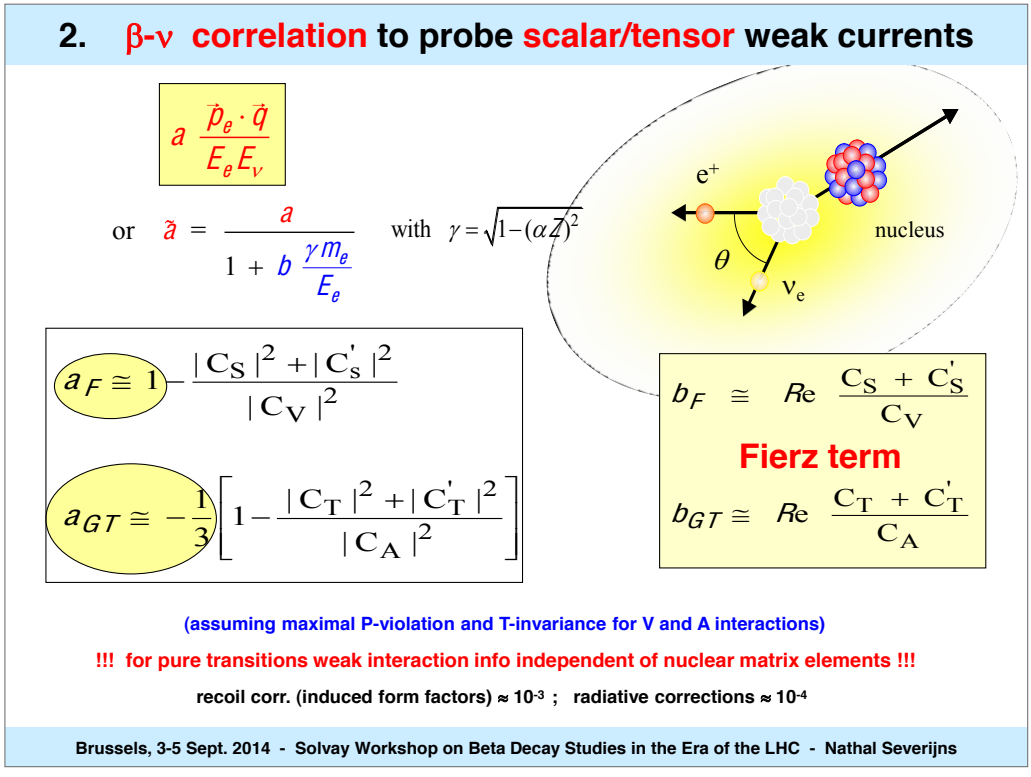
Friday **5 September** 2014

John Hardy	Fermi transitions overview
Bertram Blank	Fermi transitions exps.
Carl Svensson	Fermi transitions exps.
Oscar Naviliat-Cuncic	Beta spectrum shape
Nathal Severijns	Beta spectrum shape
Oscar Naviliat-Cuncic	Closing



Participants

Abele Hartmut (TU Wien, Vienna, Austria)
Beck Marcus (JGU, Mainz, Germany)
Behr John (UBC& TRIUMF, Vancouver, Canada)
Blank Bertram (CENBG, Gradignan, France)
Bodek Kazimierz (Jagiellonian U., Poland)
Couratin Claire (KU Leuven, Belgium)
Delahaye Pierre (GANIL, Caen, France)
Dewey Michael Scott (NIST, Gaithersburg, USA)
Fabian Xavier (GANIL, Caen, France)
Finlay Paul (KU Leuven, Belgium)
Frere Jean-Marie (ULB, Brussels, Belgium)
Gardner Susan (U. of Kentucky, USA)
Geltenbort Peter (Institut Laue Langevin, France)
Glueck Ferenc (KIT, Karlsruhe, Germany)
González-Alonso (Martín IPNL, Lyon, France)
Gupta Rajan (LANL, USA)
Guy Ron (Weizmann Institute, Rehovot, Israel)
Hardy John (Texas A&M University, USA)
Hayen Leendert (KU Leuven, Belgium)
Kirsebom Oliver (Aarhus University, Denmark)
Konrad Gertrud (TU Wien, Vienna, Austria)
Laffoley Alex (University of Guelph, Canada)
Lenaers Florence (Université de Liége, Belgium)
Liénard Etienne (UNICAEN, France)
Mawatari Kentarou (VUB, Brussels,Belgium)
Melconian Dan (Texas A&M University, USA)
Mueller Peter (Argonne National Laboratory, USA)



Murata Jiro (Rikkyo University, Tokyo, Japan)

Navilliat-Cuncic Oscar (MSU, Michigan, USA)

Perkowski Maciej (KU Leuven, Belgium)

Pocanic Dinko (U. of Virginia, USA)

Porobic Tomica (KU Leuven, Belgium)

Prieels René (Université Catholique de Louvain, Belgium)

Scielzo Nicholas (LLNL, Livermore, USA)

Serebrov Anatoly (PNPI, Gatchina, Russia)

Severijns Nathal (KU Leuven, Belgium)

Snow Michael (Indiana U, Bloomington, USA)

Soldner Torsten (ILL, Grenoble, France)

Soti Gergely (KU Leuven, Belgium)

Svensson Carl (U. of Guelph, Ontario, Canada)

Timmermans Rob (U. of Groningen, The Netherlands)

Velten Philippe (KU Leuven, Belgium)

Vos Keri (University of Groningen, The Netherlands)

Wauters Frederik (UW, Seattle, USA)

Wilschut Hans (University of Groningen, The Netherlands)

Wunderle Alexander (University of Mainz, Germany)

Wursten Elise (KU Leuven, Belgium)

Young Albert (NC Sate U., North Carolin, USA)

Zimmer Oliver (ILL, Grenoble, France)

Workshop on

"**Directional Nucleation** and Growth of **Molecular Crystals**"

26 - 28 November 2014

INTERNATIONAL SOLVAY INSTITUTES BRUSSELS

26 – 28 November 2014
Université Libre de Bruxelles
Campus Plaine, Solvay Room

www.solvayinstitutes.be

Solvay Workshop on

"Directional Nucleation and Growth of Molecular Crystals"

Organizing Committee

Yannick De Decker *(ULB, Belgium)*
Anne De Wit *(ULB, Belgium)*
Yves Geerts *(ULB, Belgium)*
Roberto Lazzaroni *(U. de Mons, Belgium)*
Simone Napolitano *(ULB, Belgium)*

Scientific Committee

Davide Bonifazi *(U. de Namur, Belgium)*
Yves Geerts *(ULB, Belgium)*
Philippe Leclère *(U. de Mons, Belgium)*
Bernard Nysten *(UCL, Belgium)*

Speakers

Aram Amasian *(KAUST, Saudi Arabia)*
Alex Briseno *(U. of Massachussets, USA)*
Basab Chattopadhyay *(IACS, India)*
Gérard Coquerel *(U. de Rouen, France)*
Gabin Gbabode *(U. de Rouen, France)*
Jun-ichi Hanna *(Tokyo Tech, Japan)*
Dieter Herlach *(DLR, Germany)*
Alain Jonas *(UCL, Belgium)*
Bart Khar *(New York U., USA)*
Rafal Klajn *(Weizmann I. of Sciences, Israel)*
Jim Lutsko *(ULB, Belgium)*
Christian Maes *(KULeuven, Belgium)*
Dominique Maes *(VUB, Belgium)*
Grégoire Nicolis *(ULB, Belgium)*
Günther Reiter *(U. of Freiburg, Germany)*
Roland Resel *(Technical U. of Graz, Austria)*
Paolo Samori *(U. de Strasbourg, France)*
Guillaume Schweicher *(ULB, Belgium)*
Natalie Stingelin-Stuzmann *(Imperial College London, UK)*
Peter Vekilov *(U. of Houston, USA)*
Stéphane Veesler *(CNRS Marseille, France)*
Lian Yu *(U. of Wisconsin, USA)*

ULB · Vrije Universiteit Brussel · fnrs · SOLVAY · VB · RICHTING MORGEN · FONDATION DAVID ET ALICE VAN BUUREN · Loterie Nationale Loterij

Workshops and School organised by the Institutes

Workshop on "**Directional Nucleation** and Growth of **Molecular Crystals**"

26 - 28 November 2014

Directional crystallization is defined as the controlled crystallization in one specific direction that can be induced, for example: by a heat flux, a magnetic or electric field, a flat or a patterned substrate, or a mesophase. Directional crystallization implies that systems are out of equilibrium and that they are controlled by kinetics. Molecular crystals are of particular interest because they tend to form low symmetry crystals with typically monoclinic or triclinic unit cells. New physics such as, for example, the unit cell alignment versus a heat flux, emerge from the low symmetry. The workshop will bring together world experts of non-equilibrium thermodynamics, kinetics, crystal growth, polymers, and molecular crystals.

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Dieter Herlach (DLR, Germany)
Alain Jonas (UCL, Belgium)
Bart Kahr (New York U., USA)
Rafal Klajn (Weizmann I. of Sciences, Israel)
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Dominique Maes (VUB, Belgium)
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Natalie Stingelin-Stuzmann (Imperial College London, UK)
Peter Vekilov (U. of Houston, USA)
Stéphane Veesler (CNRS Marseille, France)
Lian Yu (U. of Wisconsin, USA)

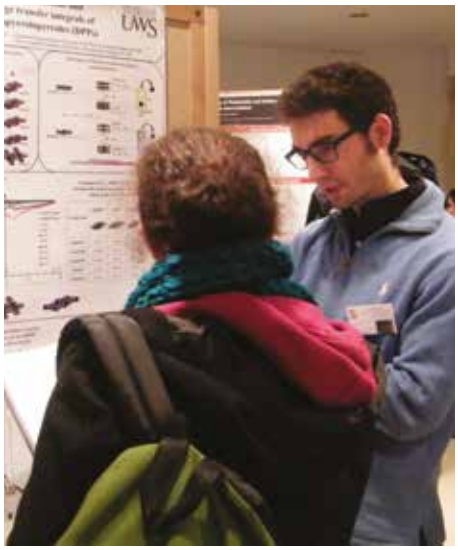
Programme

Wednesday **26 November** 2014

Welcome and introduction by Yves Geerts

Grégoire Nicolis	Kinetics, statistics and thermodynamics of fluctuation-induced transitions between metastable states
Dominique Maes	Protein clusters and crystals
Alain Jonas	Controlling orientation by crystallization in confinement: principles and application to ferroelectric devices
Basab Chattopadhyay	Substrate Induced Crystalline Phases
Guillaume Schweicher	Directional Crystal Growth of Molecular Semiconductors
Christian Maes	Statistical forces outside equilibrium
Rafal Klajn	Directed crystallization in colloidal systems
Dieter Herlach	Undercooled melts: ordering, nucleation, dendrite growth

Poster session



Thursday **27 November** 2014

Günter Reiter	Correlating polymer crystals via self-Induced nucleation
Natalie Stingelin	Nucleating-agent-assisted microstructure formation in molecular and polymer semiconductors
Gabin Gbabode	Directional crystallization of poly(ethyleneoxide)
Gérard Coquerel	Directional crystallizations concomitant to smooth desolvations
Paolo Samori	Taming complexity in molecular materials: tailoring low dimensional nanostructures
Bart Kahr	Growth induced twisting of crystals
Jun-ichi Hanna	Crystallization of mono-alkylated Benzothienobenzothiopene derivative via smectic E phase and its application to organic field effect transistors
Peter Vekilov	Recent advances in the understanding of two-step nucleation of protein crystals
Lian Yu	Crystallization of organic glasses: How molecules grow crystals in frozen liquids

Banquet downtown Brussels

Friday **28 November** 2014

Roland Resel	Organic epitaxy of rod-like conjugated molecules
Aram Amassian	Controlled nucleation of solution processed conjugated small molecules for high performance organic electronics
Jim Lutsko	A two-variable generalization of classical nucleation theory
Stéphane Veesler	Small-volume and localized fields for nucleation understanding
Alex Briseno	Rise I Say! Growth of Vertically Oriented Single-Crystalline Nanostructures
Yves Geerts	Conclusions and perspectives

Participants

Aliev Almaz (Universite libre de Bruxelles, Belgium)

Berenstein Igal (Université libre de Bruxelles Belgium)

Brau Fabian (Université libre de Bruxelles, Belgium)

Buess-Herman Claudine (Université libre de Bruxelles, Belgium)

Burel Antoine (University of Rouen, France)

Cai Ronggang (Université catholique de Louvain, Belgium)

Calvo-Castro Jesus (University of the West of Scotland, UK)

Carballido Jorge (Université libre de Bruxelles, Belgium)

Delplancke Marie-Paule (Université libre de Bruxelles, Belgium)

Dinh Huy Pham (Umons, Belgium)

Douieb Sélim (Université libre de Bruxelles, Belgium)

Dubois Jean (UNamur, Belgium)

Fraleoni Morgera Alessandro (Univ. of Trieste, Italy)

Gaspard Pierre (Université libre de Bruxelles, Belgium)

Gilbert Thomas (Université libre de Bruxelles, Belgium)

Gopalakrishnan Shyam Sunder (Université libre de Bruxelles, Belgium)

Carelle Thomas (Université libre de Bruxelles, Belgium)

Ciardi Moira (Université catholique de Louvain, Belgium)

Clevers Simon (Université libre de Bruxelles, Belgium)

Defour Maxime (Vrije Universiteit Brussel, Belgium)

Dellicour Aline (Université de Liège, Belgium)

Grosfils Patrick (Université libre de Bruxelles, Belgium)

Grossier Romain (CINaM – CNRS, France)

Huang Weide (Université libre de Bruxelles, Belgium)

Janneck Robby (KU Leuven, Belgium)

Mannsfeld Stefan (Dresden University of Technology, Germany)

Martinez-Tong Daniel (Université libre de Bruxelles, Belgium)

McHugh Callum (University of the West of Scotland, UK)

Meirzadeh Elena (Weizmann Institute of Science, Israel)

Middleton Ceri (Université libre de Bruxelles, Belgium)

Niazi Muhammad Rizwan Khan (King Abdullah University of Science and Technology, Kingdom of Saudi Arabia)

Pachmajer Stefan (Graz University of Technology, Austria)

Reiter Renate (University of Freiburg, Germany)

Richard Audrey (Université libre de Bruxelles, Belgium)

Rimez Bart (Université libre de Bruxelles, Belgium)

Roethel Christian (TU Graz, Austria)

Rolin Cedric (Imec, Belgium)

Rongy Laurence (Université libre de Bruxelles, Belgium)

Scheid Benoit (Université libre de Bruxelles, Belgium)

Sferrazza Michele (Université libre de Bruxelles, Belgium)

Shukla Priyanka (Université libre de Bruxelles, Belgium)

Tan Ke Jie (Imperial College London, UK)

Unger Katrin (Graz University of Technology, Austria)

Valentin Morgane (Université de Liège, Belgium)

Van den Brande Niko (Vrije Universiteit Brussel, Belgium)

Van Mele Bruno (Vrije Universiteit Brussel, Belgium)

Vladimirov Ilja (University of Heidelberg / BASF SE, Germany)

Voorsluijs Valérie (Université libre de Bruxelles, Belgium)

Woller Tatiana (Vrije Universiteit Brussel, Belgium)

Ziemecka Iwona (Université libre de Bruxelles, Belgium)

International Doctoral School

The **International Doctoral** School "Quantum Field Theory, Strings and Gravity"

Brussels

13 - 31 October 2014

Marco Billò
Adel Bilal
Viatcheslav Mukhanov
Alberto Lerda
Glenn Barnich

This school was organized for the eigth consecutive year in the fall of 2014. The Institute for Theoretical Physics at ETH Zürich has joined this year the International Solvay Institutes and the Service de Physique Théorique et Mathématique at U.L.B., the Theoretical Particle Physics group at V.U.B, the Laboratoire de Physique Théorique at École Normale Supérieure in Paris and the Institute for Theoretical Physics in Amsterdam as one of the main organizing node of the school. The school took place in three sites (Brussels, Paris and CERN in Geneva) where the students followed intense three-week sessions.

The participants were all beginning graduate students, from the organizing nodes and also from various other institutions in Belgium, France, the Netherlands and Switzerland. All the students followed more than 250 hours of lectures organized in various courses. The main goals were to strengthen their training in quantum field theory and string theory and to introduce them to cutting-edge research problems in the field. In Brussels, Prof. Adel Bilal (École Normale Supérieure in Paris) and Alberto Lerda (Piemonte University and INFN Turin) taught the Advanced Quantum Field Theory (30 h) and Introduction to String Theory (12 h) courses respectively, carrying on their much appreciated contribution to the school. Prof. Marco Billó from the University of Turin complemented the lectures on String theory (12 h) and Prof. Glenn Barnich, from the U.L.B., was in charge of lectures on General Relativity, Cosmology and Black holes (24 h). Finally, Prof. Viatcheslav Mukhanov, from the Arnold Sommerfeld Center for Theoretical Physics at LMU Munich, holder of the Solvay Chair in Physics, presented a course on the Physics of the early universe.

This programme is unique in Europe. It provides a great opportunity for the students to be introduced, at an unusually early stage in their training, to the "Big Picture" of a highly technical field that covers large areas of Physics and Mathematics. The possibility to meet leading experts in an informal setting and to share research interests and insights with fellow graduate students from other countries, which may become long-term collaborators after their PhD study, is also a great asset of the School.

In Brussels, the School greatly benefits from the assistance of the International Solvay Institutes, both through financial and organizational supports.

The School has now reached maturity, with an excellent organization, thoroughly chosen topics and a smooth transition between the trainings offered at the different nodes. All the participants seem extremely enthusiastic about this programme. The recent extension of the school to include several Swiss institutions led by ETH Zürich was a great success that demonstrates the high international profile and visibility of the training.

We are looking forward to welcoming the students once more in 2015!

Frank Ferrari

Organizing Committee (Brussels)

Riccardo Argurio (ULB)
Ben Craps (VUB)
Frank Ferrari (ULB)

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

Brussels (13 - 31 October 2014)

Advanced Quantum Field Theory - Adel Bilal
General Relativity, Cosmology and Black Holes - Glenn Barnich
String Theory I - Alberto Lerda
String Theory II - Marco Billò
Physics of the Early Universe - Viatcheslav Mukhanov *(2014 Solvay Chair in Physics)*

Paris (3 - 21 November 2014)

Introduction to Supersymmetry - Ullrich Ellwanger
Introduction to Supergravity - Antoine van Proeyen
Introduction to Superstrings and D-branes - Pierre Vanhove and Costas Bachas
N=2 supersymmetric gauge theories - Amir Kashani-Poor

Geneva (1 - 19 December 2014)

Integrability in QFT and AdS/CFT - Niklas Beisert
QFT in curved space - Matthias Blau
2d CFT - Matthias Gaberdiel
Large N and instantons in QFT - Marcos Marino
Introduction to AdS/CFT - Kyriakos Papadodimas

Student's opinion

by Pierre Corvilain (PhD student ULB)

I feel very lucky that I had the opportunity to participate in this doctoral school; it was for me, and I believe for all the other students, an extremely enriching experience, both from an intellectual point of view and, perhaps more importantly, from a human point of view.

There is always an inevitable gap between the knowledge one has at the end of a Master and the place current research stands. The aim of this school is to fill this gap and I think that it achieved the goal quite well.

The lectures were divided in 3 sets of 3 weeks each. The first set, held in Brussels, consisted in general courses on the three topics that make the name of this school, i.e. Quantum Field Theory, String Theory and General Relativity. The intent of these was first to bring everyone to the same footing, and then to pursue with some more advanced topics in these generals subjects. The last 2 sets of lectures, held in Paris and Geneva respectively, consisted in lectures on more specialised topics. These topics were very diversified, from N=2 Supersymmetry to AdS/CFT, through Integrability and 2d CFT, and we learned plenty of very interesting things. Generally speaking, the quality of the lectures was very high, the teachers were really good and experts in their fields. Also very enjoyable was the fact that all these courses fit well with the others, most of them having some relation to other ones of the school. In fact the lectures were very well balanced: they were broad enough so that we could make connections with other parts of the field, but at the same time they went deep enough so that we could grasp some ideas about current development in those topics. All in all, it allowed us to have an overview of the different topics existing in our vast field of mathematical physics. I am confident that this extensive scientific formation will be very valuable for our future research.

Another aspect of this school that was very valuable, if not more, was its social dimension. It was the first time I met that many students interested in the same topics as me. More than twenty-five physicists from all around Europe (from the four organising groups, but as well from Italy, Poland, etc.) attended the school, creating a very enriching atmosphere. As Marc Henneaux explained during his sixtieth birthday speech, physics is blind to borders, it joins together people from around the world to work on common interests. This school was our first real encounter with this international dimension. I met amazing people, with whom I am sure I will keep contact for good, and some of these relationships will certainly lead to fruitful collaborations.

Participants

Bartosz Benenowski (Leiden University, The Netherlands)
Jan-Willem Brijan (University of Groningen, The Netherlands)
Pierre Corvilain (ULB, Belgium)
Oscar de Felice (Université Pierre et Marie Curie, France)
Tim De Jonckheere (VUB, Belgium)
Corinne de Lacroix (École Normale Supérieure Paris, France)
Juan Diaz (KU Leuven, Belgium)
Laure-Anne Douxchamps (ULB, Belgium)
Francesca Ferrari (University of Amsterdam, The Netherlands)
Kevin Ferreira (ETH Zürich, Switzerland)
Aleksander Garus (ETH Zürich, Switzerland)
Paolo Gregori (ULB, Belgium)
Aron Jansen (Utrecht University, The Netherlands)
Remko Klein (University of Groningen, The Netherlands)
Edoardo Lauria (KU Leuven, Belgium)
Victor Lekeu (ULB, Belgium)
Eva Llabres Llambies (University of Amsterdam, The Netherlands)
Ioannis Mitsoulas (CERN, Switzerland)
Gerben Oling (University of Amsterdam, The Netherlands)
Roberto Oliveri (ULB, Belgium)
Arash Ranjbar Zidehi (ULB, Belgium)
Fernando Rejon-Barrera (University of Amsterdam, The Netherlands)
Codesido Sánchez Santiago (Unige, Switzerland)
Matthieu Sarkis (Université Pierre et Marie Curie (Paris 6), France)
Soumya Sasmal (IPhT, CEA, Saclay, France)
Tom Van Himbeeck (KU Leuven, Belgium)
Sam van Leuven (University of Amsterdam, The Netherlands)
Matthias Vereecken (UGent, Belgium)
Manus Visser (University of Amsterdam, The Netherlands)
Yvette Welling (Leiden University, The Netherlands)
Szabolcs Zakany (ETH Zürich, Switzerland)
Céline Zwikel (ULB, Belgium)

Colloquia

The **electroweak interactions** after the discovery of the Brout-Englert-Higgs boson

Professor Riccardo Barbieri
(SNS, Pisa, Italy)

28 January 2014

I describe as I view the status of particle physics, paying special attention to the electroweak interactions, after the discovery of the Brout-Englert-Higgs boson, which may or may not be the last missing particle needed to complete the spectrum of the Standard Model of the elementary particles.

Special emphasis will be given to where future experiments might lead in order to get a deeper understanding of the subject and possibly to a solution of the several open problems.

Alfred **Nobel** and the **Nobel Prizes**

Professor Lars Brink
Chairman of the Nobel Committee for Physics
(Chalmers University of Technology, Göteborg, Sweden)

4 February 2014

In this talk I will describe Alfred Nobel and his life and achievements and his famous will in which he donated his huge fortune to a foundation that should give out five prizes on a yearly basis. I will then concentrate on the physics prize and the stipulations behind it and give examples. I will also discuss last year's prize and show some pictures from it.

Hybrid Light - Matter States

Professor Thomas Ebbesen
(ISIS & USIAS, University of Strasbourg and CNRS, France)

11 February 2014

Just as atoms exchange electrons to form molecular orbitals, an electromagnetic field can interact with molecules by the exchange of photons. When this interaction is strong enough to overcome decoherence effects, new hybrid light-matter states can form, separated by what is known as the Rabi-splitting energy. This strong coupling regime is typically achieved by placing the material in the field of a photonic structure which is tuned to be resonant with a transition to an excited state. While strong coupling has been extensively studied due to the potential it offers in physics such as room temperature Bose Einstein condensates and thresholdless lasers, the implication for molecular and material science remains nearly totally unexplored.

The splitting of an excited state into two hybrid light-matter states separated by as much as 1 eV modifies the energy diagram of the molecular material and therefore the properties.
To try to understand the consequences of such changes, we have been studying strong coupling between molecules and plasmonic structures as well as Fabry-Perot cavities. After introducing the fundamental concepts, examples of photophysical, chemical and material properties of strongly coupled systems will be given which illustrate the potential of light-matter states for molecular and material sciences.

The Discovery of **Quasi-periodic materials**

Professor Dan Shechtman
(Technion, Haifa, Israel and ISU, Ames, Iowa, USA)

21 February 2014

Crystallography has been one of the mature sciences. Over the years, the modern science of crystallography that started by experimenting with x-ray diffraction from crystals in 1912, has developed a major paradigm – that all crystals are ordered and periodic. Indeed, this was the basis for the definition of "crystal" in textbooks of crystallography and x-ray diffraction. Based upon a vast number of experimental data, constantly improving research tools, and deepening theoretical understanding of the structure of crystalline materials no revolution was anticipated in our understanding the atomic or-der of solids.

However, such revolution did happen with the discovery of the Icosahedral phase, the first quasi-periodic crystal (QC) in 1982, and its announcement in 1984 [1, 2].

QCs are ordered materials, but their atomic order is quasiperiodic rather than periodic, enabling formation of crystal symmetries, such as icosahedral symmetry, which cannot exist in periodic materials. The discovery created deep cracks in this paradigm, but the acceptance by the crystallographers' community of the new class of ordered crystals did not happen in one day. In fact it took almost a decade for QC order to be accepted by most crystallographers. The official stamp of approval came in a form of a new definition of "Crystal" by the International Union of Crystallographers. The paradigm that all crystals are periodic has thus been changed. It is clear now that although most crystals are ordered and periodic, a good number of them are ordered and quasi-periodic.

While believers and nonbelievers were debating, a large volume of experimental and theoretical studies was published, a result of a relentless effort of many groups around the world. Quasi-periodic materials have developed into an exciting interdisciplinary science.

This talk will outline the discovery of QCs and describe the important role of electron microscopy as an enabling discovery tool.

[1] D. Shechtman, I. Blech, Met. Trans. 16A (June 1985) 1005-1012.
[2] D. Shechtman, I. Blech, D. Gratias, J.W. Cahn, Phys. Rev. Letters, Vol 53, No. 20 (1984) 1951-1953.

Circadian Clocks and Signalling in **Plants**

Professor Alex A.R. Webb
(Department of Plant Sciences, University of Cambridge, UK)

18 March 2014

Cells have intricate signalling mechanisms that transduce environmental, hormonal, biotic and other stimuli to evoke appropriate biological responses. Early in evolution, the calcium ion (Ca^{2+}) was co-opted to act as a second messenger in signalling networks in all cells. I will describe the temporal control of signalling networks, including those involving Ca^{2+}, and I will describe how this modulation can occur over a range of minutes to days.

I will describe new evidence demonstrating that stimulus- and cell-specific changes in the concentration intracellular free Ca^{2+} ($[Ca^{2+}]i$) encode information within the cell due to temporal modulation of [Ca2+]i signals over seconds and minutes. Additionally, I will describe how stimulus-induced $[Ca^{2+}]i$ signals and the basal level of $[Ca^{2+}]i$ are modulated by the 24h circadian clock over a time frame of hours to days. I will provide new data demonstrating how light and circadian signals are integrated to regulate $[Ca^{2+}]i$ signalling networks, to optimise seasonal response and ensure the appropriate timing of nocturnal activities. I will demonstrate that the circadian clock is regulated by sugar signalling networks, and that this regulation is essential for the correct circadian timing of plants.

I will describe our new data that show that phasing of the circadian system is dependent upon photosynthetically-derived sugar signals that act to define a metabolic dawn, essential for proper functioning of the circadian system in plants (Haydon *et al., Nature* 2013). Approaches described will include luminescent imaging and mathematical modelling of dynamical systems.

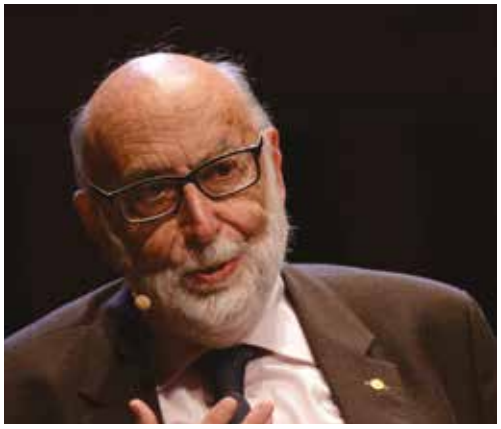
Cold Atoms in **Flatland**

Professor Jean Dalibard
(Collège de France et Ecole Normale Supérieure, Paris, France)

1 April 2014

In his world-famous novel "Flatland" published in 1884, the English writer Edwin Abbott imagined a social life in a two-dimensional world. With a very original use of geometrical notions, E. Abbott produced a unique satire of his own society. Long after Abbott's visionary allegory, microscopic physics has provided a practical path for the exploration of low-dimensional worlds. With the realization of quantum wells for example, it has been possible to produce two-dimensional gases of electrons. The properties of these fluids dramatically differ from the standard three-dimensional case, and some of them are still lacking a full understanding.

During the last decade, a novel environment has been developed for the study of low-dimensional phenomena. It consists of cold atomic gases that are confined in tailor-made electromagnetic traps. With these gases, one hopes to simulate and understand more complex condensed-matter systems. The talk will discuss some aspects of this research, both from an experimental and a theoretical perspective. Connections with other domains of 2D many-body physics, such as the Quantum Hall effect, will also be addressed.



The **Brout-Englert-Higgs** mechanism and its scalar **boson**

Professor François Englert
(ULB, Brussels, Belgium)

13 May 2014

A consistent approach to short range interactions from gauge vector fields acquiring mass through a generalisation of spontaneous symmetry breaking was proposed by Robert Brout and me, and independently by Peter Higgs. I shall explain our motivations for constructing this BEH mechanism which also gives information on the origin of elementary particle masses. I shall discuss its content and its use. I will comment on the ATLAS and CMS discovery at CERN of its predicted scalar boson: I will show how this discovery confirms the validity of the mechanism and how it may have implications on structures at yet unexplored energies.

Neutrino Oscillations at Work

Professor Jennifer Thomas
(University College London, UK)

26 May 2014

The observation that the three types of neutrino flavor oscillate among themselves led to the realisation that neutrinos have a very small but non-zero mass. This is extremely important because the supremely successful Standard Model of particle physics had expected, and indeed needed, the neutrinos to have exactly zero mass.

Since the discovery of neutrino oscillations over the last 15 years, the parameters of the oscillations have been sufficiently well measured to turn neutrino oscillations into a tool for learning more about the elusive neutrino. I will explain the concept of neutrino oscillations, and report on the recent results from around the world in context with the new challenges now facing researchers of inferring the remaining unknown neutrino properties. I will talk briefly about an exciting new project on the horizon for the very near future.

The Nobel Prize **in 2005**

Professor Richard Royce Schrock
(MIT, USA)

23 September 2014

Olefin metathesis was recognized by the Nobel Prize in Chemistry in 2005. It is a reaction in which C=C bonds are cleaved and "rearranged" to give new C=C bonds. I will present some of my own discoveries that led to over 30 years of progress and the Nobel Prize in 2005. That progress has depended upon the development of molecular catalysts that contain molybdenum, tungsten, or ruthenium. Olefin metathesis has had a major impact on the synthesis of organic molecules, polymers (from strained olefins), and chemicals from renewable feed stocks (e.g., seed oils), and could also impact pharmaceutical, fragrance, agro, and materials chemistries. I will give examples of several recent successes with recently prepared catalysts that are based on molybdenum or tungsten.

The **Quantum** Universe

Professor Viatcheslav Mukhanov
(Ludwig Maximilian University of Munich, Germany)

21 October 2014

Why are atoms stable? What caused galaxies, stars and planets to form? I will explain why quantum physics is crucial for explaining both. I will also discuss the experimental evidence that assures us that everything in our universe originated from quantum fluctuations.

Supramolecular Photosystems based on **Dye Aggregates**

Professor Frank Würthner
(Universität Würzburg, Institut für Organische Chemie & Center for Nanosystems Chemistry, Germany)

24 November 2014

Research on dye molecules has been continuing to be at the forefront of new developments in chemistry owing to their versatile functional properties associated with p-conjugation. On a supramolecular level, appropriately controlled spatial arrangement of dyes enables pivotal functions in nature, the most intriguing examples being provided by the light-harvesting systems of purple and green bacteria which contain a large number of chlorophyll and carotene chromophores organized in cyclic arrays or tubular architectures by non-covalent interactions.

During the last few years, we have intensively investigated the organization of perylene bisimide dyes by non-covalent forces into desirable nanoscale architectures as well as liquid-crystalline and crystalline solid state materials. In this lecture, I will provide an overview on our achievements in the preparation of defined perylene dye assemblies and their functional properties that originate from proper p-p-stacking.[1] In particular, charge and exciton transport in H- and J-aggregates[2] and pH-sensitive energy transfer processes in dye vesicles[3] will be discussed. Furthermore I will illustrate our recent achievements towards more defined perylene dye aggregates based on foldamer and zipper self-assembly approaches.[4,5]

[1] Z. Chen, A. Lohr, C. R. Saha-Möller, F. Würthner, Chem. Soc. Rev. 2009, 38, 564–584.
[2] F. Würthner, T. E. Kaiser, C. R. Saha-Möller, Angew. Chem. Int. Ed. 2011, 50, 3376–3410
[3] X. Zhang, S. Rehm, M. M. Safont-Sempere, F. Würthner, Nature Chem. 2009, 1, 623–629
[4] V. Dehm, M. Büchner, J. Seibt, V. Engel, F. Würthner, Chem. Sci. 2011, 2, 2094–2100.
[5] C. Shao, M. Stolte, F. Würthner, Angew. Chem. Int. Ed. 2013, 52, 7482–7486 and 2013, 52, 10463–10467

Structure and Dynamics of **Interfacial Water**

Professor Mischa Bonn
(Max-Planck-Institute, Mainz, Germany)

2 December 2014

At the surface or interface of water, the water hydrogen-bonded network is abruptly interrupted, conferring properties on interfacial water different from bulk water. Owing to its importance for disciplines such as electrochemistry, atmospheric chemistry and membrane biophysics, the structure of interfacial water has received much attention.

We elucidate the structure and structural dynamics of interfacial water using ultrafast surface-specific sum-frequency generation (SFG) vibrational spectroscopy. Specifically, for the water-air interface, we find that the interface is both structurally heterogeneous and highly dynamical. We reveal the nature of the heterogeneity, find surprisingly rapid inter- and intramolecular energy transfer processes and quantify the reorientational dynamics of interfacial water. We quantify the concentration of ions at the surface, compared to the bulk, and find a large surface propensity of halide ions at the water-air surface. At the water-mineral interface, we report a dramatic effect of flow of water along the mineral surface on the organization of water at the interface.

The path to the detection of **Earth-type planets**

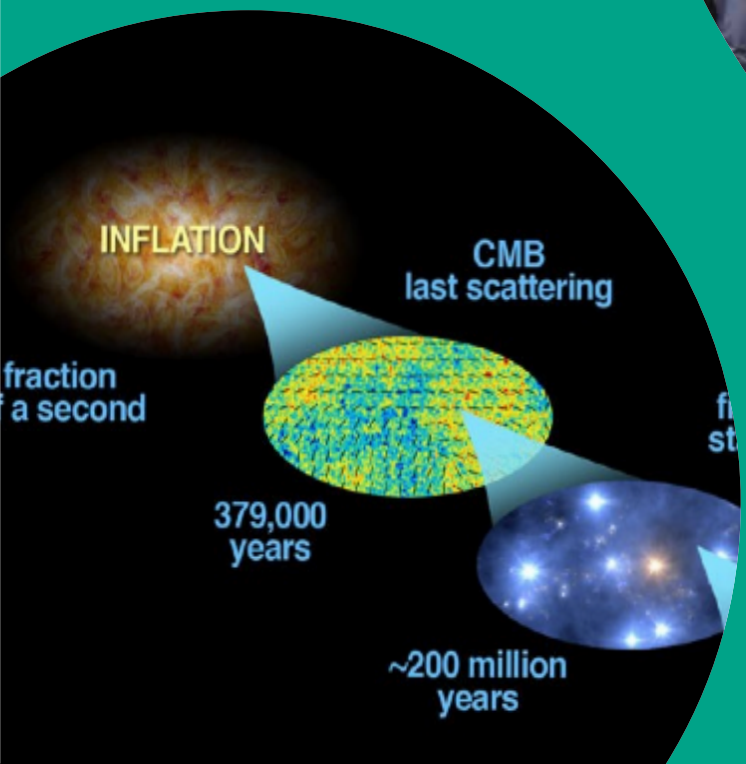
Professor Michel Mayor
(Geneva University, Switzerland)

16 December 2014

How many planets in the Milky Way? How many planets similar to our Earth? Over the last twenty years significant results have been obtained in the domain of extrasolar planets. More than one thousand planets have characterized orbits, for several hundred of them their radii are known. We have discovered an amazing diversity of planetary systems. These observations have revealed the importance of new physical process to be taken into account for the formation and evolution of planetary systems.

The synergy between ground-based radial velocity measurements and the detection of transiting planets have permitted exciting possibilities to characterize planets. Already we have the possibility to get clues on the internal composition of exoplanets and their atmosphere. Do we have the instrumental capabilities to detect and study planets as small as Earth analogues? What are the instruments in development and their scientific goals?

Workshops sponsored by the Institutes



Workshops sponsored by the **Institutes**

Workshop on "**Holography** for **black holes** and **cosmology**"

organised by the ULB

14 - 18 April 2014

The Solvay-ERC workshop "Holography for black holes and cosmology" is the first of this kind organized by the Institutes in 2014. It aimed at bringing together international scientists to focus on the development of holographic techniques in gravity, gauge theories and string theories. The format consisted in two seminars per day for a week by both established senior and promising junior researchers, with enough free time to encourage informal interactions and exchanges of ideas.

Organizing Committee

Glenn Barnich (ULB)
Geoffrey Compère (ULB)
Stéphane Detournay (ULB)
Marc Henneaux (ULB)

Speakers

Dionysios Anninos	On Black holes
Alejandra Castro	AdS2 and Kerr/CFT: random thoughts
Bin Chen	On short interval expansion of Renyi entropy
Matthias Gaberdiel	Large N=4 minimal model holography
Gaston Giribet	The n-string scattering amplitude in AdS3
Daniel Grumiller	Unitarity in flat space holography
Monica Guica	Conformal symmetries of warped AdS3
Thomas Hartman	Conformal field theory at large c
Diego Hofman	Non trivial scaling in 2 dimensions and holography
Nabil Iqbal	Holographic entanglement entropy and gravitational anomalies
Finn Larsen	Logarithmic corrections to black hole entropy v2.0
Kyriakos Papadodimas	The black hole interior in AdS/CFT and the information paradox
Eric Perlmutter	Entanglement and Renyi entropy in 2d CFTs and their duals
Andrew Strominger	Asymptotic symmetries, conservation laws and soft theorems
Ricardo Troncoso	Generalized black holes in three-dimensional spacetime

This workshop was partially supported by the ERC Starting Grant 335146 HoloBHC "Holography for realistic black holes and cosmologies" and by visit.brussels.

Workshop on "**Modeling Complex Systems** in Soft Matter"

in the honour of M. Mareschal and J-P Ryckaert

organised by the ULB

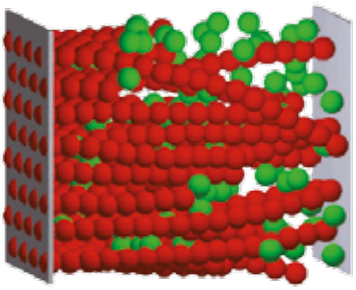
7 - 8 May 2014

Soft Matter physics deals with complex systems (polymers, liquid crystals, biomolecules,...) where thermal energy is relevant, so a subtle interplay of energy and entropy effects determines equilibrium states. Soft Matter Dynamics is Brownian in character and requires equilibrium and non equilibrium statistical mechanics tools to be analyzed and interpreted.

Next to continuous progress in the development of new experimental set ups and next to theoretical rationalisations, computer simulations play a crucial role in testing mesoscopic models bridging time and length scales in Soft Matter systems. The planned workshop focused on these Modelling and Statistical Mechanics aspects.

Organizers

Sferrazza M. (Belgium)
Lazzaroni R. (Belgium)



Confirmed speakers

Baschnagel J. (France)
Borgis D. (France)
Carlon E. (Belgium)
Ciccotti G. (Italy)
Frenkel D. (UK)
Mognetti B. (Belgium)
Mareschal M. (Belgium)
Marro J. (Spain)
Pierleoni C. (Italy)
Ramirez R. (France)
Ryckaert J-P (Belgium)
Schmid F. (Germany)
Winckler R.G. (Germany)

2014 Annual Scientific Meeting of the **Belgian Physical Society**

organised by the KU Leuven

28 May 2014

This conference brought together physicists in Belgium of different sectors and different scientific subdisciplines. A diverse program offered including plenary talks, a young scientist oral presentation competition, and a best poster competition. Parallel sessions and poster sessions were organized on:

- Astrophysics, Geophysics & Plasma Physics
- Atoms, Molecules, Optics & Photonics
- Biophysics, Medical, Statistical & Mathematical Physics
- Condensed Matter & Nanophysics
- Fundamental Interactions, Particle & Nuclear Physics
- Physics and Education

Organizing Committee

Ewald Janssens (KU Leuven)
Kristiaan Temst (KU Leuven)
Mieke De Cock (KU Leuven)
Joseph Indekeu (KU Leuven)
Riccardo Raabe (KU Leuven)
Gilles De Lentdecker (Vice-president BPS, ULB)
Jozef Ongena (President BPS, RMA)
Jacques Tempère (UA)

Confirmed plenary speakers

Prof. Francis Halzen (University of Wisconsin-Madison)
Icecube and the Discovery of High-Energy Cosmic Neutrinos

Prof. Carlo W. J. Beenakker (Leiden University)
The Search for Majorana Fermions in Superconductors

Workshops sponsored by the Institutes

Workshop on "**Cosmological Frontiers** in **Fundamental Physics**"

APC, Paris

10 - 13 June 2014

The purpose of this informal workshop was to discuss and exchange ideas on recent developments at the interface of modern cosmology and fundamental physics.

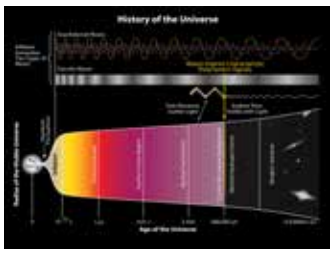
This workshop was the 8th in a series organized jointly by the International Solvay Institutes (Brussels, Belgium), APC Laboratory (Paris, France) and the Perimeter Institute (Waterloo, Canada). The previous edition was held in Waterloo in July, 2013.

Scientific Committee

Binetruy Pierre (APC, France)
Craps Ben (Solvay Institutes, VUB)
Johnson Matthew (Perimeter)
Kiritsis Elias (APC and University of Crete)
Langlois David (APC, France)
McFadden Paul (Perimeter)
Riotto Toni (Univ. Genève)
Sasaki Misao (Yukawa)
Steer Daniele (APC, France)

Local Organizing Committee

Binetruy Pierre
Davila Céline
Kiritsis Elias
Langlois David
Steer Daniele
Vydelingum Sarodia



Speakers

Daniel Baumann (DAMTP, Cambridge)
Fedor Bezrukov (CERN)
Cliff Burgess (McMaster Univ. & Perimeter Institute)
Marco Cirelli (CEA)
Ken Ganga (APC)
Jaume Garriga (Univ. Barcelona)
Jean-Christophe Hamilton (APC)
Steen Hannestad (Univ. Aarhus)
Kurt Hinterbichler (Perimeter Institute)
Rishi Khatri (MPA, Garching)
Kazuya Koyama (Univ. Portsmouth)
Chethan Krishnan (ISS Bangalore)
Jihad Mourad (APC)
Federico Piazza (PCCP, Paris)
Levon Pogosian (Simon Fraser Univ.)
Clem Pryke (Univ. of Minnesota)
Lorenzo Sorbo (Univ. of Massachusetts, Amherst)
Radek Stompor (APC)
Rashid Sunyaev (MPA, Garching)
Atsushi Taruya (Yukawa, Kyoto Univ.)
Nico Yunes (Montana State University)

30th International Colloquium on "Group Theoretical Methods in Physics"

organised by UGent

14 - 18 July 2014

The 30th International Colloquium on Group Theoretical Methods in Physics (Group30) took place at Ghent University in Ghent, Belgium, from Monday 14th July until Friday 18th July 2014.

The ICGTMP series is traditionally dedicated to the application of symmetry and group theoretical methods in physics, chemistry and mathematics, and to the development of mathematical tools and theories for progress in group theory and symmetries. Over the years, it has further broadened and diversified due to the successful application of group theoretical, geometric and algebraic methods in life sciences and other areas.

The conference had an interdisciplinary character. It aimed at bringing together experts and young researchers from different fields encouraging cross disciplinary interactions.

Organizing Committee

Jean-Pierre Antoine (UCL, Louvain-La-Neuve University, Belgium)

Francoise Bastin (Maths Dept, Liège University, Belgium)

Pierre Bieliavsky (Maths Dept, UCL, Louvain-La-Neuve, Belgium)

Fred Brackx (Ghent University, Belgium)

Stefaan Caenepeel (VUB Brussels, Belgium)

Frans Cantrijn (Ghent University, Belgium)

Hennie De Schepper (Ghent University, Belgium)

David Eelbode (Antwerp University, Belgium)

Simone Gutt (Maths Dept, ULB Brussels, Belgium)

Marc Henneaux (Physics Dept, ULB, Brussels, Belgium)

Erik Koelink (Maths Dept, Nijmegen, The Netherlands)

Joris Van der Jeugt (Ghent University, Belgium)

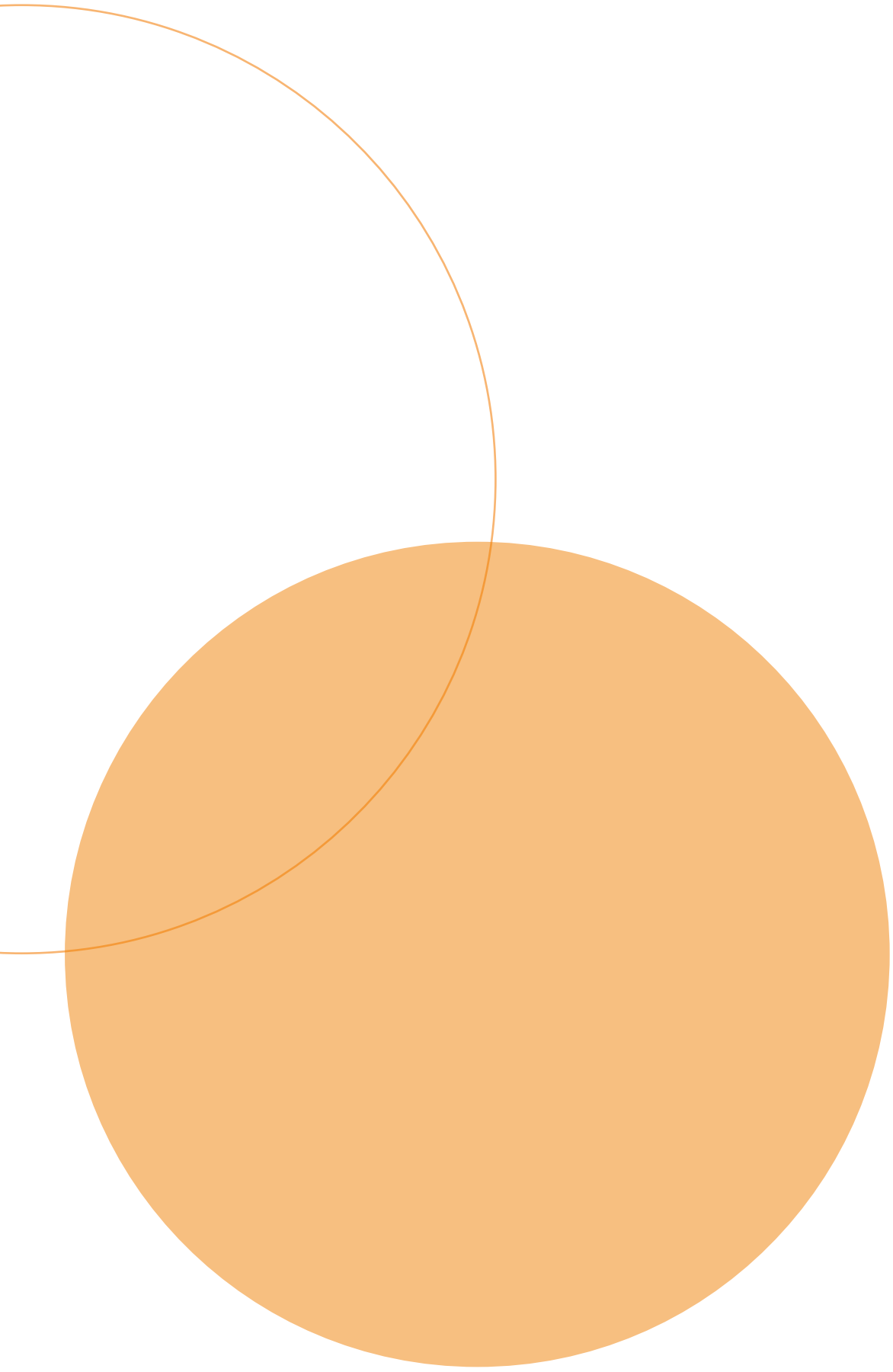
Piet Van Isacker (GANIL, Caen, France)

Pierre Van Moerbeke (Maths Dept, UCL, Louvain-La-Neuve, Belgium)

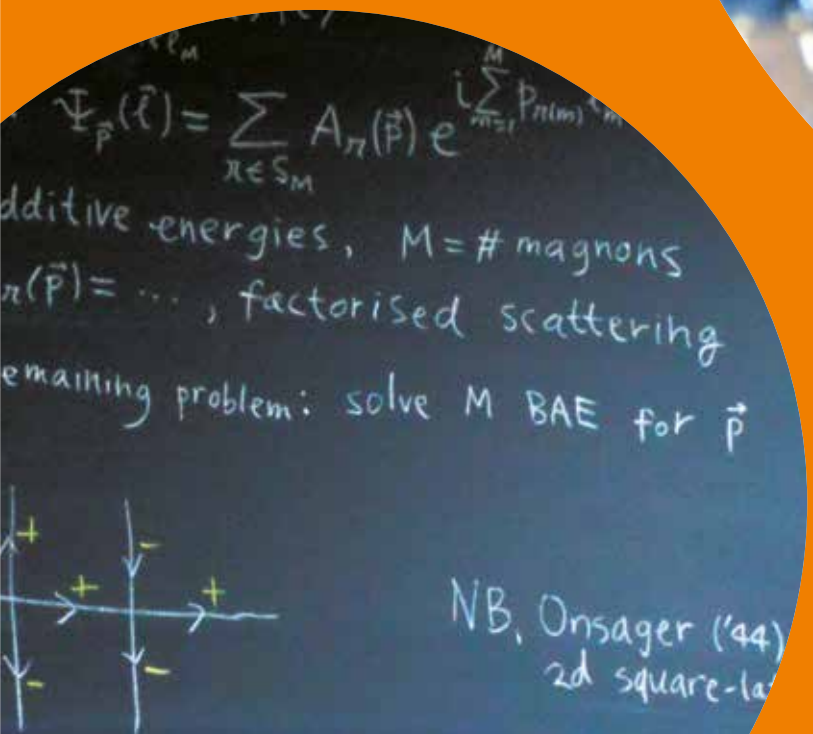
Topics

- Lie groups, Lie superalgebras, representation theory
- Quantum systems and quantum mechanics
- Group theory in quantum information theory and quantum computation
- Statistical models, exact solutions
- Integrable models and related topics
- Symmetries and group theory in biosciences
- Clifford algebras, Clifford analysis and applications
- Wavelets
- Hopf algebras and quantum groups
- Geometric mechanics and symmetry
- String theory, quantum gravity and conformal field theory
- Superintegrable and exact solvable systems, special functions, Lie symmetries
- Group theory in many-body systems
- Random matrix theory

Workshops sponsored by the Institutes



Seminars


dditive energies, M = # magnons
, factorised scattering
emaining problem: solve M BAE for p
NB, Onsager ('44)

The seminars below have been jointly organized by the theoretical physics groups of the ULB, the VUB and the KU Leuven, with support from the Institutes.

January

- Non-relativistic conformal invariance, its logarithmic extensions and physical ageing
  Malte Henkel (University of Nancy)

February

- Counterterms in gravity and N=8 Supergravity! - Lars Brink
- Exceptional Form of D=11 Supergravity
  Henning Samtleben
- The Boulware-Deser mode in Zwei-Dreibein gravity - Miguel Pino (Universidad de Santiago de Chile)
- Higher spins, holography and strings
  Per Sundell
- Chiral Liouville gravity and AdS3 - Geoffrey Compère
- Throat quantization of the Schwarzschild-Tangherlini (-AdS) black hole - Hideki Maeda (CECs, Valdivia)
- Flat Space Holography: Cosmological Entropy, Chiral Gravity and Phase Transitions - Stéphane Detournay
- Higher spin theory in 3D flat space
  Jan Rosseel
- On renormalized AdS action and Critical Gravity - Rodrigo Olea (U. Andrés Bello, Santiago)
- Entanglement entropy of massive flavor fields - Giuseppe Policastro
- Microstate geometries and their (double) CFT description - Rodolfo Russo

March

- Conformal Invariance in Momentum Space - Adam Bzowski (KUL)
- Holographic Thermal Helicity
  Tatsuo Azeyanagi
- Pure states and black hole complementarity - Larus Thorlacius
- Brane deformations in Supergravity
  Vasilis Niarchos
- Higher Spin Lifshitz Holography
  Michael Gary
- A Holographic Model of the Kondo Effect - Andy O'Bannon
- A New Class of QFTs: from D-branes to the Geometry of Scattering Amplitudes - Sebastian Franco
- Scanning Tunneling Macroscopy, Black Holes, and AdS/CFT Bulk Locality
  Vladimir Rosenhaus (Berkeley)

April

- Strings in compact cosmological spaces
  Oleg Evnin
- Lifshitz & hyperscaling violating holography with arbitrary critical exponent z>1 - Ioannis Papadimitriou
- Boundary dynamics of 3D asymptotically flat gravity - Hernan Gonzales
- The geometry of supersymmetric partition functions - Guido Festuccia
- Pre-Inflationary Clues from String Theory? - Augusto Sagnotti
- Inflating the Bicep (2)
  Diego Chialva (UMONS)

- Virasoro group and AdS3 gravity
  Alan Garbarz (U. Nacional de la Plata)
- Phase Structure of Higher Spin
  Black Holes - Arunabha Saha (Harish-
  Chandra Res. Inst., Allahabad)
- BPS Quivers and N=2 superconformal
  theories - Simone Giacomelli
- Effective world-volume theory
  of charged black branes - Niels Obers

May

- Black hole deconstruction and 5D
  supergravity with hypermultiplets
  Joris Raeymaekers (Academy of Sciences
  of the Czech Republic, Prague)
- W infinity and triality - Tomas Prochazka
  (Academy of Sciences of the Czech
  Republic, Prague)
- Integrability and Inverse Scattering
  in Supergravity - Amitabh Virmani (Institute
  of Physics, Sachivalaya Marg, Bhubaneswar)
- Locally USp(8) invariant IIB Supergravity
  and E6(6) covariance - Bernard de Wit
- Non-BPS walls of marginal stability
  Stefanos Katmadas
- Dimitris Giataganas

October

- The Coulomb branch formula for quiver
  indices - Boris Pioline
- Electromagnetic response of strongly
  coupled plasmas - Andrea Mezzalira
- Exploring New Ideas in AdS3 Quantum
  Gravity - Shahin Sheikh Jabbari
- Minimal massive 3D gravity:
  the Third Way - Paul Townsend
- Hovering black holes - Jorge Santos

November

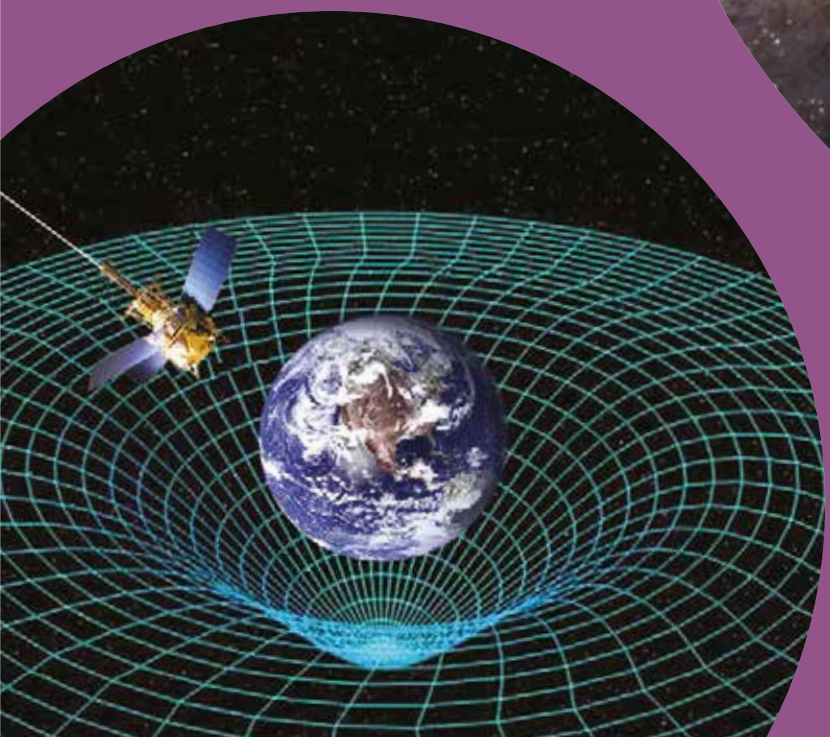
- Six-dimensional superconformal theories
  in string theory - Alessandro Tomasiello
- B-mode cosmology - Paolo Creminelli
- The superconformal bootstrap program
  Balt Van Rees
- Recent Highlights (and more) in AdS/CFT
  Integrability - Klose
- An introduction to resurgence in the
  principal chiral model - Daniele Dorigoni
- Entanglement Entropy and Holography
  one day workshop at the VUB:
  - MERA & holography
    Karel Van Acoleyen (UGENT)
  - Continuous MERA
    Jutho Haegeman (UGENT)
  - Prospects of real-time evolution
    & thermal states with MERA
    Matthias Bal (UGENT)
  - An Introduction to Holographic
    entanglement entropy
    Nabil Iqbal (UVA)
  - Holographic Entanglement Entropy
    & Gravitational Anomalies
    Nabil Iqbal (UVA)
- Non-associative Geometry and Double
  Field Theory - Dieter Luest
- Holographic lattices, metals
  and Insulators - Jerome Gauntlett

December

- F-theory on singular spaces
  Andrés Collinucci
- Holography for N=2* on S^4
  Nikolay Bobev
- Quantizing conical spaces in 3D gravity
  Joris Raeymaekers
- The Effective Field Theory
  of Large Scale Structures - Enrico Pajer

Research on Gravitation, Strings and Cosmology

Groups of
Professors Marc Henneaux (ULB)
and Alexander Sevrin (VUB)



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

Researchers

Permanent members

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

Part-time staff (10 %)

Vijay Balasubramanian (VUB)
Oleg Evnin (VUB)

Part-time staff (10 %) and **post-doc** (90 %)

Laura Lopez Honorez (VUB)
Alberto Mariotti (VUB)
Kentarou Mawatari (VUB)
Dan Thompson (VUB)

Postdoctoral members

Jay Armas (ULB)
Andrea Campoleoni (ULB)
David Chow (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)
Manuela Kulaxizi (ULB)
Arnaud Lepage-Jutier (ULB)
Andrea Mezzalira (ULB)
Christoffer Petersson (ULB)
Rakibur Rahman (ULB)
Waldemar Schulgin (ULB)
Anastasios Taliotis (VUB)
David Tempo (ULB)
Pantelis Tziveloglou (VUB)
Hongbao Zhang (VUB)

Graduate students

Dries Coone (VUB)
Pierre Corvilain (ULB)
Karen De Causmaecker (VUB)
Tim De Jonckheere (VUB)
Laura Donnay (ULB)
Laure-Anne Douxchamps (ULB)
Marco Fazzi (ULB)
Paolo Gregori (ULB)
Sergio Hörtner (ULB)
Pierre-Henry Lambert (ULB)
Victor Lekeu (ULB)
Amaury Léonard (ULB)
Jonathan Lindgren (ULB-VUB)
Gustavo Lucena Gómez (ULB)
Pujian Mao (ULB)
Andrea Marzolla (ULB)
Micha Moskovic (ULB)
Blagoje Oblak (ULB)
Roberto Oliveri (ULB)
Pablo Pais (ULB)
Arash Ranjbar (ULB)
Diego Redigolo (ULB)
Patricio Salgado Rebolledo (ULB)
Joris Vanhoof (VUB)
Matthias Vereecken (VUB)
Céline Zwikel (ULB)

Master students

Timothée Defoin (ULB)
Mehdi Delanoeije (VUB)
Saskia Demulder (VUB)
Sybille Driezen (UAntwerpen)
Yannick Wachel (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. Supersymmetric extensions of the standard model will be tested at the experiments planned in the Large Hadron Collider at CERN in Geneva.

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 2014

We have continued our research along the general directions outlined above. This has led to 101 published papers and preprints submitted for publication. These are listed on pages 158 - 163. Specific achievements by some researchers from the group are described in the subsequent pages.

Support from the **Solvay family**

As in previous years, the research group has benefited from the support of the Solvay family, which is gratefully acknowledged. This support was precious to cover international collaborations as well as doctoral and postdoctoral grants to researchers.

Researchers whose **fellowship** was **partly funded** by the **Solvay family**

Eduardo Conde Pena (ULB)

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.
Here is a more detailed description of his recent results.

Since the advent of Relativity at the beginning of the 20th century, *space-time* is a basic concept that any theoretical physicist nowadays is familiar with.
Of course it was revolutionary at that moment to think that the intuitive notions of space and time could be entangled, yet the theory of General Relativity by Einstein has taught us to think of space-time as a single dynamical entity that bends and evolves according to a certain set of equations. But another revolution is likely due for the upcoming years, where our notion of space-time will be again modified (or better, refined)!

The basic reason for this coveted revolution arises from the joint effort that the community of theoretical physicists has being undertaking for the last decades. That is to combine the two pillars that were established at that magic beginning of the 20th century: General Relativity (the theory of space-time) and Quantum Mechanics (the rules for how particles and fields must interact). By the middle of the century, we had already learnt how to combine the two theories in a particular case: when the space-time is described

by a fixed flat Minkowski metric that does not evolve in time (this particular instance of General Relativity is called Special Relativity). The framework that came out from there is called *Quantum Field Theory*, and it is at present our basic language for talking about physical theories and computing quantities that we can measure in the lab. For instance, our most accurate description of Nature so far, the Standard Model, is a quantum field theory.

However successful, we know that Quantum Field Theory cannot be the final answer to our quest. As we just said, there we take the space-time to be fixed and we do not let it evolve. In particular a very energetic particle would traverse it without modifying it, when precisely we learnt in General Relativity that space-time has to bend in the presence of such type of particles.

Since the middle of the century, the community has had a lot of time to think about this; so what remedies have we found?

One possibility, that started to be explored in the 70s, is String Theory. In principle this is radically different from Quantum Field Theory, although actually there is a research avenue called holography trying to show that both are the same thing in (an intrincate) disguise! String Theory is complicated to deal with. It will be soon 50 years old and, despite all of its accomplishments, we still do not know how to answer some basic questions, most notably whether it is a theory that describes our Universe.

Another possibility, that has been embraced more recently, is to reformulate Quantum Field Theory in such a way that the role of space-time is reduced to a minimum. In this way, hopefully one could understand the role played by a rigid space-time in the framework, and whether and how we can modify it to accommodate for a dynamical space-time.

I am involved in research on both of the lines described above, but the last year I have focused more on the second one. So let me describe it in some more detail below.

An *on-shell* perspective on Quantum Field Theory

As one can guess from its name, in Quantum Field Theory one has to quantize the fields that permeate space-time. As a result of this quantization, any given field can only vibrate in a certain discrete manner, and the basic minimum oscillation is identified with an elementary particle. Thus the dynamics of the fields can be understood in terms of the propagation and interaction of these particles in space-time. Since a field has to oscillate at all times (due to its quantum nature), particles are created and destroyed continuously.

Therefore, when we scatter some initial particles (as we do for example at the Large Hadron Collider in Geneva) to observe other final ones, in the middle a very complicated process is going on, where infinitely many particles are both created and destroyed. The particles that we prepare at the beginning and observe at the end are called *on-shell*, meaning that they are real particles that we can detect. Instead, the particles that are created and destroyed during the process by definition can never be observed, and they are called virtual or *off-shell*.

One may immediately wonder why we should care about these off-shell particles

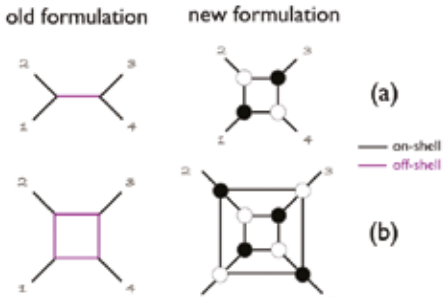
(Eduardo Conde Pena)

that we can never observe. The answer lies in the way we think about Quantum Field Theory: in a scattering process particles have to evolve through the "inside" of space-time, from the infinite past to the infinite future; and during this evolution they encounter infinitely many particles popping up and off. In order to calculate the probability of the scattering process to happen, we need to know about all of these virtual particles. And in particular we need to know the internal details of the space-time.

It turns out that for theories which contain only massless particles (e.g. photons, gluons, gravitons), we are taking the first steps to understanding them using only on-shell particles! Like this we can achieve our goal of describing a quantum field theory without needing any detail about space-time other than just its asymptotic structure. Moreover, we also avoid all the complications that come with all the virtual particles (the off-shell structure of the theory), recovering indeed some of the results of Quantum Field Theory in a much simpler way.

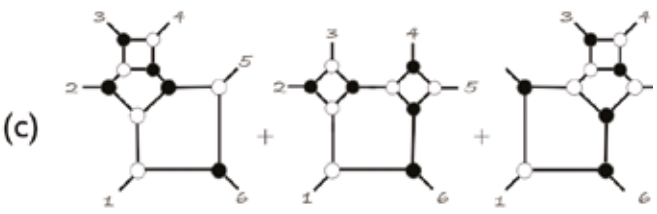
In the new formulation there are a couple of basic processes (denoted by white and black vertices), describing the only two ways three particles can interact. These three-particle interactions can happen solely when some of the particles have complex momenta. So we are trading the virtual off-shell particles from before to complex on-shell particles here, and of course neither of them is observable.

Things look very different now. What used to be the interchange of a virtual particle is now a process with four three-particle interactions (figure (a)). The latter diagram actually looks like the one we used to draw for a so-called one-loop process, but in the new formulation such a process now looks like the one on the right of figure (b).



Of course there are some equations that instruct us how to extract a probability from these new diagrams. In the case of some diagrams (like the one of figure (b)), the equations give an infinite probability. This was already happening in the old formulation of Quantum Field Theory, where one has to introduce a method to tame these infinities. This is called *regularization*. The work I have carried out, in collaboration with people at the Institute of Theoretical Physics in Madrid, aims at providing a way to regularize the diagrams in the new formulation.
Our proposal is to deform the spins of the particles involved in the diagram, and we showed so far that this indeed provides a regularization for the diagram in figure (b). Our hope is that the method will work for any generic diagram, like for instance the one in figure (c), which gives the semi-classical contribution to the probability of a six-particle-scattering.

We are really taking baby steps at the moment, but these are already pointing



out at a different conception of Quantum Field Theory, where virtual processes within space-time have been substituted by interactions in some auxiliary complex space that we must still figure out. Space-time has been removed from the picture, and wishfully thinking one will be able to reconstruct it from its asymptotic structure plus the interactions encoded in these black and white diagrams!

Pierre Corvilain (ULB)

Pierre Corvilain is doing research towards his PhD degree under the supervision of Andrés Collinucci (ULB). He is working on string theory and F-theory, using the tools of algebraic geometry.

Michael Kay (ULB)

Dr. Michael Kay got his PhD degree at the University of Munich (LMU, Germany) in 2014 before joining the ULB group in October of 2014. He is working in mathematical physics. His research uses the powerful tools of algebraic geometry to explore remarkable properties of string theory.

Manuela Kulaxizi (ULB)

Dr. Manuela Kulaxizi got her PhD degree in 2007 from the State University of New York at Stony Brook (USA). After two doctoral stays at the University of Amsterdam (2007-2010) and the University of Uppsala (2010-2011), she joined the ULB group in September of 2011. Her research deals with conformal field theory, holography, quantum entanglement and higher spin fields. A more detailed description of her work can be found in the 2013 annual report.

Andrea Marzolla (ULB)

Andrea Marzolla is pursuing work towards the doctoral degree under the supervision of Prof. Riccardo Argurio (ULB). His field of research focuses on supersymmetry and quantum gauge field theory.

Andrea Mezzalira (ULB)

Dr. Andrea Mezzalira got his PhD degree at the University of Turin (Italy) in 2013 before joining the ULB group in the Fall of 2013. He explores the extremely rich holographic correspondence in string theory and in particular its applications to condensed matter and fluid dynamics.

Waldemar Schulgin (ULB)
(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. Waldemar Schulgin is the first holder of the Marina Solvay fellowship (2012-2015). 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 annual report.

David Tempo (ULB)

Dr. David Tempo got his PhD degree at the University of Concepción (Chile) in 2013 while working at CECs (Valdivia). He joined the UBL group in October of 2014. His expertise covers the Einstein theory of gravity and its extension. He currently works on black holes and higher spin gauge theories.

Céline Zwikel (ULB)

Céline Zwikel is a PhD student working under the supervision of Prof. Stéphane Detournay (ULB). She investigates black holes. A description of her work follows.

One of today's biggest challenges in theoretical physics is the unification of its two pillars, quantum mechanics and gravitation theory, into a unique *theory of quantum gravity*. The former describes the atomic phenomena. It is really different from the intuition we have from our classical world but it is important to stress that some common phenomena need quantum mechanics to be explained. For example, the color spectrum of a heated metal. The second describes how masses interact. For example, the movement of the planets around the sun. Naturally, one would ask the following question: why do we need to put these two theories together? Beyond the beauty to have an unique theory to describe everything, there are phenomena in the universe that we cannot explain with our two theories in the form we currently know. We have to build a larger one that includes both of them. Several non explained phenomena concern the physics of black holes and are some of the deepest questions of 21th century in physics.

They concern the nature of singularities, the black hole information paradox, and the black hole entropy problem. A defining characteristic of black hole is that as soon as anything (even light) enters in it, it can never come out. This is the reason for the adjective "black" in their name.

A very popular approach to try to better understand the quantum aspects of gravitation is to consider what is called *holographic dualities.* The dualities have always played a prominent role in physics. They have taught us either to view seemingly distinct phenomena in a unified framework (e.g. electricity and magnetism), or to consider single entities from two different yet complimentary points of view (e.g. the wave-particle duality for quantum matter). Here, the conjectured duality is a equivalence between two theories of completely different nature: a gravitational theory and a quantum field theory, non gravitational, which describes the particle world. More precisely, this duality conjectures that all gravitational phenomena in D dimensions can been described in terms of a quantum field theory in D-1 dimensions. The adjective holographic was chosen because it is exactly like a generalization of a hologram: all the information of an object in the three dimensions is encoded in a two-dimensional surface. The most known holographic duality, the AdS/CFT correspondence, concerns a type of space-time that is unfortunately quite far from our universe. Recently, new dualities which have been proposed bring us a step further in the knowledge of relevant space-times to describe our universe but they are not yet well known. During my Ph. D. I am exploring them by computing several quantities that help us to better understand them.

Moreover, in physics, a very popular strategy to answer a hard question is to look at a simpler related problem. Here, we choose to look at gravitation in three dimensions instead of four. Indeed, the *three-dimensional* case is qualitatively easier than the fourth: there is no local degrees of freedom but black holes solutions exist. So the equations are simpler but still non trivial. The first example of a three-dimensional black hole is the BTZ black hole. It appears as a solution of general relativity with a negative cosmological constant, i.e. in a anti-de Sitter background (the same one as in the famous AdS/CFT correspondence).

One of the new dualities in which I am interested imply the description of four-dimensional extreme Kerr black holes, some of which correspond to astrophysical objects. The relevant class of three-dimensional black holes are the *warped anti-de Sitter black holes.* They are a deformation of the BTZ black holes. The other duality I consider is related to *asymptotically flat space time*. Their study is done through a limit of the BTZ black holes.

One phenomenon I have considered is the *thermodynamics* of black holes and the *Hawking-Page transition*, already known for certain black holes, for example the BTZ black holes. In the seventies, it was demonstrated that black holes satisfy four laws similar to the four laws of thermodynamics. Soon after, Hawking showed that black holes actually are not really black but emit a radiation at a certain temperature. Therefore it was concluded that black holes are thermodynamic objects and their entropy was associated to the horizon area and their energy to the mass. In classical physics, thermodynamics can be used to describe phase transitions, e.g. the one

(Céline Zwikel)

between the liquid water and the vapor. It can be asked if in black holes physics a phase transition can happen. Hawking and Page showed that it is true in an anti-de Sitter background. The transition happens between two space-times: the black hole and the background space-time filled with a thermal gas of particles. Intuitively, this transition can be understood in the following way: at high temperature, the energy of particles is so big that the gas will collapse on itself and form a black hole and at low temperature, the gas will stay free. I showed that the warped anti-de Sitter black holes have also this phase transition. It is well understood in the holographic picture: the transition happens at the self dual point of the partition function, as usually in the conformal field theories in two dimensions.

Research **Interests** of some **other members**

Victor Lekeu's master thesis (ULB)

Laureate of the 2014 Robert Brout ULB Prize

"Hidden Symmetries of Gravity and Kac-Moody Algebras"

In all areas of physics, understanding the symmetry properties of a theory is crucial to get a better understanding of the theory itself. As gravity is currently the least understood of all fundamental forces, the recent evidence coming from various directions that gravitational theories might have a huge unexpected symmetry group, which might even be infinite-dimensional, is very promising. The goal of my master thesis is to review the attempts at finding a formulation of these theories where the symmetry is manifest and not hidden anymore, which would be very helpful for their understanding. One approach is through the comparison between their equations of motion and the ones of a "nonlinear sigma model" constructed from the conjectured symmetry group.

Hidden symmetries first arose in the dimensional reduction of gravitational theories, the procedure by which one can reduce a theory defined in higher dimensions to the point of view of a lower-dimensional observer: it turns out that this can reveal some symmetries that were not clear in its higher-dimensional formulation. Hidden symmetries also appear in the dynamics of Einstein gravity or supergravity theories around a spacelike singularity: it has been shown that close to the singularity, the gravitational dynamics is equivalent to the dynamics of a hard ball bouncing in a billiard. For most theories of interest, the shape of the billiard table is precisely related to the symmetry found in the dimensional reduction procedure. These two indirect arguments strongly suggest that hidden symmetries must play a role in the full gravitational theory.

My thesis is divided into two parts. First of all, I had to familiarize myself with the necessary mathematical background.

I began by studying the theory of Kac-Moody algebras, a class of infinite-dimensional Lie algebras that generalize the usual simple Lie algebras and encode much of the hidden symmetry. In order to better understand their complicated structure, I reviewed their so-called "level decomposition" into finite- dimensional slices. This required the study of tensors with mixed Young symmetry, which appear naturally in this decomposition. The second part of my thesis is devoted to reviewing the construction of "nonlinear sigma models on coset spaces". The idea is that, given a symmetry group, we can construct a model which possesses this symmetry in a manifest way. We can then compare this model to the gravitational theory that has the corresponding hidden symmetry. This has been done in the literature for maximal supergravity and its E_{10} hidden symmetry, and remarkable agreement has been found: not only does the sigma model reproduces the correct field content of the theory, but it gives also the correct dynamics up to a certain level in the level decomposition of the E_{10} algebra. This is a partial success in exhibiting the hidden symmetry. I applied this method to six-dimensional chiral supergravity, which is known to enjoy a F_4^{++} hidden symmetry. The comparison with the sigma model has shown remarkable agreement, similar to (but more involved than) the one of maximal supergravity. This is the original part of the thesis.

This work can be continued in several directions. First, we should continue the search for a formulation where the hidden symmetry is manifest. This would require the study of gravitational dualities, similar to the usual electric/magnetic duality, since the approach presented in the master thesis stops working exactly when the dual graviton appears. Second, the inclusion of fermions should be done, since hidden symmetries and supersymmetry have very intriguing links: often, they both give identical predictions for the bosonic sector. Finally, these symmetries already have some important physical consequences: for example, it should be possible to find invariant formulae for the entropy of black holes, thus allowing for further study of their thermodynamics.

Pantelis Tziveloglou
(Postdoctoral fellow VUB)

The primary and long-term orientation of my research is to connect theory to experiment in high-energy physics. It involves discovering novel mechanisms and phenomena that inspire new experiments and experimental analyses. Its goal is to provide answers to the most pressing questions regarding the fundamental laws of nature and the origin of the universe. The focus of my research since I joined the particle physics phenomenology group of VUB in October of 2013, has been the study of supersymmetry, of theories of dark matter and their signatures at experiments.

Dark Matter

The speed at which different parts of a galaxy rotate depends on the amount of matter this galaxy contains. Scientists have found that the rotation speeds of galaxies are too large to be supported by the luminous matter they contain. In order to match the rotation speeds with their matter content, we need to assume that they contain extra matter, apart from the luminous one that we observe *(figure 1)*.

Searches for dark astrophysical objects in our galaxy have practically excluded the possibility that the extra, "dark" matter is made up of ordinary matter, like the one that is described by the Standard Model. Therefore, in order to describe dark matter, we need to extend the particle content of the Standard Model.

Another indirect indication that confirms the existence of dark matter was discovered by observing the sky in the microwave spectrum. At these frequencies, we can detect radiation that was emitted when the universe became transparent, almost 13.8 billion years ago and only 380.000 years after the Big Bang *(figure 2)*. The correlation between temperature fluctuations of this radiation allowed us to determine how much matter the universe contains and also how much of this matter is made up from ordinary particles. It was found that ordinary matter contributes only around 20% to the whole matter of the universe *(figure 3)*. Therefore, the remaining 80% must be attributed to some new type of matter that is not described by the Standard Model.

One of the most pressing challenges in fundamental physics today is the detection

of dark matter and the determination of its properties. To this purpose, many experiments have been built that can detect dark matter by looking for its recoils against nuclei ("direct searches"), by detecting emitted particles from dark matter annihilating with itself ("indirect searches") and by directly creating the dark matter particle (colliders).

One of the focuses of our phenomenology group is the study of the properties and dynamics of dark matter. In one of our projects we have used the results of these experiments to set constraints on how dark matter interacts with ordinary particles, like quarks and leptons. Another project of our group is to study the properties of dark matter candidates that interact with ordinary particles via electroweak interactions. We have studied limits from indirect searches and shown that if these

limits are used in complementarity with limits from direct searches and colliders, they can improve our understanding of the dynamics of these models.

Since the 60s and the development of particle colliders, many new particles have been discovered that radically extended our understanding of the microcosmos. However, these numerous discoveries were perceived as successes of the Standard Model, since all the new particles were perfectly described by the ingredients of the Standard Model alone.

The importance of the discovery of dark matter is far greater than the discovery of yet another particle of nature. If dark matter is found, it will necessarily signify the end of the Standard Model as the established model for the description of nature and it will carve the path for a theory beyond the Standard Model, revolutionising our perception of the fundamental laws and ingredients of nature and bringing high-energy physics into new, uncharted lands.

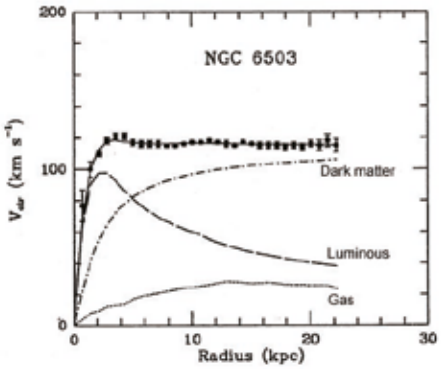


Figure 1:

The rotation velocity (y-axis, measured in km per second) of the galaxy NGC6503 at different distances from its center (x-axis, distance measured in kpc. One kpc is around $3 \cdot 10^{16}$ km). The points are the measured velocities. The dotted and dashed curves show the contribution to the velocity from the observed matter of the galaxy ("luminous" and "gas"). It is obvious that at large distances, the observed matter cannot account for the measured velocities. The dashed-dotted curve shows the contribution from the hypothetical dark matter component, that can be used to explain the discrepancy. Credit: Begeman, Broeils, Sanders, Mon. Not.R.astr.Soc.(1991)249, 523-537.

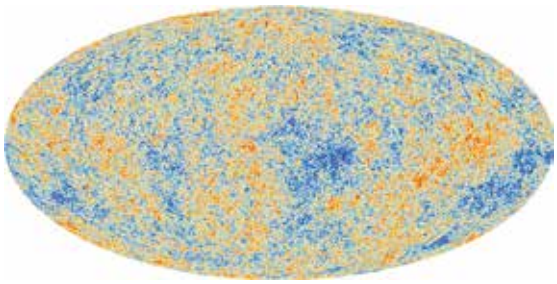


Figure 2:

A full-sky map of the temperature fluctuations of the primordial light that was emitted 380.000 after the Big Bang and arrived to us as microwave radiation. The blue and red colouring shows tiny fluctuations around the average temperature of the microwave radiation, at -270.42 ° C. Hotter and colder regions correspond to different densities. These primordial tiny density anisotropies evolved into what is today the stars and galaxies of our universe. The correlation of these fluctuations at different distances allows us to extract information about the composition of the universe (see figure 3). Credit: ESA/Planck Collaboration.

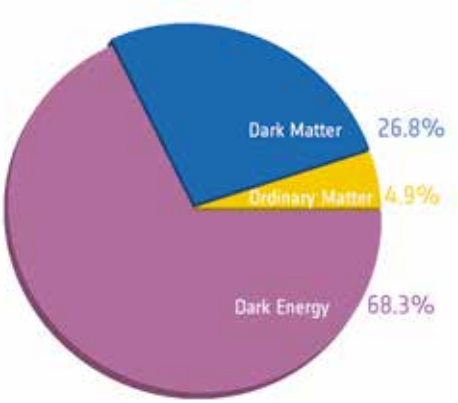


Figure 3:

The precise observation of the microwave radiation has allowed us to determine the matter and energy composition of the whole universe. Most of the matter-energy of the universe consists of an unknown force called "dark energy" that is responsible for the acceleration of the expansion of the universe today. Dark matter contributes 26.8% to the matter-energy of the universe while the ordinary matter that is described by the Standard Model occupies only 4.9%. Credit: ESA/Planck Collaboration

Hongbao Zhang
(FWO Postdoctoral fellow VUB)

Applied AdS/CFT to Quantum Turbulence

Compared to the other conventional techniques, AdS/CFT correspondence is naturally suited for addressing the notoriously difficult non-equilibrium problems of many- body systems by solving a few of dual bulk coupled partial differential equations. Due to the rareness of the exact solution, applied AdS/CFT has been entering into the era of numerical holography. I have been working on applied AdS/CFT to out-of-equilibrium physics such as the vortex dynamics in the superfluid turbulence by numerics since I came to Brussels two years ago.

1. Road to unification, quantum gravity and AdS/CFT correspondence

The very theme in physics is to unify various seemingly distinct phenomena by as a few principles as possible, which can help us to develop a sense of safety while being faced up with the unknown world. This may be regarded as another contribution of the unification in physics to our society on top of its induced technology innovations as briefly summarized below.

Along the road to unification in physics, Newton unifies the apple on the Earth and the Moon in the sky, which eventually leads to the artificial satellite; Maxwell unifies electricity and magnetism, which further predicts that light is essentially kind of electromagnetic waves; quantum theory unifies particles and waves, which has been stimulating various technology revolutions; Einstein unifies space, time, and gravity, which triggers the nuclear power and GPS technology. With this series of unification, we still end up with two distinct entities, namely quantum field theory and general relativity.

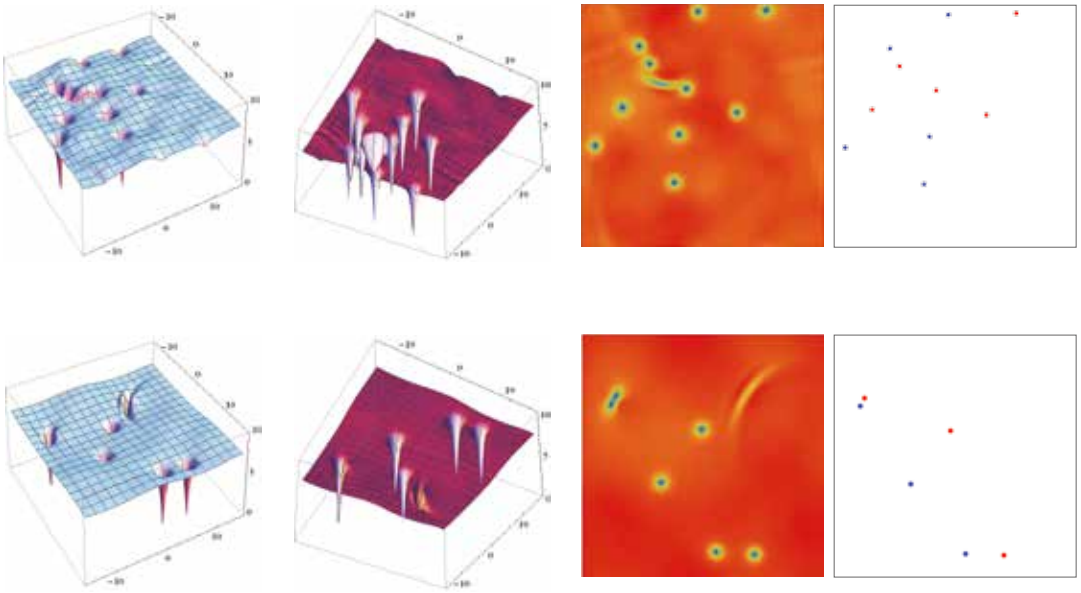
Reconciling them has been a long-standing goal for theoretical physics since the last century. In particular, when the spacetime is asymptotically Anti-de Sitter (AdS), the string theory inspired AdS/CFT correspondence can be thought of a natural home for the successful marriage of quantum field theory and general relativity, at which a gravitational theory in a $d + 1$ dimensional asymptotically AdS is dual to a quantum field theory on the d dimensional boundary of the bulk spacetime.

It is noteworthy that such a holographic duality is also a strong-weak duality. Each weakly coupled gravitational theory is dual to a strongly coupled quantum field theory with one less dimension and vise versa. With this, one can study a strongly coupled system by its weakly coupled dual, which is generically much easier to attack. One of the mundane analogs of AdS/CFT correspondence is a cup of Belgian beer, where the brand related pictures and words on the cup correspond to the boundary quantum field theory and the beer in the cup corresponds to the bulk gravity. As to a guy who is allergic to alcohol but literate, he can know the content of beer in the cup by reading the pictures and words on the cup. While as to a guy who is blind but a beer taster, he can guess out the pictures and words on the cup by drinking beer in the cup. This explains why this kind of duality is useful to us.

AdS/CFT as seen in a cup of Belgian beer.

2. Applied AdS/CFT, numerical holography and quantum turbulence

Actually, since the advent of AdS/CFT correspondence, more and more efforts have been focusing onto its applications in various fields such as QCD and condensed matter physics, where most of strongly coupled systems can not be attacked by the conventional methods. With AdS/CFT correspondence, such a strongly coupled system in equilibrium with finite temperature and finite chemical potential corresponds to a static charged black hole in the bulk with one extra dimension, where the near-equilibrium state of boundary system is dual to a small perturbation on top of the black hole such that the linear approximation is reliable on both sides as it should be the case. Over the last few years, such a picture has offered us remarkable insights in our understanding various universal equilibrium and near-equilibrium properties of strongly coupled systems.



The snapshots of the holographic turbulent superfluid at the finite temperature, where the top is for some early time and the bottom is for some late time [arXiv:1412.8417].

(Hongbao Zhang)

However, recent experimental breakthroughs in atomic physics, quantum optics and nano-science have made it possible to manipulate various systems at hand out of equilibrium in a controllable way. This has been spurring a lot of theoretical investigations of non-equilibrium physics in condensed matter systems. On the other hand, the study of non-equilibrium behaviors is also highly significant in other fields of physics like high energy physics and the physics of the early universe, where the stimulus is being provided in particular by the ongoing LHC and Planck experiments respectively. All of these are making the study of non-equilibrium physics a very exciting field with various rapid developments. Among others, AdS/CFT correspondence is naturally suited for attacking the notoriously difficult problems of non-equilibrium systems. But by holography the central task is to solve a set of bulk coupled partial differential equations, which is generically not amenable to analytical solution. Here comes the era of numerical holography, which is the state of the art I have been working on since I came to Brussels.

In particular, inspired by the recent experiment on vortex annihilation in superfluid turbulence, my peers from Chinese Academy of Sciences Yiqiang Du, Chao Niu, Yu Tian and I make a first principles investigation of the dynamical evolution of vortex number in a two-dimensional (2D) turbulent superfluid by holography through numerically solving its highly non-trivial gravity dual. The superfluid dynamics at zero temperature is generally described with the Gross-Pitaevskii equation. But in order to address the finite temperature superfluid dynamics, the dissipative terms are usually introduced in a phenomenological way. On the contrary, holographic duality, as a new laboratory and powerful tool, offers a first principles method to study vortex dynamics in the turbulent superfluid, where the superfluid at finite temperature is dual to a hairy black hole in the bulk and the dissipation mechanism is naturally built in the bulk in terms of excitations absorbed by the hairy black hole.

With the randomly placed vortices and antivortices prepared as initial states, we find that the temporal evolution of the vortex number can be well fit statistically by two-body decay due to the vortex pair annihilation featured relaxation process and the behavior of the decay rate for our holographic turbulent superfluid is consistent with the effective theory of 2D superfluid turbulence. Such a result is believed to have a direct impact on the further experiments on the turbulent superfluid in highly oblate Bose-Einstein condensates.

Appraisals & Prizes – Thesis defended in 2014

Appraisals and Prizes

Profs. V. Balasubramanian, O. Evnin, L. Lopez Honorez, A. Mariotti and D. Thompson all received a 10 % professorship at the VUB.

Mr. Tim De Jonckheere and Mr. Matthias Vereecken both received an FWO "aspirant" PhD fellowship.

Prof. Stéphane Detournay and Prof. Frank Ferrari obtained a prestigious ARC Research Grant.

Prof. Marc Henneaux and Prof. Valery Rubakov (RAS INR, Moscow) were awarded the N.N. Bogolubov Award 2014 for 'their outstanding achievements in the fields of theoretical and mathematical physics, contribution in development of international cooperation and training of young scientists'.

Prof. A. Sevrin was elected as a member of the "International Union of Pure and Applied Physics" where he will participate in the activities of commission "C18 Mathematical Physics".

Dr. Hongbao Zhang was awarded a prestigious FWO postdoctoral fellowship.

Thesis defended in 2014

Nele Callebaut (VUB) - "Background field and time dependence effects in holographic models" - 28 August 2014 (thesis advisors: Prof. Ben Craps and Prof. David Dudal).

Pierre-Henry Lambert (ULB) - "Conformal symmetries of gravity from asymptotic methods: further developments" - 12 September 2014 (thesis advisor: Prof. Glenn Barnich).

Gustavo Lucena-Gómez (ULB) - "Aspects of higher-spin theory with fermions" 18 April 2014 (thesis advisor: Prof. Marc Henneaux).

Micha Moskovic (ULB) - "Holographic backgrounds from D-brane probes" 30 May 2014 (thesis advisor: Prof. Frank Ferrari).

Bettina Oexl (VUB) - "Gravitino production in colliders" - 1 July 2014 (thesis advisors: Prof. Ben Craps and Prof. Kentarou Mawatari)

Diego Redigolo (ULB) - "Supersymmetry breaking from Holography to Colliders" 10 September 2014 (thesis advisor: Prof. Riccardo Argurio).

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 2014.

The workshop "Fast is Beautiful: Supersymmetry and Strings in a Null Frame" (in honour of Lars Brink) was co-organized with CECs on 14 - 15 May 2014, with support from the ASC (Munich).

Visits of **Belgian Scientists** to Chile

Prof. Glenn Barnich
29 December 2014 - 4 January 2015

Prof. Andrea Campoleoni
9 - 31 January 2014

Laura Donnay
10 October - 7 November 2014

Prof. Marc Henneaux,
1 - 12 January 2014
22 April - 1 May 2014
26 - 30 December 2014

Visits of **Chilean Scientists** to Belgium

Prof. Claudio Bunster
13 - 15 May 2014

Prof. Andrés Gomberoff
10 - 21 November 2014

Dr. Hernan Gonzalez Leiva
(postdoctoral researcher)
1 January - 31 December 2014

Pablo Pais *(PhD student)*
1 December - 31 December 2014

Arash Ranjbar *(PhD student)*
1 October - 31 December 2014

Patricio Salgado Rebolledo
(PhD student)
1 January - 31 December 2014

Dr. David Tempo
(postdoctoral researcher)
1 September - 31 December 2014

Prof. Ricardo Troncoso
7 - 19 April 2014

Joint Publications

G. Barnich, L. Donnay, J. Matulich and R. Troncoso
"Asymptotic symmetries and dynamics of three-dimensional flat supergravity"
JHEP 1408 (2014) 071 [arXiv: 1407.4275 [hep-th]].

G. Barnich, A. Gomberoff and H. A. González
"A 2D field theory equivalent to 3D gravity with no cosmological constant"
Springer Proc. Math. Stat. 60 (2014) 135 [arXiv: 1303.3568 [gr-qc]].

C. Bunster, M. Henneaux, S. Hörtner and A. Leonard
"Supersymmetric electric-magnetic duality of hypergravity"
Phys. Rev. D 90 (2014) 4, 045029 [arXiv: 1406.3952 [hep-th]].

C. Bunster, M. Henneaux, A. Perez, D. Tempo and R. Troncoso
"Generalized Black Holes in Three-dimensional Spacetime"
JHEP 1405 (2014) 031 [arXiv: 1404.3305 [hep-th]].

Cooperation with **Russia**

The international collaboration with the Lebedev Institute (Moscow, Russia), also based on a collaboration agreement, was active in 2014.

Visits of **Belgian Scientists** to Russia

Prof. Glenn Barnich
8 - 13 December 2014

Visits of **Russian Scientists** to Belgium

Dr. Maxim Grigoriev
15 - 27 September 2014

Invited talks at Conferences, Seminars and Schools

January 13:
Andrea Campoleoni
Conical defects in 3D Vasiliev theory
CECs, Valdivia, Chile.

January 13:
Christoffer Petersson
Multilepton and multiphoton signatures of supersymmetry at the LHC
Ecole Polytechnique, Paris, France.

January 14:
Glenn Barnich
3d gravity and BMS3
Albert-Einstein-Institut, Golm, Germany.

January 15:
Karen De Causmaecker
EFT and the calculation of anomalous dimensions
CERN, Geneva, Switzerland.

January 16:
Christoffer Petersson
Multilepton and multiphoton signatures of supersymmetry at the LHC
LPTHE, Univ. Pierre et Marie Curie Paris, France.

January 16:
Stéphane Detournay
Flat Space Holography: Cosmological Entropy, Chiral Gravity and Phase Transitions
LMU, Munich, Germany.

January 23:
Laura Lopez Honorez
Scalar DM
VUB- IIHE miniworkshop on the scalar sector, Brussels, Belgium.

January 23:
Marc Henneaux
Gravitational Duality and Hyperbolic Kac-Moody Algebras
Institute for Basic Science/Yonsei University, Seoul, Korea.

January 28:
Manuela Kulaxizi
Constraints on CFT three-point functions
Kavli Institute for Theoretical Physics, University of California, Santa Barbara, USA.

February 3:
Alberto Mariotti
Gauge Mediation of Exact Scale Breaking
University of Sussex, Brighton, UK.

February 4:
Riccardo Argurio
Correlators, Supersymmetry and Holography: theory and applications
University of Oviedo, Spain.

February 4:
Ben Craps
Holographic Renormalization
Chulalongkorn University, Bangkok, Thailand.

February 6:
Ben Craps
Inhomogeneous Holographic Thermalization
Chulalongkorn University, Bangkok, Thailand.

February 6:
Christoffer Petersson
Multiphoton and monophoton signatures of supersymmetry at the LHC
ATLAS Experiment, CERN, Geneva, Switzerland.

February 6:
Frank Ferrari
On D-Branes in Gauge Theories and Holography
Ludwig Maximilian U., Munich, Germany.

February 13:
Glenn Barnich
Dual dynamics of 3d asymptotically flat Einstein gravity
Université de Lorraine, Nancy, France.

February 19:
Stéphane Detournay
Holographic Flatland
ULB, Brussels, Belgium.

February 25:
Nele Callebaut
A magnetic instability of the Sakai-Sugimoto model
University of Oxford, UK.

February 25:
Daniel Thompson
Dualising the Baryonic Branch: Dynamic SU(2) & confining backgrounds in IIA
KULeuven, Belgium.

February 27:
Glenn Barnich
BMS3 representations, Virasoro coadjoint orbits and positive energy theorems in 3d gravity
Harvard University, USA.

February:
Geoffrey Compère
Chiral Liouville gravity and AdS3
ULB, Bruxelles, Belgium.

March 4:
Alexander Sevrin
Towards a Supersymmetric Doubled Worldsheet Formalism
JINR, Dubna, Russia.

March 5:
Anastasios Taliotis
Injecting energy in confining theories
Instituto de Física Teórica UAM/CSIC, Madrid, Spain.

March 5:
Christoffer Petersson
Multilepton and multiphoton signatures of supersymmetry at the LHC
Scuola Normale Superiore, Pisa, Italy.

March 13:
Simone Giacomelli
BPS quivers and N=2 superconformal theories
University of Cambridge, UK.

March 14:
Waldemar Schulgin
Asymptotic symmetry group of the flat space string theory
Nordita, Stockholm, Sweden.

March 14:
Nele Callebaut
A magnetic instability of the Sakai-Sugimoto model
Utrecht University, The Netherlands.

March 21:
Christoffer Petersson
Multilepton and multiphoton signatures of supersymmetry at the LHC
Conference ``Rencontres de Moriond, EW Session", La Thuile, Italy.

March 25:
Andrea Campoleoni
Conical defects in 3D Vasiliev theory
Albert Einstein Institute, Potsdam, Germany.

March 25:
Glenn Barnich
BMS3 representations & Virasoro coadjoint orbits
Université du Luxembourg, Luxembourg.

March 25:
Marc Henneaux
Higher-spin black holes in three-dimensional spacetime
University of Washington, Seattle, USA.

March:
Geoffrey Compère
Chiral Liouville gravity and AdS3
Jussieu, Paris, France.

April 3:
Ben Craps
Inflation and the BICEP2 results
VUB, Brussels, Belgium.

April 9:
Ben Craps
Infalling shells in hard wall models
University of Southampton, UK.

April 9:
Kentarou Mawatari
Effective theory approach in H-boson coupling determination
CIEMAT, Madrid, Spain.

April 14:
Tim De Jonckheere
Perturbations in non-local higher-derivative gravity
Theory at Sea, Oostende, Belgium.

April 14:
Laura Lopez Honorez
Sharp gamma ray spectral features: Scalar versus Majorana
Theory at Sea, Oostende, Belgium.

April 15:
Karen De Causmaecker
Non-minimal flavor violation in supersymmetry
Theory at Sea, Oostende, Belgium.

April 15:
Christoffer Petersson
Exotic Higgs decay to monophoton+MET
Conference ``Hunting for a Non-Standard Higgs Sector'', Benasque, Spain.

April 17:
Alberto Mariotti
The geometry of on shell diagrams
Queen Mary University, London, UK.

April 24:
Manuela Kulaxizi
Constraints on CFT three-point functions
Crete Center for Theoretical physics, University of Heraklion, Greece.

April 30:
Simone Giacomelli
BPS quivers and N=2 superconformal theories
KU Leuven, Belgium.

April:
Geoffrey Compère
Chiral Liouville gravity and AdS3
Southampton, UK.

April:
Geoffrey Compère
Chiral Liouville gravity and new view on AdS3
Texas A&M, College Station, USA.

May 1:
Daniel Thompson
Duality Geometry in String and M-theory
KU Leuven, Belgium.

May 2:
Anastasios Taliotis
Thermalization in confining geometries
Utrecht University, The Netherlands.

May 5:
Hongbao Zhang
Holographic Peierls metal insulator transition
Centre de Physique Théorique, Ecole Polytechnique, Paris, France.

May 14:
Ben Craps
Gravitational infall in the hard wall model
ENS, Paris, France.

May 15:
Glenn Barnich
3d gravity in flat and AdS backgrounds
University of Barcelona, Spain.

May 16:
Laura Lopez Honorez
Dark matter scenarios with significant Bremsstrahlung: Spectral features
Nordita workshop, Stockholm, Sweden.

May 19:
Ignacio Cortese
Electric-magnetic duality and Horava-Lifshitz gravity
University of Mons, Belgium.

May 20:
Marc Henneaux
Generalized Black Holes in Three-Dimensional Higher-Spin Gravity
University of Tours, France.

May 21:
Stéphane Detournay
Holographic Entanglement Entropy and Gravitational Anomalies: the Cone, the Anyon and the Ribbon
Vienna University, Austria.

May 21:
Frank Ferrari
On Quantum Black Holes
Universität zu Köln, Germany.

May 22:
Daniel Thompson
Duality Geometry in String and M-theory
Theory at Sea, Oostende, Belgium.

May 23:
Kentarou Mawatari
Higgs characterisation via the FeynRules and MadGraph5 aMC@ NLO frameworks
IBS, Daejeon, Korea.

May 26:
Frank Ferrari
A Quantum Model of Black Hole
Princeton University, USA.

May 27:
Alberto Mariotti
Gauge Mediation of Exact Scale Breaking
Mainz Institute for Physics, Mainz, Germany.

May 27:
Kentarou Mawatari
Gravitino production at colliders
KIAS, Seoul, Korea.

May 27:
Stéphane Detournay
Holographic Entanglement Entropy and Gravitational Anomalies: the Cone, the Anyon and the Ribbon
UvA, Amsterdam, The Netherlands.

May 28:
Simone Giacomelli
BPS quivers and N=2 superconformal theories
Scuola Normale Superiore, Cortona, Italy.

May 30:
Kentarou Mawatari
Simulation tools as a communication language among TH-PH-EXP
Sungkyunkwan, Suwon, Korea.

June 3:
Karen De Causmaecker
Multilepton signatures of GMSB at the LHC
Ecole Polytechnique, Paris, France.

June 3:
Waldemar Schulgin
Asymptotic symmetry group of flat space string theory
King's College, London, UK.

June 5:
Kentarou Mawatari
Higgs characterisation in the effective field theory approach
Warwick, UK.

June 6:
Alexey Koshelev
Strings -> non-locality -> cosmology
Quarks 2014, Suzdal, Russia.

June 6:
Christoffer Petersson
Multilepton and multiphoton signatures of supersymmetry at the LHC
Cambridge University, UK.

June 11:
Glenn Barnich
BMS3 representations, Virasoro coadjoint orbits & positive energy theorems
Morningside Center of Mathematics, Chinese Academy of Sciences, Beijing, China.

June 13:
Glenn Barnich
Dual dynamics of 3d asymptotically flat gravity
Morningside Center of Mathematics, Chinese Academy of Sciences, Beijing, China.

June 16, 19, 20, 23:
Glenn Barnich
Lectures on symmetries in gauge field theories
Morningside Center of Mathematics, Chinese Academy of Sciences, Beijing, China.

June 18:
Glenn Barnich
Holographic current algebras and BMS4
Kavli Institute for Theoretical Physics, Chinese Academy of Sciences, Beijing, China.

June 24:
Manuela Kulaxizi
Higher spin modes and Domain Walls
Theoretical Physics Dept at CERN, Geneva, Switzerland.

June 25:
Laura Lopez Honorez
Cosmological limits on DM annihilation
TeVPa IDM, Amsterdam, The Netherlands.

June 25:
Andrea Campoleoni
A journey into higher-spin gauge theories. Part I
University of Catania, Italy.

June 25:
Glenn Barnich
Quantum Coulomb solution and black hole microstates
Peking University, Beijing, China.

June 26:
Andrea Campoleoni
A journey into higher-spin gauge theories. Part II
University of Catania, Italy.

July 4:
Christoffer Petersson
Disappearing charged tracks in association with displaced leptons from supersymmetry
Conference ``ICHEP 2014'', Valencia, Spain.

July 7:
Andres Collinucci
F-theory on singular manifolds
ICTP, Trieste, Italy.

July 7:
Eduardo Conde Pena
Probing holography with probranes: the enhançon example
International Center for Theoretical Physics (ICTP), Trieste, Italy.

July 7:
Davide Forcella
Electromagnetic properties of viscous charged fluids
International Conference Strongly Correlated Electron Systems 2014, Grenoble, France.

July 8:
Glenn Barnich
Quantum Coulomb solution and black hole microstates
University of Munich, Germany.

July 14:
Karen De Causmaecker
EFT and Automatic Calculation of Anomalous Dimensions in FeynRules
IPPP, Durham, UK.

July 16:
Glenn Barnich
3d gravity and coadjoint orbits
Ghent University, Belgium.

July 17:
Kentarou Mawatari
Four-fermion interactions with more than one Majorana particles
Durham, UK.

July 21:
Kentarou Mawatari
Higgs characterisation via the FeynRules and MadGraph5 aMC@NLO frameworks
Manchester, UK.

July 21:
Christoffer Petersson
Multiphoton signatures of supersymmetry at the LHC
Conference ``SUSY 2014'', Manchester, UK.

July 22:
Alberto Mariotti
Gauge Mediation of Exact Scale Breaking
SUSY conference 2014, Manchester, UK.

July 24:
Pantelis Tziveloglou
Flavour in Dirac Gauginos
University of Manchester, UK.

July 31:
Alexey Koshelev
What does gravity learn from SFT
SFT 2014, Trieste, Italy.

July 31:
Rakibur Rahman
Massive Higher-Spin Fields in a Gravitational Background
Tomsk State Pedagogical University, Russia.

July:
Geoffrey Compère
Black holes of N=8 supergravity
Conference center, Ascona, Switzerland.

August 20:
Ben Craps
AdS (in)stability, secular term resummation and the renormalization group
University of Iceland, Reykjavik, Iceland.

August 25:
Alexey Koshelev
Non-local theories
Mathematical Physics School, Belgrade, Serbia.

August 27:
Kentarou Mawatari
Mono-X signals in light gravitino production
KUBEC, Brussels, Belgium.

August 28:
Laura Lopez Honorez
Bremsstrahlung and gamma ray line in different dark matter scenarios
KUBEC workshop, Brussels, Belgium.

September 11:
Kentarou Mawatari
CP violation in ttH
Vienna University of Technology, Austria.

September 16:
Hongbao Zhang
Holographic Peierls metal insulator transition
Mainz Institute for Theoretical Physics, Germany.

September 22:
Andrea Campoleoni
Asymptotic symmetries of metric-like higher spins
Workshop "Frontiers in field and string theory", Yerevan, Armenia.

September 24:
Glenn Barnich
Quantum Coulomb solution and black hole microstates
University of Craiova, Sinaia, Romania.

September 24:
Marc Henneaux
Topics in 2+1 anti-de Sitter higher spin gravity
Meeting on "Quantum Field Theory and Nonlinear Dynamics", Sinaia, Romania.

September 25:
Pantelis Tziveloglou
Majorana vs Dirac masses in Supersymmetry
VUB, Brussels, Belgium.

September 26:
Riccardo Argurio
Anatomy of new SUSY-breaking holographic RG-flows
Mainz Institute for Theoretical Physics, Germany.

September 29, 30 and October 1:
Glenn Barnich
QFT for mathematicians
University of Brest, Aber Wrac'H, France.

October 9:
Davide Forcella
Electromagnetic properties of viscous charged fluids
CERN, Geneve, Switzerland.

October 10:
Davide Forcella
Electromagnetic properties of viscous charged fluids
University of Mons, Belgium.

October 13, 14, 15, 16, 17:
Glenn Barnich
Advanced General Relativity
Amsterdam-Brussels-Geneva-Paris Doctoral School, Université Libre de Bruxelles, Belgium.

October 17:
Kentarou Mawatari
Light gravitino productions at the LHC
CERN, Geneva, Switzerland.

October 18:
Stéphane Detournay
Relativités, Gravitation et Trous Noirs
Jeunesse et Science, Modave, Belgium.

October 22:
Ben Craps
Snaartheorie
Ghent University, Belgium.

October 24:
Marc Henneaux
E(10) and Gravitational Duality
"Workshop on "Superfields, Selfcompletion and Strings & Gravity", Munich, Germany.

October 27:
Daniel Thompson
Non-Abelian T-duality and lambda deformed spacetime
Swansea, UK.

October 28:
Kentarou Mawatari
MadGraph5 aMC@NLO for e+e-
LPNHE, Paris, France.

November 5:
Andres Collinucci
F-theory on singular spaces
King's College, London, UK.

November 7:
Davide Forcella
Electromagnetic properties of viscous charged fluids
VUB, Bruxelles, Belgium.

November 10:
Marc Henneaux
Manifestly duality symmetric actions
Nanyang Technological University, Singapore.

November 10:
Andres Collinucci
F-theory on singular spaces
Université de Lyon, France.

November 11:
Glenn Barnich
Holographic aspects of gravity in 4 and 3 dimensions
CERN Theory Division, Geneva, Switzerland.

November 12:
Waldemar Schulgin
Asymptotic symmetry group of flat space string theory
Trinity College Dublin, Ireland.

November 13:
Frank Ferrari
Holography, Probe Branes and Isoperimetric Inequalities
Queen Mary College, London, UK.

November 18:
Riccardo Argurio
Anatomy of new SUSY-breaking holographic RG-flows
Albert Einstein Institute, MPI, Potsdam, Germany.

November 20:
Ben Craps
Holographic thermalization, AdS instability and secular term resummation
Leiden University, The Netherlands.

November 28:
Christoffer Petersson
Multiphoton signatures of supersymmetry at the LHC
Conference ``Partikeldagarna 2014'', Vaxjo, Sweden.

November:
Geoffrey Compère
Black holes of N=8 supergravity
Conference center, Singapore.

December 1:
Kentarou Mawatari
MadGraph5 aMC@NLO for linear colliders
Grenoble, France.

December 3:
Daniel Thompson
Geomety and Duality in String Theory: New approaches and Applications
Athens, Greece.

December 3:
Andres Collinucci
F-theory on singular spaces
Mons, Belgium.

December 3:
David Tempo
Higher spin black holes in 3D: asymptotic symmetries and thermodynamics
Academy of Sciences of the Czech Republic, Prague, Czech Republic.

December 3:
Marc Henneaux
Three-dimensional gravity: a superb theoretical laboratory
Institute of Physics, Prague, Czech Republic.

December 3:
Marc Henneaux
Asymptotic symmetries of three-dimensional higher-spin gravity: the metric approach
Institute of Physics, Prague, Czech Republic.

December 4:
Ignacio Cortese
Electric-magnetic duality and Horava-Lifshitz gravity
Institute of Physics AS CR, Prague, Czech Republic.

December 4:
Glenn Barnich
Holographic aspects of gravity in 4 and 3 dimensions
Cambridge University, UK.

December 4:
Arnaud Lepage-Jutier
dS/CFT and Topologies in Higher Spin Gravity
Prague St. Nicolas seminar on Strings and Higher spins,
Prague, Czech Republic.

December 5:
Eduardo Conde Pena
An on-shell perspective on QFTs: from tree level to one loop
Institute of Physics AS CR,
Prague, Czech Republic.

December 8:
Glenn Barnich
Quantum Coulomb solution and black hole microstates
Lebedev Physical Institute,
Moscow, Russia.

December 8:
Davide Forcella
Scattering Amplitudes and Toric Geometry
Conference: "Grassmannian Geometry of Scattering Amplitudes",
Caltech, Pasadena,
Los Angeles, USA.

December 9:
Hongbao Zhang
Metal insulator transition by holographic charge density waves
CERN, Geneva, Switzerland.

December 10:
Glenn Barnich
Holographic aspects of gravity in 4 and 3 dimensions
Lebedev Physical Institute,
Moscow, Russia.

December 15:
Anastasios Taliotis
Gravitational infall in the hard wall model
CERN, Geneva, Switzerland.

December 16:
Stéphane Detournay
Holographic Entanglement Entropy and Gravitational Anomalies: the Cone, the Anyon and the Ribbon
UBA, Buenos Aires, Argentina.

December 17:
Andrea Campoleoni
Higher spins and strings
X Avogadro meeting, Pisa, Italy.

December 19:
Joris Vanhoof
Holographic thermalization and AdS (in)stability
KUL, Leuven, Belgium.

December 19:
Christoffer Petersson
Theoretical motivation for neutron-antineutron oscillation experiments
European Spallation Source,
Lund, Sweden.

December 28:
Glenn Barnich
3d gravity as group theory
Centro de Estudios Científicos,
Valdivia, Chile.

December 28:
Alexander Sevrin
Le charme pas nécessairement discret de la symétrie
CECs, Valdivia, Chile.

December 29:
Riccardo Argurio
Gravitational duality and supersymmetry
Centro de Estudios Científicos,
Valdivia, Chile.

December:
Geoffrey Compère
3d gravity and dual (warped) CFTs
Conference center,
Bhubaneswar, India.

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] A. Alvarez, E. Ayon-Beato, H. A. González and M. Hassaïne, "Non- linearly charged Lifshitz black holes for any exponent z > 1," JHEP 1406 (2014) 041 [arXiv: 1403.5985 [gr-qc]].

[3] P. D. Alvarez, P. Pais, E. Rodríguez, P. Salgado-Rebolledo and J. Zanelli, "The BTZ black hole as a Lorentz-flat geometry," Phys. Lett. B 738 (2014) 134 [arXiv: 1405.6657 [gr-qc]].

[4] A. Amariti and D. Forcella, "Spin(7) duality for N = 1 CS-matter theories," JHEP 1407 (2014) 082 [arXiv: 1404.4052 [hep-th]].

[5] F. Apruzzi, M. Fazzi, A. Passias, D. Rosa and A. Tomasiello, "AdS6 solutions of type II supergravity," JHEP 1411 (2014) 099 [arXiv:1406.0852 [hep-th]].

[6] F. Apruzzi, M. Fazzi, D. Rosa and A. Tomasiello, "All AdS7 solutions of type II supergravity," JHEP 1404 (2014) 064 [arXiv:1309.2949 [hep-th]].

[7] M. Archidiacono, L. Lopez-Honorez and O. Mena, "Current constraints on early and stressed dark energy models and future 21 cm perspectives," Phys. Rev. D 90 (2014) 12, 123016 [arXiv:1409.1802 [astro-ph.CO]].

[8] R. Argurio, M. Bertolini, L. Pietro, F. Porri and D. Redigolo, "Supercurrent multiplet correlators at weak and strong coupling," JHEP 1404 (2014) 123 [arXiv:1310.6897 [hep-th]].

[9] G. Barnich, L. Donnay, J. Matulich and R. Troncoso, "Asymptotic symmetries and dynamics of three-dimensional flat supergravity," JHEP 1408 (2014) 071 [arXiv: 1407.4275 [hep-th]].

[10] G. Barnich and B. Oblak, "Notes on the BMS group in three dimensions: I. Induced representations," JHEP 1406 (2014) 129 [arXiv: 1403.5803 [hep-th]].

[11] G. Barnich and B. Oblak, "Holographic positive energy theorems in three-dimensional gravity," Class. Quant. Grav. 31 (2014) 152001 [arXiv: 1403.3835 [hep-th]].

[12] G. Barnich, A. Gomberoff and H. A. González, "A 2D field theory equivalent to 3D gravity with no cosmological constant," Springer Proc. Math. Stat. 60 (2014) 135 [arXiv:1303.3568 [gr-qc]].

[13] D. S. Berman and D. C. Thompson, "Duality Symmetric String and M-Theory," Phys. Rept. 566 (2014) 1 [arXiv:1306.2643 [hep-th]].

[14] A. Bilal, F. Ferrari and S. Klevtsov, "2D Quantum Gravity at One Loop with Liouville and Mabuchi Actions," Nucl. Phys. B 880 (2014) 203 [arXiv:1310.1951 [hep-th]].

[15] T. Biswas, A. Conroy, A. S. Koshelev and A. Mazumdar, "Generalized ghost- free quadratic curvature gravity," Class. Quant. Grav. 31 (2014) 015022 [Erratum-ibid. 31 (2014) 159501] [arXiv:1308.2319 [hep-th]].

[16] A. P. Braun, A. Collinucci and R. Valandro, "Hypercharge flux in F-theory and the stable Sen limit," JHEP 1407 (2014) 121 [arXiv:1402.4096 [hep-th]].

[17] A. P. Braun, A. Collinucci and R. Valandro, "The fate of U(1)'s at strong coupling in F-theory," JHEP 1407 (2014) 028 [arXiv:1402.4054 [hep-th]].

[18] C. Bunster, M. Henneaux, S. Hörtner and A. Leonard, "Supersymmetric electric-magnetic duality of hypergravity," Phys. Rev. D 90 (2014) 4, 045029 [arXiv:1406.3952 [hep-th]].

[19] C. Bunster, M. Henneaux, A. Perez, D. Tempo and R. Troncoso, "Generalized Black Holes in Three-dimensional Spacetime," JHEP 1405 (2014) 031 [arXiv:1404.3305 [hep-th]].

[20] L. Calibbi, A. Mariotti, C. Petersson and D. Redigolo, "Selectron NLSP in Gauge Mediation," JHEP 1409 (2014) 133 [arXiv:1405.4859 [hep-ph]].

[21] N. Callebaut, B. Craps, F. Galli, D. C. Thompson, J. Vanhoof, J. Zaanen and H. b. Zhang, "Holographic Quenches and Fermionic Spectral Functions," JHEP 1410 (2014) 172 [arXiv:1407.5975 [hep-th]].

[22] F. Canfora, P. Pais and P. Salgado-Rebolledo, "Gribov gap equation at finite temperature," Eur. Phys. J. C 74 (2014) 2855 [arXiv:1311.7074 [hep-th]].

[23] A. Castro, S. Detournay, N. Iqbal and E. Perlmutter, "Holographic entanglement entropy and gravitational anomalies," JHEP 1407 (2014) 114 [arXiv:1405.2792 [hep-th]].

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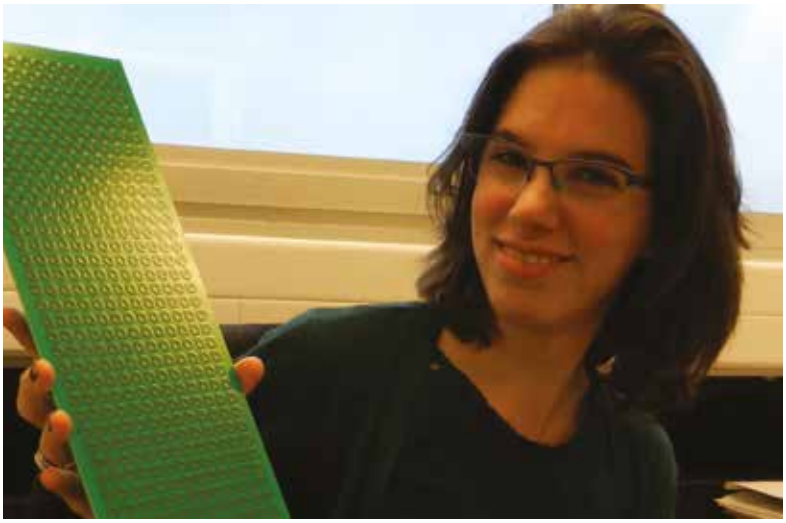
The Robert Brout Prizes and The Ilya Prigogine Prizes

Victor Lekeu



Sophie Viaene

Valérie Voorsluijs

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 students finishing their master studies in **physics**, provided they have a brilliant curriculum (one prize at the ULB, one prize at the VUB).

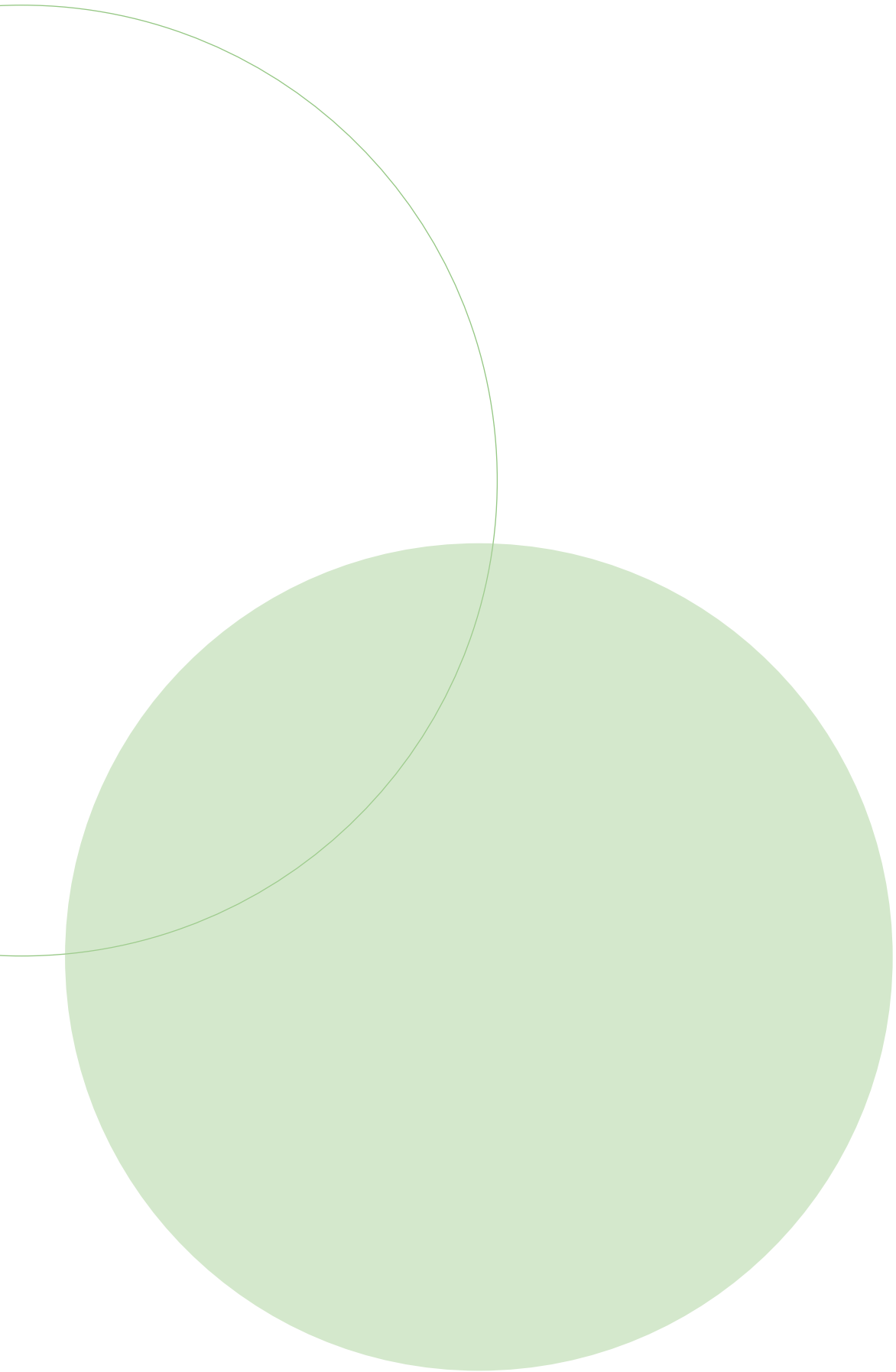
Given the close ties of these two personalities with the Institutes, the International Solvay Institutes are associated with this initiative.

In **2014**, the prizes have been awarded to:

Victor Lekeu (Robert Brout Prize ULB)

Sophie Viaene (Robert Brout Prize VUB)

Valérie Voorsluijs (Ilya Prigogine Prize ULB)



Appendix

Groepsportret van de eerste Solvayconferentie in 1911, met Marie Curie zittend aan tafel en Albert Einstein schuin achter haar staand, als tweede van rechts.

26STE SOLVAYCONFERENTIE OVER KOSMOLOGIE EN ASTROFYSICA VAN START

Brussel ontvangt de kosmos

De wereldtop van sterrenkundigen en kosmologen is drie dagen bijeen in de hoofdstad van ons land. Op het programma: alle vraagstukken waar de natuurkunde mee worstelt. 'Vuurwerk gegarandeerd.'

HILDE VAN DEN EYNDE

Het statige hotel Métropole in Brussel vormt vandaag en de komende dagen het decor voor een uitzonderlijke bijeenkomst. Stephen Hawking heeft wegens zijn slechte gezondheid afgezegd, maar een hele parade van Nobelprijswinnaars en ander schoon natuurkundig volk maakt in Brussel zijn opwachting voor de 26ste Solvayconferentie over fysica.

Thema waarover de eminente heren en dames geleerden het zullen hebben, is de kosmos. 'Zwarte gaten, donkere materie, de geboorte van het heelal', somt organisator Alexander Sevrin van de VU Brussel op. Allemaal kwesties waarover het laatste woord nog niet is gezegd.

Bij de geïnviteerde onderzoekers (zonder uitnodiging kom je de conferentiezaal niet binnen) zijn de Amerikaanse astrofysici die de sinds Einstein hypothetische zwaartekrachtgolven menen te hebben waargenomen, én hun Europese opponenten die denken dat ze gewoon stof uit onze eigen melkweg hebben gezien. 'Vuurwerk gegarandeerd', zegt Sevrin – de gesprekken verlopen op een Solvayconferentie traditioneel behoorlijk geanimeerd – versta: er wordt flink over en weer geroepen.

De Solvayconferenties genieten een haast mythische status in de geschiedenis van de natuurkunde. Bij de eerste conferentie in 1911, ook toen al in Hotel Métropole, trad op invitatie van de Belgische industrieel Ernest Solvay de crème de la crème van de natuurkunde aan. Er vonden legendarische twistgesprekken plaats tussen Niels Bohr en Albert Einstein over de toen nagelnieuwe kwantumtheorie (Einstein moest de duimen leggen).

Zo stijf als honderd jaar geleden gaat het er in de salons van het Métropole niet meer aan toe, zegt Sevrin, al wordt nog steeds wel enige vestimentaire discipline van de deelnemers verwacht – 'al loopt er altijd wel een Amerikaan in T-shirt tussen.'

Belgische genodigden zijn de Nobelprijswinnaar fysica 2013, François Englert, en de Leuvense sterrenkundige Conny Aerts. Met de Britse sterrenkundige Martin Rees geven zij zondag na afloop van de conferentie een publiekslezing in het Flageygebouw. Onnodig u daarheen te spoeden: alle plaatsen zijn al weken uitverkocht.

De Standaard (09.10.2014)

Astrophysique et cosmologie au menu du 26ème Conseil de Physique Solvay

SOCIETE | Mis à jour le vendredi 10 octobre 2014 à 9h55

C'est un événement pour la communauté scientifique. Il tombe en pleine période de distribution des prix Nobel, mais c'est à Bruxelles que ça se passe jusqu'à samedi. C'est le 26ème Conseil de Physique Solvay. Les scientifiques y débattent cette année d'astrophysique et de cosmologie. Des rencontres qui ont leur importance.

Si les tapis rouges du célèbre hôtel Métropole à Bruxelles se confiaient, ils livreraient les grands secrets de la science en marche, ils ont vu dans leurs salons feutrés la rencontre des plus éminents esprits, des plus brillants physiciens, des visionnaires du progrès de la créativité.

Les physiciens adorent cet endroit mythique. Albert Einstein, Marie Curie, Georges Charpak, Hendrik Antoon Lorentz, et bien sûr François Englert y ont travaillé. Les fauteuils de cuir ont accueilli pour des heures de discussions structurées tous les grands prix Nobel et beaucoup de participants internationaux invités sont en général les Nobel de demain.

On y parle pour ce 26ème congrès sous la direction du professeur Roger Blandford de l'université de Stratford : des étoiles à neutrons, des trous noirs de la matière noire, de la formation des galaxies...

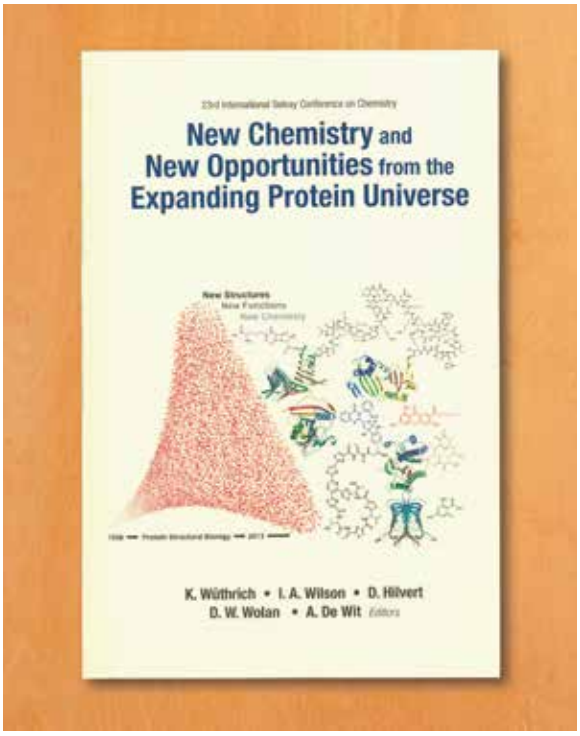
François Englert, notre prix Nobel 2013, est de la partie. Un éminent spécialiste a préparé son exposé, les contradicteurs leurs réponses, la discussion est libre mais préparée.

Des auditeurs, des scientifiques belges ont pour mission de prendre note de tout ce qui est dit. Tout est minutieusement préparé par un comité scientifique basé à Bruxelles et si pas d'invitation pas de participation au Conseil de Physique Solvay. Pas de place pour la révolution en marche.

F. Baré

http://www.rtbf.be/info/societe/detail_astrophysique-et-cosmologie-au-menu-du-26eme-conseil-de-physique-solvay?id=8374784

www.rtbf.be (10.10.2014)



Proceedings of the 23rd Solvay Conference on Chemistry (2013)

CONNY AERTS, STERRENKUNDIGE

Een hedendaagse Marie Curie

Conny Aerts, sterrenkundige bij de KU Leuven, is een van de vijf vrouwen die vandaag mogen aanschuiven bij de Solvay-conferentie in Brussel. Vijf: veel is het niet, maar het zijn toch al vier vrouwen meer dan in de beginjaren van deze conferentie, toen Marie Curie zich als enige overeind moest zien te houden tussen alleen maar mannen.

'Dat valt te bezien', zegt Aerts. 'In Curies tijd kwamen twintig fysici naar de conferentie, vandaag zijn het er vijfenzestig. Een op de twintig versus vijf op de vijfenzestig: er is voor vrouwen in honderd jaar echt niet zo veel veranderd.'

Maar voorts vindt Aerts het wel prettig om deel uit te mogen maken van het selecte clubje kosmologen en astrofysici dat drie dagen in het Métropole Hotel komt brainstormen.

'De meesten ken ik van eerdere conferenties. Maar zoals hier hebben we nog nooit samen gezeten: met zijn allen rond één grote tafel, debatteren van 's morgens tot 's avonds, met voor iedereen evenveel spreekrecht.'

Aerts verwacht dat de meningen aardig zullen botsen. 'Kosmologen en astrofysici bestuderen in wezen hetzelfde: de kosmos, de sterren. Maar kosmologen doen dat op een heel theoretische manier, met veel wiskundige formules. Daarbij durven ze de realiteit die sterrenkundigen door hun kijkers waarnemen, wel eens uit het oog te verliezen. En omgekeerd gaan astrofysici wel eens wat te gemakkelijk aan de theorie voorbij.'

Al is de topfysica nog steeds een mannenbastion, zoals in de tijd van Marie Curie, voor discriminatie is ze de komende dagen niet bang, zegt Aerts. 'Eens je je als vrouw bij de internationale top hebt geworsteld, is daarvan geen sprake meer – eerder omgekeerd. Dan krijg je enorm veel respect van de mannelijke collega's en ondervind je veel goodwill om wat aan het sekse-onevenwicht te doen.'

'Maar ondertussen blijf ik het zonde vinden, die afwezigheid van vrouwelijk talent, en prettig is het ook niet – hoe modern die mannen verder ook zijn.'

Eén voordeel zit er aan haar sekse, zegt Aerts. Terwijl de mannelijke deelnemers aan Solvayconferenties geacht worden in pak en das aan te treden, krijgen vrouwen geen dresscode opgelegd. Ze lacht. 'Wij worden verondersteld zélf te weten hoe je je voor zo'n gelegenheid hoort te kleden.' (hvde)

De Standaard (09.10.2014)

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, 2004 Nobel Laureate in Physics, Santa Barbara (USA)
2009 Valery Rubakov, Moscow (Russia)
2010 Serge Haroche, 2012 Nobel Laureate in Physics, Paris (France)
2011 Nathan Seiberg, Princeton (USA)
2012 Jan Zaanen, Leiden (The Netherlands)
2013 Gian Giudice, CERN (Switzerland)
2014 Viatcheslav F. Mukhanov, LMU Munich (Germany)

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)

2011 Solvay **Centenary** Chair

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

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	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
- "**Exploring the Postgenomic Protein Universe**" by Kurt Wüthrich (Zürich and La Jolla), 2002 Nobel Laureate in Chemistry

20 October **2013**

- "**How proteins are made in the cell: Visualizing the ribosome in action**" by Joachim Frank (Columbia University, USA)
- "**Reprogramming the genetic code**" by Jason Chin (University of Cambridge, UK)

12 October **2014**

- "**Starquakes and Exoplanets in our Milky Way galaxy**" by Conny Aerts (KU Leuven, Belgium)
- "**From a 'simple' big bang to our complex cosmos**" by Martin Rees (Cambridge, UK)
- "**The Brout-Englert-Higgs mechanism and its scalar boson**" by François Englert (ULB, Belgium), 2013 Nobel Laureate in Physics

Colophon

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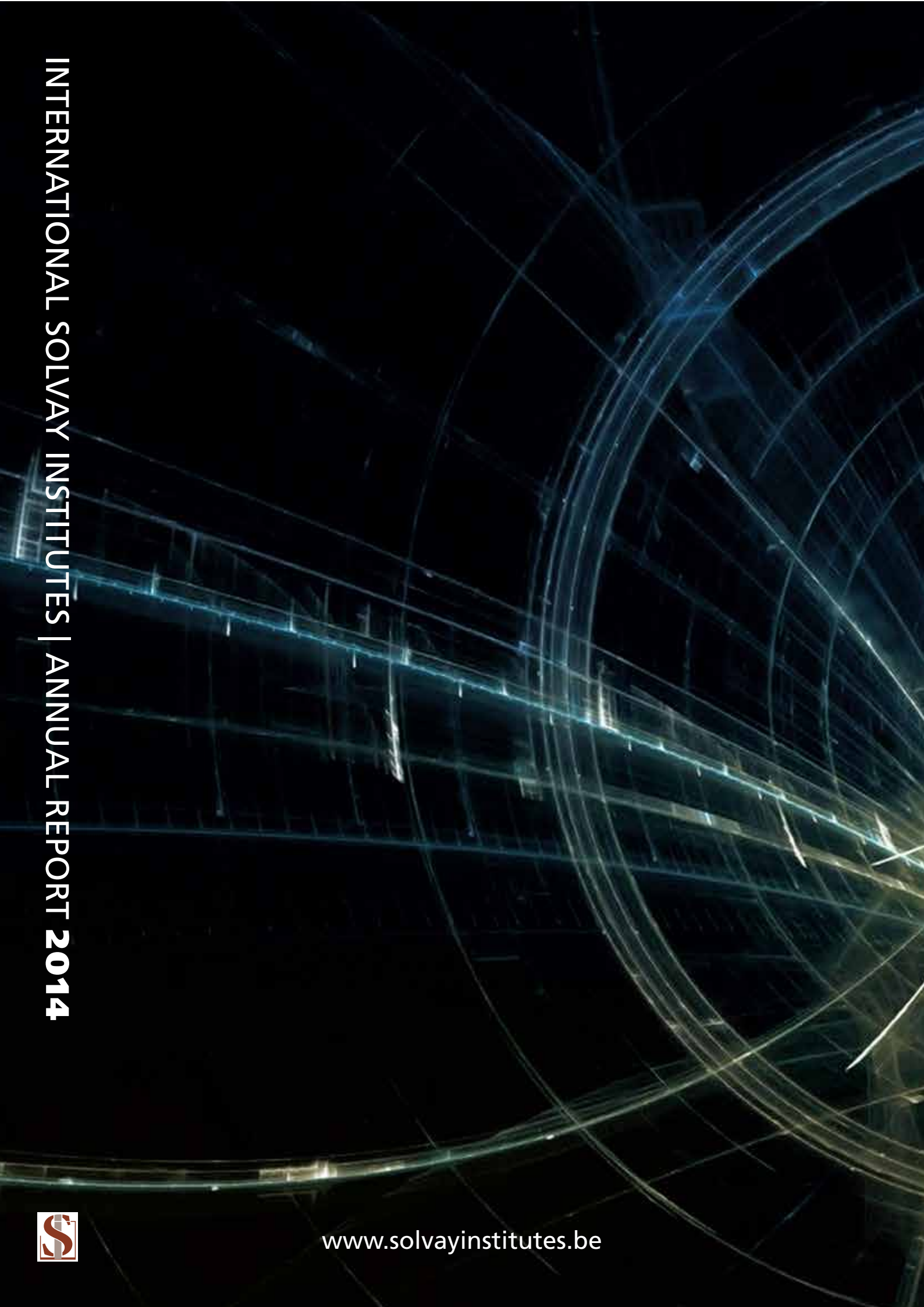
Postal address

International Solvay Institutes
Campus Plaine ULB / CP 231
Bd du Triomphe
B-1050 Brussels | Belgium

Delivery and visiting address

International Solvay Institutes
Campus Plaine ULB / Access 2
Bd de la Plaine
Building N-O
5th Floor - Office 2N5 105A
B-1050 Brussels | Belgium

Ms Bogaerts: + 32 2 650 55 42
dominique.bogaerts@ulb.ac.be
Ms Van Geet: + 32 2 650 54 23
isabelle.vangeet@solvayinstitutes.be
Fax: + 32 2 650 50 28
Website: www.solvayinstitutes.be
Webdesigner: Thomas Philippe
Webmaster: Isabelle Van Geet



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