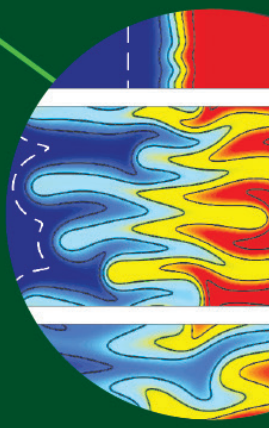
Instituts Internationaux
de Physique et de Chimie
fondés par Ernest Solvay asbl

Internationale Instituten
voor Fysica en Chemie
gesticht door Ernest Solvay VZW

INTERNATIONAL
SOLVAY
INSTITUTES
BRUSSELS



ANNUAL REPORT
2018

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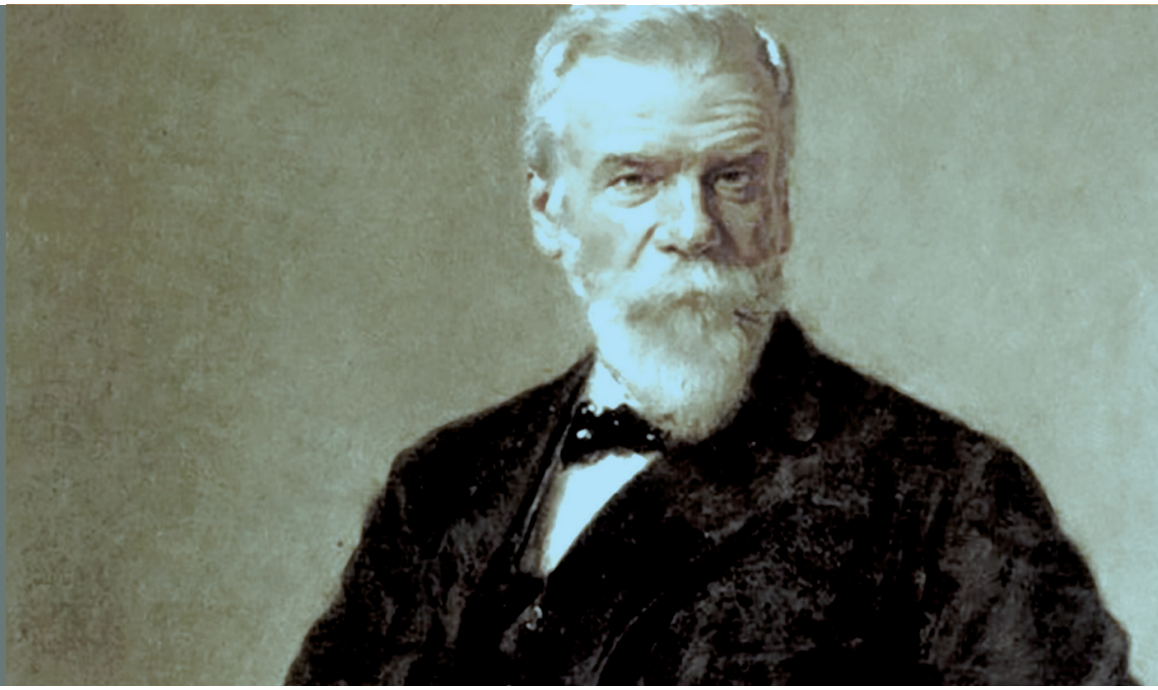

ERNEST SOLVAY

there are no limits
to what science can explore

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

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SOLVAY
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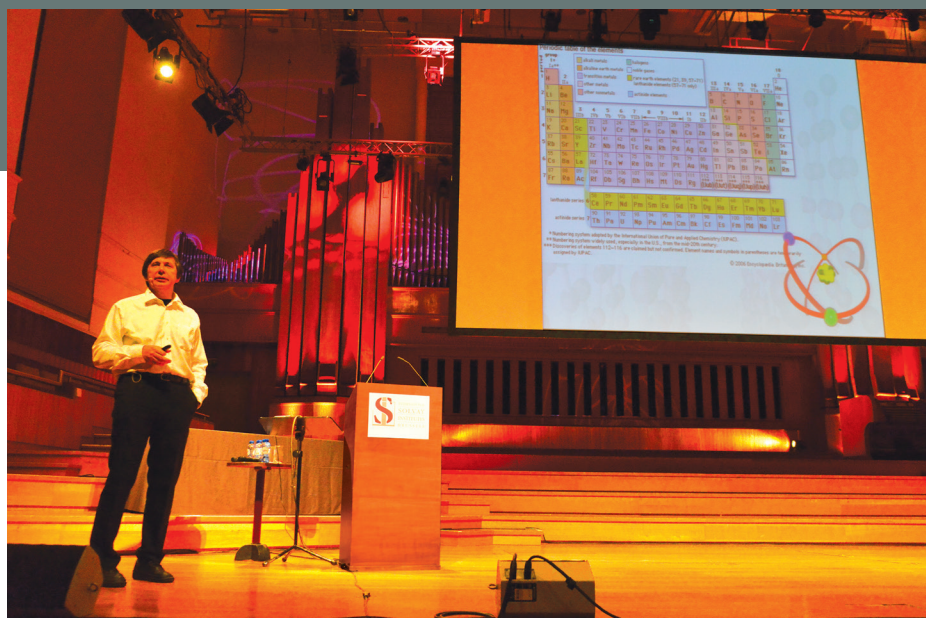
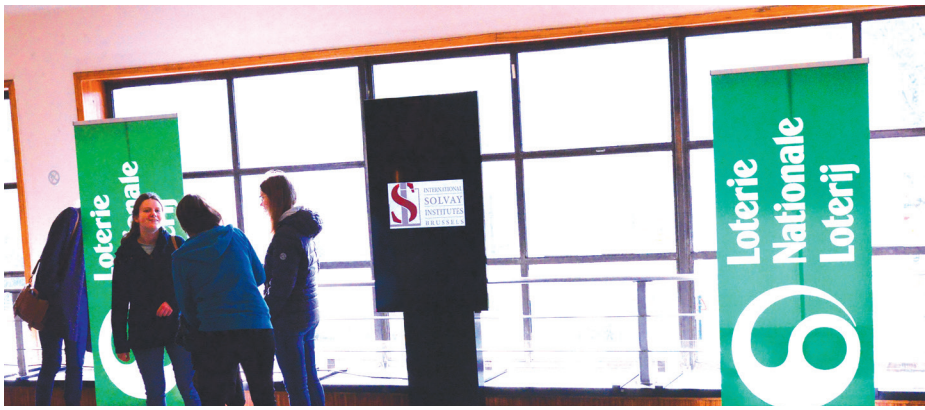
Met steun van de Vlaamse overheid

FÉDÉRATION WALLONIE-BRUXELLES




Spelen is ook
steunen, bedankt
aan onze spelers!
Loterie
Nationale
Loterij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THE BELGIAN NATIONAL LOTTERY

and the International Solvay Institutes: a long-term partnership

The Belgian National Lottery is one of the main philanthropic organizations in Belgium, which has consistently supported the activities of the International Solvay Institutes for decades. We gratefully acknowledge all those who make this support possible.

This support contributes to the international visibility of Belgium. Most of the greatest chemists and physicists of the 20th and 21st century have come to Brussels to participate in the prestigious “Solvay Congresses”, the pictures of which are known worldwide and have become a symbol of excellence. The Solvay Conferences have put Brussels on the scientific world map.

The support of the National Lottery also paves the way to the future of our society. Investment in scientific knowledge and brainpower is more crucial than ever. Specific activities of the Institutes targeted to inspire the young generations towards science as well as to develop training-through-research (Colloquia, open Workshops, Public Event) directly benefit from the support of the National Lottery.

CONTENTS

Jean-Marie Solvay, great-great-grandson of Ernest Solvay

A WORD

from the President

2018 was a year without a Solvay Conference, yet it was another full year of activities dedicated to the local academic scientific community involving our Belgian universities. We pioneered a new program called the “New Horizon Lectures” that is focused to bringing together new young established international talent with our local scientific community. Younger generations relate quickly and easily when the right conditions exist. The format used creates the conditions for dynamic discussions between the visiting professor and the students. We were fortunate enough to film some of these exchanges that proved to be very lively and inspiring. These are posted on the website in order to give more visibility to these activities and to stimulate younger people to engage in the passion for science. We thank Professor Alexandre Tkatchenko in chemistry and Professor Zohar Komargodski in physics for the very valuable contributions and their engagement with students.

We were very pleased to welcome Nobel laureate Ben Feringa to Brussels in September: we were able to organize a series of poster session presentations with various students. Ben has an uncanny ability to stimulate passion on all subjects of scientific discovery. We are very grateful for his contribution that is truly inspiring.

We also launched the “Solvay Science Project” with the help of the ULB and the VUB on May 7th with simultaneous physical and virtual expositions in the grandiose “Hall of Marble” of the building A on the ULB campus. The launch of “Solvay Science Project” consisted of a presentation of twenty archives that document the first 1911 Solvay Conference that is represented on the famous picture of Ernest Solvay surrounded by scientific icons such as Hendrik Lorentz, Max Planck, Albert Einstein and the other famous contributors to that first conference. The virtual exposition presents to the world the digital archives that narrates the creation of the first conference and another 8 themes that outline the history of the conferences and their influence on the evolution of modern science. Our goal is to continue to contribute more archives and content to the site in order to document the beauty of the evolution of the scientific thought as it explores new frontiers and constantly discovers new areas of unknown. We are very grateful to the ULB for its support in caring for the archives, digitalizing them and structuring the website. We are thankful for the support of the ULB and the VUB for translating the site to make it accessible to the public across communities.

In the name of the board of directors and of all our donors, I would like to thank the director and his team for the outstanding work in making all this possible. Special thanks go to Profs. Yves Geerts, Riccardo Argurio, Frank Ferrari and Nicolay Bobev for the organization of the New Horizon Lectures and film sessions, to the members of the archives committee: Prof. Kenneth Bertrams, Prof. Brigitte van Tiggelen, Prof. Franklin Lambert, Prof. Anne De Wit, Nicolas Coupain, Marina Solvay, Yoanna Alexiou and the keeper of the archives, Didier Devriese.

My thanks also go to the members of our International Scientific Committees for their commitment and their guidance.

Jean-Marie Solvay
President

A WORD

from the Director

The report that follows reviews in detail the activities organized or supported by the International Solvay Institutes during the year 2018. These activities (2 Chairs, 2 sets of "New Horizons Lectures", 7 workshops, 15 colloquia, 1 graduate school in theoretical physics, 1 public event) attracted to Brussels hundreds of scientists and covered a wide spectrum of developments at the frontiers of physics and chemistry. As usual, a balance between physics and chemistry, and an opening towards promising emerging fields, inspired the 2018 program.

All the information can be found in the core of the report. I will just briefly mention in this introductory section the new developments that took place in 2018.

The year 2018 witnessed the launch of a new activity: the "New Horizons Solvay Lectures" in Chemistry and in Physics. Suggested by our International Advisory Committee, the purpose of this new program, which benefits from the generous financial support of the Solvay Group, is to invite a brilliant young scientist with already high visibility and well-established stature to give a series of lectures in Brussels and in other Belgian universities.

The first New Horizons Solvay Lecturers were respectively Professor Alexandre Tkatchenko for chemistry and Professor Zohar Komargodski for physics. They delivered stimulating and inspiring talks in Brussels, Gent, Leuven and Mons, where they had also intense scientific discussions with PhD students and postdoctoral fellows.

The success of the first year of the program, for which we warmly thank the two lecturers, has convinced us that it should continue. It is planned to have each year "New Horizons Solvay Lectures in Chemistry" and "New Horizons Solvay Lectures in Physics".

Another important development that occurred in 2018 was the launch of "The Solvay Science Project", a virtual exhibition recounting key moments in the history of the Solvay Institutes.

I strongly recommend you to visit the web site of this remarkable exhibit, *http://ladigitheque.ulb.ac.be/exhibits/show/the-solvay-science-project?lang=en* which contains documents and testimonies of exceptional value. The project is the fruit of a collaboration between the Solvay Institutes, the ULB and the VUB. I want to congratulate and thank all the persons who carried this splendid project to successful completion.

The triennial visit of the Solvay International Advisory Committee took place in 2018. This Committee is composed of distinguished scientists who have the tasks of periodically evaluating all the scientific activities of the Solvay Institutes, making suggestions if appropriate, reporting to the Board of Directors and providing advice for future developments. Periodic reviews by an external eye are extremely healthy. In 2018, the Committee visited the Institutes for the fourth time and resolutely discussed various questions related to the long-term future of the Institutes. The report of their visit is enclosed at the end of this document.

I am very grateful for the careful work done by the International Advisory Committee and wish to thank all its members, and especially its chair Professor Lars Brink, for their evaluation and advice.

Besides the above-mentioned activities, this report also describes the research carried in the groups of the Director and of the Scientific Secretaries of the International Scientific Committee for Chemistry and the International Scientific Committee for Physics. The research highlights of other researchers connected with the Institutes are also outlined.

The research of the group of the Director benefited from the direct and most precious support of the Solvay family and the Solvay group. I heartily thank them.

The activities described in this report would not have been possible without the help of the sponsors of the International Solvay Institutes, to whom I would like to express our gratitude. These are the Université Libre de Bruxelles, the Vrije Universiteit Brussel, the Solvay company, the Belgian National Lottery, the Brussels-Capital Region, the Fédération Wallonie-Bruxelles, the Vlaamse Regering, and last but not least – and as recalled above -, the Solvay family who continues with the same conviction a more than a century-old tradition of support to fundamental research.

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

Marc Henneaux
Director

GENERAL INFORMATION

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Eric Boyer de la Giroday | Chairman of the Board of Directors ING Belgium sa/nv	**Philippe Busquin** | Minister of State	**Eddy Van Gelder** | Chairman of the Board of Directors of the VUB

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Members

BOARD OF DIRECTORS

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Emeritus Professor VUB | Former Vice president and Treasurer of the Solvay Institutes

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Marina Solvay

Didier Viviers
Secretary of the Royal Academy for Science and the Arts of Belgium

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

MANAGEMENT

and Staff

The Director is assisted in his scientific tasks by:

- The International Scientific Committees for Physics and Chemistry, which are fully responsible for the scientific organization of the “Conseils Solvay”.
- The Executive Committee and the Local Scientific Committees, which help him for the organization of all the other activities (workshops, colloquia, chairs, New Horizons Lectures).

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Professor Marc Henneaux I ULB
Director

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

Professor Lode Wyns | VUB
Deputy Director for Chemistry

Professor Glenn Barnich I ULB
Solvay Colloquia in Physics

Professor Ben Craps I VUB
Doctoral School

Professor Anne De Wit I ULB
Archives and Secretary of the International Scientific Committee for Chemistry

Professor Yves Geerts I ULB
Solvay Colloquia and New Horizons Lectures in Chemistry

He is assisted in his management tasks by the administrative staff

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Office manager

Ms Marie-France Rogge
Researchers logistic support

Ms Isabelle Van Geet
Project coordinator

Ms Chantal Verrier
Accounting officer

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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Professor David Gross
2004 Nobel Laureate
Kavli Institute for Theoretical Physics
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Vrije Universiteit Brussel, Belgium

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Stanford University, USA

Professor Steven Chu
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Stanford University, USA

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IAS Princeton, USA

Professor Fabiola Gianotti
CERN, Switzerland

Professor Bertrand Halperin
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Professor Wolfgang Ketterle
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MIT, Cambridge, USA

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IAS Princeton, USA

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Università La Sapienza, Roma, Italy

Professor Peter Zoller
University of Innsbruck, Austria

INTERNATIONAL SCIENTIFIC COMMITTEE

for Chemistry

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and ETH-Zurich, Switzerland

SCIENTIFIC SECRETARY

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Université Libre de Bruxelles, Belgium

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Harvard University, Cambridge, USA

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Boulder, Colorado, USA

Professor Gerhard Ertl
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Berlin, Germany

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Professor Robert H. Grubbs
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Professor Stefan Hell
2014 Nobel Laureate
Max Planck Institute, Göttingen, Germany

Professor JoAnne Stubbe
Massachusetts Institute of Technology
Cambridge, USA

Professor Bert Weckhuysen
University of Utrecht, The Netherlands

Professor George M. Whitesides
Harvard University, Cambridge, 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 Solvay 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.

CHAIR

Professor Lars Brink
Chalmers University of Technology
Göteborg, Sweden

MEMBERS

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Université Pierre et Marie Curie, Paris VI
France

Professor Karen I. Goldberg
University of Pennsylvania, USA

Professor Bert Meijer
Eindhoven University of Technology
The Netherlands

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Max-Planck-Institut für Gravitationsphysik,
Golm, Germany

Professor Hirosi Ooguri
California Institute of Technology, Pasadena, USA

Professor Jacques Prost
Institut Curie, Paris, France

Professor Gunnar von Heijne
Stockholm University, Sweden

LOCAL SCIENTIFIC COMMITTEES

for physics and chemistry

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

Members are appointed for a 3-year period term.

LOCAL SCIENTIFIC COMMITTEE FOR PHYSICS

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Professor Marc Henneaux
ULB, Brussels

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Professor Conny Aerts I KU Leuven
Professor Nicolas Boulanger I UMONS
Professor Ben Craps I VUB, Brussels
Professor Jan Danckaert I VUB, Brussels
Professor Pierre Gaspard I ULB, Brussels
Professor Jean-Marc Gérard I UCL, Louvain
Professor Joseph Indekeu I KU Leuven
Professor Philippe Lambin I FUNDP, Namur
Professor Dirk Ryckbosch I UGent
Professor Alexander Sevrin I VUB, Brussels
Professor Jacques Tempere I UAntwerp
Professor Petr Tinyakov I ULB, Brussels
Professor Christian Van den Broeck I UHasselt
Professor Sophie Van Eck I ULB, Brussels
Professor Nicolas Vandewalle I ULg, Liège

OBSERVER

Professor Anne De Wit I ULB, Brussels

LOCAL SCIENTIFIC COMMITTEE FOR CHEMISTRY

CHAIR

Professor Lode Wyns
VUB, Brussels

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Professor Benoît Champagne I FUNDP, Namur
Professor Pierre-François Coheur I ULB, Brussels
Professor Gert Desmet I VUB, Brussels
Professor Anne De Wit I ULB, Brussels
Professor Paul Geerlings I VUB, Brussels
Professor Yves Geerts I ULB, Brussels
Professor Jeremy Harvey I KU Leuven
Professor Sophie Hermans I UCL, Louvain
Professor Roberto Lazzaroni I UMONS
Professor Luc Moens I UGent
Professor Jean-Christophe Monbaliu I ULg, Liège
Professor Han Remaut I VUB, Brussels
Professor Marlies Van Bael I UHasselt

OBSERVERS

Professor Pierre Gaspard I ULB, Brussels
Professor Marc Henneaux I ULB, Brussels

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Centro de Estudios Científicos, Valdivia, Chile

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1997 Nobel Laureate
Ecole Normale Supérieure, Paris, France

Professor Manfred Eigen
1967 Nobel Laureate
Max-Planck Institut, Göttingen, Germany

Professor François Englert
2013 Nobel Laureate
Université Libre de Bruxelles, Belgium

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University of Berkeley, USA

† Professor Stephen Hawking,
Cambridge University, UK

Professor Gerard 't Hooft
1999 Nobel Laureate
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Former CEO Solvay Group, Belgium

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Landau Institute of Theoretical Physics, Moscow, Russia

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University of California, San Diego, USA

Professor Pierre Ramond
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University of Chicago, USA

Professor Victor A. Sadovnichy
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University of Maryland, College Park, USA

Madame Solvay de la Hulpe, Belgium

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

Professor Klaus von Klitzing
1985 Nobel Laureate
Max-Planck-Institut, Stuttgart, Germany

Professor Chen Ning Yang
1957 Nobel Laureate
Chinese University Hong Kong & Tsinghua University, Beijing, China

IN MEMORIAM

It is with great sadness and deep emotion that the International Solvay Institutes recall the memory of Stephen Hawking, one of the greatest scientists of the past century and an exceptional human personality, who passed away on March 14, 2018. His seminal contributions to gravity (both classical and quantum), to black hole physics and to cosmology were rewarded by many prestigious prizes, including the Wolf Prize in 1988, which he shared with Roger Penrose, and the BBVA Foundation Frontiers of Knowledge Award in Basic Sciences in 2015, which he shared with Viatcheslav Mukhanov.

Stephen was a great friend of the Institutes and visited Brussels many times, to give public lectures or to participate in Solvay scientific activities. He was one of the key participants in the 2011 Solvay centenary conference.

We will deeply miss him.

GENERAL ASSEMBLY

IN MEMORIAM

The International Solvay Institutes also mourn the departure on 18 October 2018 of Grégoire Nicolis, professor at the University of Brussels and former director of the Center for Nonlinear Phenomena and Complex Systems (CENOLI). Professor Nicolis was elected Member of the Belgian Academy in 1976.

Exceptional colleague and teacher, his work on irreversible processes and nonlinear phenomena have been a source of inspiration with remarkable international influence.

His scientific contributions will keep a long-lasting impact.

Antoniou Ioannis
Barnich Glenn
Baron Gino
Bingen Franz
Boël Nicolas
Boyer de la Giroday Eric
Bonnefous Thierry
Busquin Philippe
Craps Ben
Defourny Michel
De Keuleneer Eric
De Vos Gabrielle
De Wit Anne
Dumortier Freddy
Englert Yvon
Gaspard Pierre
Geerlings Paul
Geerts Yves
Goldbeter Albert
Halloin Véronique
Henneaux Marc
Janssen Daniel
Janssen Emmanuel
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Jourquin Christian
Lambert Franklin
Levy-Morelle Jacques
de Maret Pierre
Misonne Jean-François
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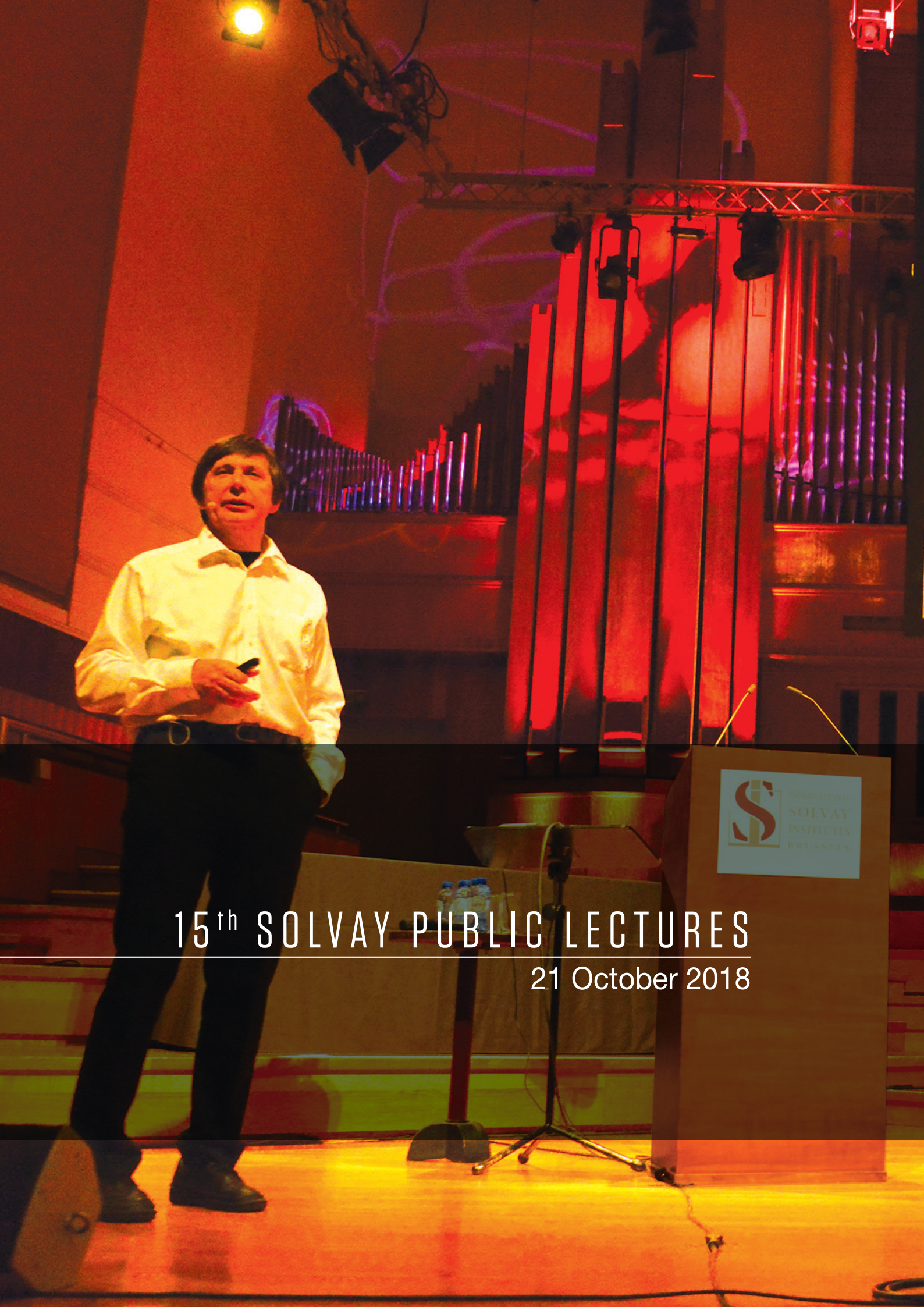
Pauwels Caroline
Piret Jean-Marie
Querton Alain
Querton Cédric
Rolin Olivia
Rolin Patrick
Sanglier Michèle
de Selliers de Moranville Jacques
Sevrin Alexander
Madame Solvay de La Hulpe
Solvay Anne-Christine
Solvay Carole
Solvay Denis
Solvay Jean-Marie
Solvay Marina
Van Camp Benjamin
Van den Broeck Christian
Van Gelder Eddy
Vanherweghem Jean-Louis
Veretennicoff Irina
Viviers Didier
Wyns Lode
Wielemans Patrick
Willems Hans
Willox Ralph



15th SOLVAY PUBLIC LECTURES

21 October 2018

15th SOLVAY PUBLIC LECTURES

The annual Solvay public event took place on October 21.

Two very inspiring lectures were delivered by distinguished Professors David Baker from the University of Seattle and Andre Geim (2010 Nobel Laureate in Physics) from the University of Manchester. These lectures brilliantly illustrated the marvelous diversity of science and were respectively devoted to “De Novo Protein Design: Bringing Biology out of the Stone Age” and “Random Walk to Graphene”.

The public had the opportunity to ask questions to the speakers, right after the talks and also during the drink offered at the end of the event.

One of the goals of the Solvay public event is to stimulate interest for science and scientific research, especially among the young generations. In that spirit, a Solvay Award Ceremony took place between the lectures, which celebrated students in physics, chemistry and engineering at the ULB and the VUB who had been distinguished for their work. These Solvay Awards are given by the Solvay Company.

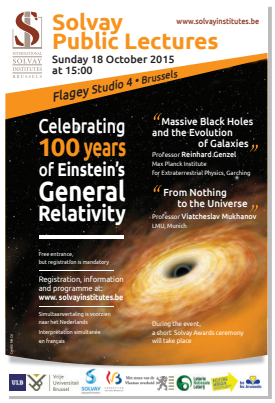
A tradition that goes back to 2005

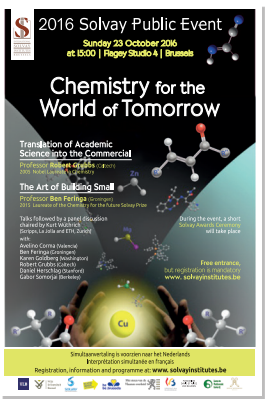
In 2005, the International Solvay Institutes initiated the tradition of organizing an annual public event during which distinguished scientists deliver lectures on the state-of-the-art in their field of research with an overview of the most pressing current issues. Organized jointly with the ULB, the VUB and the Solvay Group, this event popularizes science and aims at making it more attractive to the younger generations.

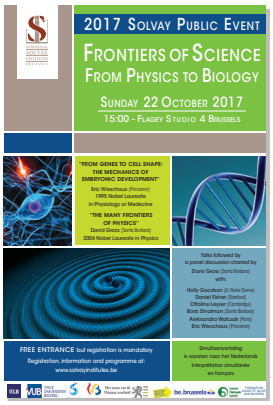
The talks are given in English but simultaneous interpretations in Dutch and French are provided.

The event closes with a drink offered to all the participants, which allows the public to interact more closely with the invited scientists. The event is free.

The high attendance of the annual public event provides great satisfaction and encouragement.







Program

15:00 - 15:15	Opening by Professor Marc Henneaux, director of the Solvay Institutes
15:15 - 16:05	Lecture by Professor David Baker “De novo protein design: bringing biology out of the Stone Age”
16:05 - 16:15	Questions
16:15 - 16:50	Solvay Award Ceremony (Mr Clamadieu, CEO, Mr Nicolas Cudré-Mauroux, Group general Manager, Research & Innovation, Mrs Huart, Jury Chairwoman)
16:50 - 17:40	Lecture by Professor Andre Geim “Random Walk to Graphene”
17:40 - 17:50	Questions
17:50 - 17:55	Closing by Professor Marc Henneaux
17:55 - 18:30	Reception

From left to right: Mrs Vanderkerken, Vice-rector Research (VUB), Marina Solvay, Mme Solvay de la Hulpe, Mr. Gurdjian, chairman of the Board of Directors (ULB), Mrs Gurdjian, Jean-Marie Solvay, Mrs Boël, Mr Boël, chairman of the Board of Directors (Solvay Group), Mrs Cudré-Mauroux, Mr Cudré-Mauroux, Group general Manager, Research & Innovation (Solvay Group) and Mr Clamadieu, CEO (Solvay Group).

Lecturers

The International Solvay Institutes are extremely grateful to the two lecturers who captivated an audience that filled once again the Flagey studio 4.

Professor David Baker from Seattle is an American biochemist and computational biologist

Professor Baker is the Henrietta and Aubrey Davis Endowed Professor in Biochemistry, Director of the Institute for Protein Design, Investigator of the Howard Hughes Medical Institute, and adjunct professor of Genome Sciences, Bioengineering, Chemical Engineering, Computer Science, and Physics at the University of Washington.

He received his Ph.D. degree in biochemistry with Randy Schekman at the University of California, Berkeley and did postdoctoral work in biophysics with David Agard at UCSF. His research group is focused on the prediction and design of macromolecular structures, interactions and functions.

Dr. Baker received in 2002 the Overton Prize and in 2004 the Feynman Prize in Nanotechnology. For his work on protein folding, Professor Baker received the 2008 Sackler International Prize in Biophysics. He is a member of the National Academy of Sciences and the American Academy of Sciences. His research group is a world leader in computational protein design and protein structure prediction.

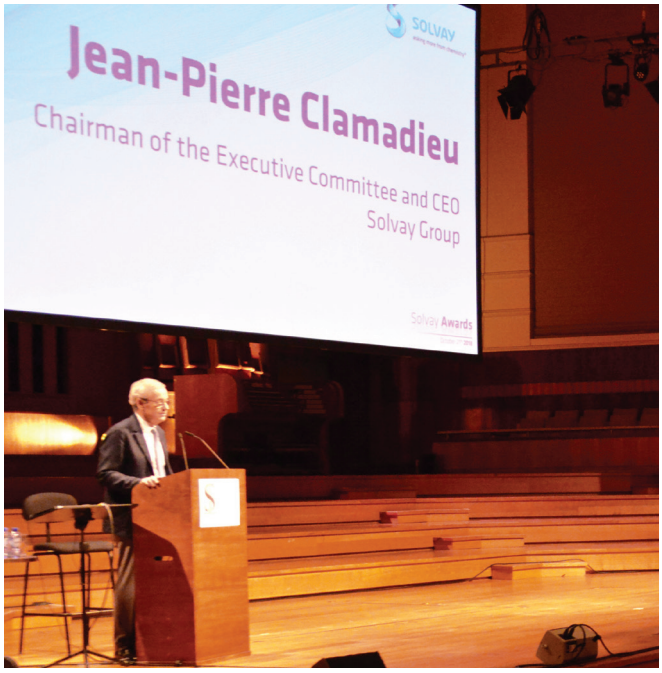
Sir Andre Geim is the Regius and Royal Society Research Professor at the University of Manchester. He was awarded the 2010 Nobel Prize for his groundbreaking work on graphene, a one-atom-thick material made of carbon. He has also received numerous international awards and distinctions, including medals from the Royal Society and the US National Academy of Sciences, and holds honorary doctorates and professorships from many countries and universities.

Andre Geim was born in Russia to German parents and holds dual Dutch and British citizenship. He started his academic career in Moscow, spent several years as a postdoctoral researcher at the universities of Nottingham, Bath and Copenhagen and then moved to the Netherlands as a tenured professor, before coming to Manchester in 2001.

Thomson-Reuters repeatedly named him among the world's most active scientists and attributed to him three new research fronts – diamagnetic levitation, gecko tape and graphene. More than twenty of his papers have been cited >1,000 times with five of them >10,000 times which has placed two of the latter among 100 most cited research papers in human history. He was also awarded the 2000 Ig Nobel prize for his work on levitation, becoming the first and only recipient of both Nobel and Ig Nobel Prizes. He has also received both Dutch and British knighthoods.

Professor Andre Geim, 2010 Nobel Laureate in Physics

The Solvay Awards



The Solvay Awards rewarded 21 PhD students and bright minds from the Faculty of Sciences and the Faculty of Engineering of both Université Libre de Bruxelles (ULB) and Vrije Universiteit Brussel (VUB), renewing Solvay's commitment to Open innovation to help address shared future challenges with the best of scientific advancement.

The Solvay Awards ceremony celebrates the talent and expertise of the laureates, their specialties, and distinguished academic career in chemistry or physics presenting ground-breaking research.

The selection done by the Solvay Awards Jury takes into account work submitted for evaluation both for basic or applied nature, focusing on one of the following fields:

- the investigation and understanding of matter (structure, properties, transformation, chemical reactivity, material science)
- the study of the mechanisms and chemistry of life
- new production technologies
- new resources, energy storage and generation
- environmental sciences and sustainable development

Mrs Huart, Jury Chairwoman and Mr Cudré-Mauroux, Group general Manager, Research & Innovation

The 2016 and 2017 Laureates

ULB	AJOUAOU Yousra	VUB	BRANCART Joost
ULB	ATHANASSIADIS Aristide	VUB	COLLET Thomas
ULB	BAUDUIN Sophie	ULB	de FORMANOIR Charlotte
ULB	BELLEMANS Aurélie	ULB	DOHET-ERALY Jérôme
ULB	BOUCQUEY Elodie	ULB	FAZZI Marco

ULB	FONTAINE Martina
ULB	FORTUNATO Valentina
VUB	HELBER Bernd
ULB	JACOBS Luc
ULB	MOHAMMADI Azadeh
ULB	PAPAGEORGIOU Alexia
ULB	PIZZUTO Malvina
ULB	SAADALLAH Dounia
ULB	SPACCAPANICCIA Chiara
ULB	THEUNISSEN Cédric
VUB	WOUTERS Sam

INTERNATIONAL SOLVAY CHAIRS

INTERNATIONAL SOLVAY CHAIRS

The International Solvay Chair programme enables the Institutes to invite to 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 program in chemistry was launched in 2008 thanks to a generous grant from the Solvay Company, which the Institutes gratefully acknowledge.

2018 International Solvay Chair in Chemistry

Professor Ben Feringa I University of Groningen, The Netherlands

The eleventh International Chair in Chemistry was held by Professor Ben Feringa from the University of Groningen (The Netherlands).

Professor Feringa is a world-leading expert in the fields of stereochemistry, organic synthesis, asymmetric catalysis, optopharma, molecular switches and motors, self-assembly and molecular nanosystems. His discovery of the molecular motor ranks highly among the many discoveries made over the years and was rewarded by many prizes, including the Nobel Prize in 2016.

His splendid opening lecture "The Joy of Discovery" was given on September 24 and attended by many students and researchers from the ULB, the VUB and other Belgian universities.

Professor Ben Feringa and Mr Jean-Marie Solvay

Ben L. Feringa obtained his PhD degree at the University of Groningen in the Netherlands under the guidance of Professor Hans Wynberg. After working as a research scientist at Shell in the Netherlands and at the Shell Biosciences Centre in the UK, he was appointed lecturer and in 1988 full professor at the University of Groningen and named the Jacobus H. van't Hoff Distinguished Professor of Molecular Sciences in 2004. He was elected Foreign Honory member of the American Academy of Arts and Sciences and is member and vice-president of the Royal Netherlands Academy of Sciences. In 2008, he was appointed Academy Professor and was knighted by Her Majesty the Queen of the Netherlands.

During his stay in Brussels, Professor Feringa was hosted in the group of Professor Yves Geerts, who successfully coordinated many enriching exchanges with young researchers from Brussels and other Belgian universities. The Institutes thank him for his very efficient help in organizing the chair.

Professor Feringa is also a member of the Solvay International Scientific Committee for Chemistry.

The research program of the Feringa group ("The art of building small") is focused on synthetic and physical organic chemistry. Inspired by Nature's principles of molecular assembly, recognition, transport, motion and catalysis, the goal is to exploit the full potential of synthetic chemistry to create new structures and functions. A major part of the research is directed towards dynamic molecular systems. The focus is on molecular nanoscience, novel responsive materials and photo-pharma exploring biohybrid systems, self-assembly, molecular switches and motors. A second part of the program deals with the development (and application in chemical biology) of novel stereoselective synthesis methods and asymmetric catalysis. Chirality is a leading theme and over the years a unique and broad expertise in fundamental aspects of stereochemistry has been acquired including chiroptical phenomena, chiral amplification and origin of chirality.

Feringa's research has been recognized with a number of awards including the Spinoza Award (2004), the Prelog gold medal (2005), the Humboldt Award (2012), the Grand Prix Scientifique Cino del Duca (French Academy 2012), the Marie Curie medal (2013), the Nagoya Gold Medal (2013) and more recently, the Chemistry for the Future Solvay Prize (2015) and the Nobel Prize in Chemistry (2016), which he received with Jean-Pierre Sauvage and Sir J. Fraser Stoddart "for the design and synthesis of molecular machines".

Inaugural Lecture I 24 September 2018

The Joy of Discovery

Exploring across the current frontiers of chemical sciences there is vast uncharted territory to experience the joy of discovery. Far beyond Nature's design, the creative power of synthetic chemistry provides unlimited opportunities to realize our own molecular world as we experience every day with products ranging from drugs to displays that sustain modern society. In their practice of the art of building small, chemists have shown amazing success in the past decades. Moving from molecules to dynamic molecular systems the fundamental challenge is how to control and exploit motion at the nanoscale. In this presentation the focus is on my journey in the world of molecular switches and motors, the process of discovery and my personal experiences through my scientific career. I will also share with you memorable moments after 'The Magic Call from Stockholm'. Based on recent development in nanotechnology, perspectives for the future will be presented. In particular I will address how fundamental questions and molecular beauty have guided me on this journey.

Lecture 1 I 25 September 2018

Exploring Catalytic Space

Chemical catalysis is at the heart of chemical processes and key to deliver the products for our society ranging from drugs to materials. Major challenges are associated with the design of sustainable catalysts and chemical transformations. Organometallic reagents and transition metal catalysts are continuously at the frontier in the search for novel reactivity and synthetic methodology. Controlling chemo- and stereo-selectivity and low E-factor methods offer major challenges while novel approaches toward dynamic functions controlled by catalysis and transformations in aqueous media emerge. In this lecture various approaches to address these challenges will be discussed. Specific topics will be catalytic enantioselective allylation, Murahashi-Feringa cross coupling with organolithium reagents, sustainable low-E-factor transformations and adaptive catalysts.

The rest of Prof. Feringa's lectures will be given in April 2019.

2018 International Jacques Solvay Chair in Physics

Professor Bernard Derrida I Collège de France, Paris

The 2018 International Jacques Solvay Chair in Physics was held by Professor Bernard Derrida from the Collège de France (Paris).

Bernard Derrida is a leading figure in statistical mechanics, where he made central and very inspiring contributions to the theory of disordered systems, out-of-equilibrium systems and the dynamics of complex networks. He has also adapted statistical-physics ideas to various problems in biology, including questions of genetics and neural networks and extending even to traffic problems.

"The importance of large deviations in non-equilibrium systems" is a profound question of statistical mechanics with far-reaching implications. This fascinating topic was the subject of Professor Derrida's inaugural lecture, which he gave on October 23, 2018. The inaugural lecture was followed by a course of lectures on "Disorder, Growth and Exclusion".

During his stay in Brussels, Professor Derrida was hosted by the group of our colleague Pierre Gaspard. The Solvay Institutes heartily thank him for orchestrating Bernard Derrida's visit.

Professor Bernard Derrida studied physics at the Ecole Normale Supérieure in Paris. He received his PhD degree in 1979. He then worked at the theoretical physics group at the CEA in Saclay. In 1993, he became professor of physics at the Université Pierre et Marie Curie and at the ENS. Since 2015, he holds the chair of statistical physics at the Collège de France. Professor Derrida visited many prestigious institutions, including the Niels Bohr Institute, the Courant Institute in New York and the Institute for Advanced Study at Princeton.

For his remarkable achievements, Professor Derrida received an impressive collection of awards and distinctions of which only a limited sample is mentioned here. In 1985, he was awarded the physics IBM prize, in 2001, he received the Ampère Prize from the French Academy and in 2010, he received the Boltzmann medal. He is a member of the French Academy of Sciences since 2004 and in 2017 he became "Chevalier de la Légion d'Honneur".

Mrs Marina Solvay, Mme Solvay de La Hulpe, Prof. Marc Henneaux & Prof. Bernard Derrida

Inaugural Lecture I 23 October 2018

The importance of large deviations in non-equilibrium systems

Statistical Physics allowed to unify, at the end of the 19th century, Newton's mechanics and thermodynamics. It gave a way to predict the amplitude of fluctuations around the physical laws which were known at that time. Einstein, in his very first works, showed that the measurement of these fluctuations allowed to estimate the size of atoms. His reasoning, which was at the origin of the linear response theory, applied to the black body gave one of the first evidences of the duality wave-particle in Quantum Mechanics. Statistical Physics gives also a framework to predict large deviations for systems at equilibrium. In the last two decades, major efforts were devoted to extend our understanding of the statistical laws of fluctuations and large deviations to non-equilibrium systems. This talk will try to present some of the main recent progresses.

Course of lectures - Disorder, growth and exclusion

Chemical catalysis is at the heart of chemical processes and key to deliver the products for our society ranging from drugs to materials. Major challenges are associated with the design of sustainable catalysts and chemical transformations. Organometallic reagents and transition metal catalysts are continuously at the frontier in the search for novel reactivity and synthetic methodology. Controlling chemo- and stereo-selectivity and low E-factor methods offer major challenges while novel approaches toward dynamic functions controlled by catalysis and transformations in aqueous media emerge. In this lecture various approaches to address these challenges will be discussed. Specific topics will be catalytic enantioselective allylation, Murahashi-Feringa cross coupling with organolithium reagents, sustainable low-E-factor transformations and adaptive catalysts.

Lecture 1 I 18 October 2018
Lecture 2 I 24 October 2018
Lecture 3 I 25 October 2018
Lecture 4 I 26 October 2018

News

Professor Dam Thanh Son (University of Chicago), holder of the 2016 International Jacques Solvay Chair in Physics was awarded the 2018 Dirac Medal.

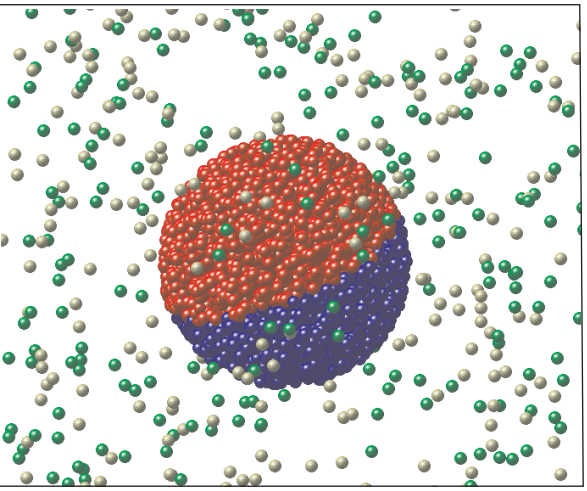
Professor Dam Thanh Son (University of Chicago), holder of the 2016 International Jacques Solvay Chair in Physics was awarded the 2018 Dirac Medal and prize with Subir Sachdev (Harvard University) and Xiao-Gang Wen (Massachusetts Institute of Technology) for their independent contributions towards understanding novel phases in strongly interacting many-body systems, introducing original transdisciplinary techniques.

Dam Thanh Son was the first to understand that gauge/gravity duality could be used to address basic questions in strongly interacting many-body problems from cold trapped atoms to the quark-gluon plasma. He was able to show that one could compute transport coefficients, such as viscosity and conductivity, analytically in these systems, and that strong coupling typically gives rise to a bound on these coefficients. More recently, he has argued for the emergence of a Dirac fermion at the half-filled Landau level, work which has stimulated rapid developments in our understanding of three-dimensional gauge theories.

The collaboration with Professor Raymond Kapral (University of Toronto) holder of the 2016 Solvay International Chair in Chemistry has led to a series of publications.

- Fluctuating chemohydrodynamics and the stochastic motion of self-diffusiophoretic particles, P. Gaspard and R. Kapral, J. Chem. Phys. **148**, 134104 (2018).
- Nonequilibrium thermodynamics and boundary conditions for reaction and transport in heterogeneous media, P. Gaspard and R. Kapral, J. Chem. Phys. **148**, 194114 (2018).
- Dynamics of Janus motors with microscopically reversible kinetics, M.-J. Huang, J. Schofield, P. Gaspard, and R. Kapral, J. Chem. Phys. **149**, 024904 (2018).
- Finite-time fluctuation theorem for diffusion-influenced surface reactions, P. Gaspard and R. Kapral, J. Stat. Mech. 083206 (2018).
- Finite-time fluctuation theorem for diffusion-influenced surface reactions on spherical and Janus catalytic particles, P. Gaspard, P. Grosfils, M.-J. Huang, and R. Kapral, J. Stat. Mech. 123206 (2018).

This work has shown that Einstein's theory of Brownian motion can be extended to describe the stochastic motion of active particles. Contrary to Brownian particles that are passively set in motion by thermal fluctuations, active particles are propelled by self-diffusiophoresis and the chemical power of reactions at the catalytic surface of the particles. Although active particles have been much studied recently, the present study is the first to be consistent with the fundamental property of microreversibility.



The theoretical predictions have been confirmed by microscopically reversible numerical simulations. Furthermore, the symmetry of microreversibility has also been investigated in systems with diffusion-influenced surface reactions.

The figure illustrates an active particle with its catalytic hemisphere (in red) inside a solution containing fuel and product molecules (in green and yellow).

The Solvay Institutes are warmly thanked for their support.

Professeur Pierre Gaspard

WORKSHOPS AND SCHOOLS

organized by the Institutes


Challenging Gauß theorem

CONTENTS

"SuGAR 2018:

Searching for the sources of galactic and extra galactic cosmic rays"

23 - 26 January 2018

The goal of the workshop was to provide an updated overview of the long-standing enigma of the origin of galactic and extragalactic cosmic rays.

The SuGAR workshop offered an opportunity to bring together leading experts exploring the physics of cosmic rays both from the experimental and theoretical point of view. The latest experimental results from gamma-ray (CTA, HAWC), neutrino astronomy (IceCube, KM3NeT), cosmic ray (Pierre Auger Observatory, Telescope Array, AMS-II, Lofar) and gravitational waves (LIGO, Virgo) experiments were presented, as well as the latest developments in phenomenological interpretations and theoretical models. The interplay between subjects proposed in this workshop reflected the multi-messenger observational approach followed by the cosmic ray physics community. This workshop represented an excellent platform for discussion and exchange among researchers working in the wide field of astroparticle physics. The format of the workshop allocated time for open discussions that allowed the participants to explore and discuss the experimental results and consequences of different theoretical models on the origin of cosmic rays and their acceleration and transport in the interstellar medium.

SuGAR 2018 was the third edition of a series of successful workshops, the latest of which took place in Geneva in January 2015.

Organising Committee

J. A. Aguilar Sánchez (ULB, Brussels, Belgium) - Chair
S. Buitink (VUB, Brussels, Belgium)
K. D. de Vries (VUB, Brussels, Belgium)
I. C. Maris (ULB, Brussels, Belgium)
D. Ryckbosch (UGent, Belgium)
O. Scholten (VUB, Brussels, Belgium & U. of Groningen, The Netherlands)
A. Sevrin (VUB, Brussels, Belgium)
P. Tinyakov (ULB, Brussels, Belgium)
S. Toscano (VUB, Brussels, Belgium)
N. van Eijndhoven (VUB, Brussels, Belgium)

Scientific Committee

J. A. Aguilar Sánchez (ULB, Brussels, Belgium) - Chair
J. Becker Tjus (RUB, Bochum, Germany)
F. Halzen (UW-Madison, USA)
A. Haungs (KIT, Karlsruhe, Germany)
T. Montaruli (U. of Geneva, Switzerland)
J. F. J. van den Brand (VU Amsterdam & Nikhef, The Netherlands)

Planned sessions included:

Galactic and extragalactic cosmic rays: spectrum / composition / anisotropy

Modeling: particle acceleration and propagation

Neutrino astronomy: highlights and future developments

Gamma-ray astronomy: highlights and future developments

Gravitational waves: highlights and future developments

Speakers

M. Ahlers (University of Copenhagen, Denmark)
P. Blasi (Osservatorio Astrofisico di Arcetri, Firenze, Italy)
J.C. Díaz-Vélez (UW-Madison, WI, USA)
B. Dingus (LANL, Los Alamos, NM, USA)
S. De Ridder (UGent, Belgium)
P. Desiati (UW-Madison, WI, USA)
R. Engel (KIT, Karlsruhe, Germany)
S. Gabici (APC, Paris, France)
L. Gergely (U. of Szeged, Hungary)
E. Hays (NASA Goddard Space Flight C. Greenbelt, MD, USA)
J. J. Hernández-Rey (IFIC, Valencia, Spain)
S. de Jong (Radboud U., Nijmegen, The Netherlands)
C. Jui (University of Utah, USA)
K. Kotera (IAP, Paris, France)
M. Kowalski (Desy, Zeuthen, Germany)
K. Mannheim (Würzburg U., Germany)
K. Mase (Chiba U., Japan)
A. Nelles (UC Irvine, CA, USA)
A. Neronov (ISDC, Versoix, Switzerland)
M. Paniccia (U. of Geneva, Switzerland)
E. Prandini (U. of Padova, Italy)
A. Santangelo (Tübingen U., Germany)
P. Schmidt (Radboud U., Nijmegen, The Netherlands)
A. Taylor (DIAS, Dublin, Ireland)
M. Unger (KIT, Karlsruhe, Germany)
C. Van Den Broek (Nikhef, Amsterdam, The Netherlands)
B. Vercnocke (KU Leuven, Belgium)
T. Winchen (VUB, Brussels, Belgium)
E. Zweibel (UW-Madison, WI, USA)

Program

Tuesday 23 January 2018

Welcome by Marc Henneaux (Director of the Solvay Institutes, Brussels)

Cosmic rays I: overview on experimental results, origin, acceleration and propagation
Convener: Juan Antonio Aguilar Sánchez

Ralph Engel	*Review talk on Cosmic Rays*
Pasquale Blasi	*Cosmic ray origin and acceleration process*
Sam De Ridder	*IceTop composition results*
Mercedes Paniccia	*AMS results*

Cosmic Rays II: Anisotropy in the knee region
Convener: Stijn Buitink

Ellen Zweibel	*Cosmic ray propagation through the ISM*
Paolo Desiati	*Galactic CR anisotropy with IceCube/IceTop*
Juan Carlos Díaz-Vélez	*Full sky Galactic anisotropy HAWC/IceCube*

Cosmic Rays III: From the knee to the ultra-high energy spectrum
Convener: Ioana Maris

Tobias Winchen	*Lofar composition measurements + acceleration models*
Michael Unger	*Highligths from AUGER: composition and anisotropy*
Charles Jui	*Highlights from TA:composition/anisotropy*

Wednesday 24 January 2018

Neutrino Astronomy I
Convener: Nick Van Eijndhoven

Marek Kowalski	*Neutrino Astronomy and Higlights from IceCube*
Juan José Hernández-Rey	*KM3NeT and ANTARES*
Andrii Neronov	*Interpretation of the astrophysical neutrino signal*
Markus Ahlers	*Origin of the neutrino astrophysical flux*

Neutrino Astronomy II
Convener: Krijn De Vries

Kumiko Kotera	*Cosmogenic Neutrinos*
Anna Nelles	*Highlights from ARIANNA*
Keiichi MASE	*Highlights from ARA*

Neutrino Astronomy III
Convener: Peter Tinyakov

Sijbrand de Jong	*GRAND*
Krijn de Vries	*RADAR*

POSTERS Session

Thursday 25 January 2018

Gamma-ray astronomy III: TeV gamma rays
Convener: Dirk Ryckbosch

Elizabeth Hays	*Review talk on Gamma-ray Astronomy*
Andrew Taylor	*Extragalactic gamma-ray sources and their cutoffs*

Gamma-ray Astronomy II
Convener: Simona Toscano

Karl Mannheim	*The e-astrogram program*
Andrea Santangelo	*X-rays astronomy and multi-wavelength observations*

Gamma-ray astronomy III: TeV gamma rays
Convener: Alexander Sevrin

Elisa Prandini	*Highlights from MAGIC and CTA*
Dingus Brenda	*Highlights from HAWC*
Stefano Gabici	*Gamma-rays and the sources of galactic cosmic rays*

Discussion Panel
Convener: Nick van Eijndhoven

Friday 26 January 2018

Gravitational Waves
Convener: Olaf Scholten

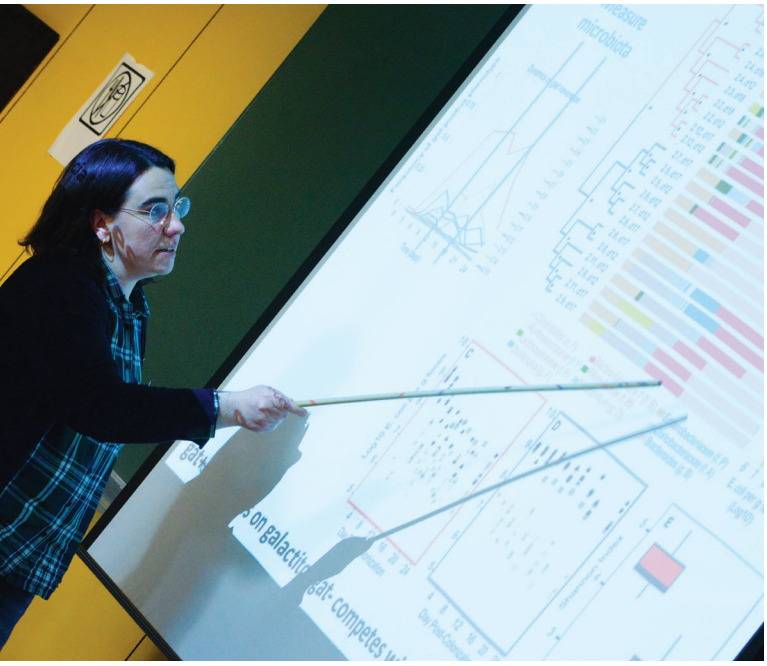
Chris Van Den Broeck	*Review talk on Gravitational Waves*
Patricia Schmidt	*LIGO/Virgo highlights*
Bert Vercnocke	*Fundamental physics with LISA and Einstein Telescope*
László Gergely	*Multimessenger connection of gravitational waves*

Summary of the workshop
Convener: Juan Antonio Aguilar Sánchez

"DYNAMICS OF BIOLOGICAL SYSTEMS:

Modelling genetic, signalling and microbial networks"

2 - 4 May 2018



The workshop aimed to bring together leading scientists who study, through computational modelling, the role of networks in the dynamics of biological systems. It focused on the multidisciplinary efforts made by researchers to understand the basic mechanisms by which interacting organisms, cells, signalling molecules and genes can give rise to the specific, highly organized characteristics of biological systems.

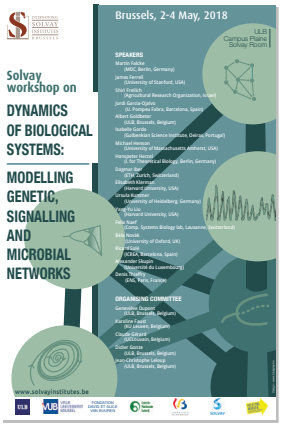
The workshop was divided in five sessions, covering the following topics:

- Development and cell differentiation
- Circadian rhythms
- Cell cycle
- Calcium signalling
- Microbial systems biology

For each topic, it was expected that the theoretical, analytical or computational approach provided significant biological insight, through a close link with experimental approaches. The cross-disciplinary exchange of ideas between the participants of the various sessions benefited all researchers using network science to understand how living systems organize and adapt.

Organising Committee

Geneviève Dupont (ULB, Brussels, Belgium)
Karoline Faust (KU Leuven, Belgium)
Claude Gérard (UCL, Louvain, Belgium)
Didier Gonze (ULB, Brussels, Belgium)
Jean-Christophe Leloup (ULB, Brussels, Belgium)



Speakers

Martin Falcke (MDC, Berlin, Germany)
Shiri Freilich (Agricultural Research Organization, Israel)
Jordi Garcia-Ojalvo (U. Pompeu Fabra, Barcelona, Spain)
Albert Goldbeter (ULB, Brussels, Belgium)
Isabelle Gordo (Gulbenkian Science Institute, Oeiras, Portugal)
Michael Henson (U. of Massachusetts Amherst, USA)
Hanspeter Herzel (ITB, Berlin, Germany)
Dagmar Iber (ETH, Zurich, Switzerland)
Elisabeth Klerman (Harvard University, USA)
Ursula Kummer (University of Heidelberg, Germany)
Yang-Yu Liu (Harvard University, USA)
Felix Naef (Comp. Systems Biology lab, Lausanne, Switzerland)
Béla Novàk (University of Oxford, UK)
Alexander Skupin (Université du Luxembourg)
Ricard Solé (ICREA, Barcelona, Spain)
Mary Teruel (Stanford University, USA)
Denis Thieffry (ENS, Paris, France)

Wednesday 2 May 2018

Welcome by Marc Henneaux (Director of the Solvay Institutes, Brussels)

Development and cell differentiation

Denis Thieffry	*Logical modelling of developmental regulatory networks*
Dagmar Iber	*From Networks to Function –Computational Models of Organogenesis*
Jordi Garcia-Ojalvo	*Dynamical strategies for resource sharing in bacteria*

Circadian Rhythms

Elisabeth Klerman	*Mathematical modeling ofhuman sleep and circadian rhythms*
Hanspeter Herzel	*The circadian clock -a system of coupled oscillators*
Felix Naef	*Systems Chronobiology: quantitative analysis of circadian rhythms incells and tissues*

Thursday 3 May 2018

Microbial Systems Biology

Ricard Solé	*Engineering microorganisms for major transitions*
YangYu Liu	*Controlling Human Microbiota*
Isabelle Gordo	*Real time evolution of commensal bacteria in the mammalian gut*
Michael Henson	*Spatiotemporal metabolic modeling of multispecies bacterial biofilms*
Shiri Freilich	*Metabolic network approaches for studying microbial community function*
SESSION POSTER	

Friday 4 May 2018

Cell Cycle

Béla Novák	*Cell cycle regulation by systems-level feedback controls*
Albert Goldbeter	*The cell cycle and the circadian clock: Dynamics of two coupled cellular rhythms*

Signalling 1

Mary Teruel	*Control of mammalian cell differentiation by feedback and noise*

Signalling 2

Ursula Kummer	*Different modes of calcium information processing in fish vs mammalian liver cells*
Alexander Skupin	*Spiking calcium as a mediator in metabolism and cell fate*
Martin Falcke	*Theory for the basic dynamic signatures of Ca^{2+} spiking*

Joint ERC (HoloQosmos) Solvay-Perimeter-APC Workshop on

"COSMOLOGICAL FRONTIERS IN FUNDAMENTAL PHYSICS"

14 - 16 May 2018

The workshop was part of a series organized jointly by the International Solvay Institutes, Laboratoire APC (University Paris VII, France) and the Perimeter Institute (Waterloo, Canada). The series aims to discuss, in an informal setting, recent developments at the interface of cosmology and fundamental physics. The previous edition was held by the Perimeter Institute in June 2016.

Two other workshops on closely related topics were organized by the Solvay Institutes in the continuous week:

- "Infrared Physics: Asymptotic & BMS symmetry, soft theorems, memory, information paradox and all that"
- "Holography"

Organising and Scientific Committee

Niayesh Afshordi (U. of Waterloo/Perimeter Institute, Waterloo, Canada)
Riccardo Argurio (ULB, Brussels, Belgium)
Ben Craps (VUB, Brussels, Belgium)
Marc Henneaux (SI & ULB, Brussels, Belgium)
Thomas Hertog (KU Leuven, Belgium)
Elias Kiritsis (APC, Paris, France)
Thomas Van Riet (KU Leuven, Belgium)

Speakers

Niayesh Afshordi (U. of Waterloo/Perimeter Institute, Waterloo, Canada)
Vijay Balasubramanian (U. of Pennsylvania, USA)
William Cottrell (Stanford U, California, USA)
Claudia De Rham (Imperial College, London, UK)
Gia Dvali (LMU, Munich, Germany & NYU, USA)
François Englert (ULB, Brussels, Belgium)
Willy Fischler (UT, Texas, USA)
Arthur Hebecker (U. of Heidelberg, Germany)
Luis Ibanez (U. Autónoma de Madrid, Spain)
Kyriakos Papadodimas (CERN, Geneva, Switzerland)
Gui Pimentel (UvA, Amsterdam, The Netherlands)
Tom Rudelius (IAS, Princeton, USA)
Jorge Santos (Cambridge U., UK)
Gary Shiu (U. of Wisconsin, Madison, USA)
Erik Verlinde (UvA, Amsterdam, The Netherlands)
Richard Woodard (U. of Florida, USA)

Program

Monday 14 May 2018

Welcome Address

Vijay Balasubramanian	*Statistical couplings: a signature of entanglement with dark matter*
Jorge Santos	*Connecting the weak gravity conjecture to the weak cosmic censorship?*
Claudia De Rham	
Tom Rudelius	*Emergence of the Swampland and Weak Gravity Conjectures*
Luis Ibanez	*Quantum gravity constraints on Particle Physics*
François Englert	*A story of Physics and Friendship*

Tuesday 15 May 2018

Gia Dvali	*Black holes as brains: Neural networks with area-law entropy and holography*
Arthur Hebecker	*Axionic Field Ranges, Weak Gravity and Euclidean Wormholes*
Gary Shiu	*The String Swampland and Cosmological Frontiers*
Kyriakos Papadodimas	*Traversable wormholes and the interior of black hole microstates*
Niayesh Afshordi	*Quantum Black Holes in the Sky: From Quantum Gravity, to Cosmology and Astrophysics*
Willy Fischler	*A holographic approach to cosmology*
William Cottrell	*Evidence and Consequences of Weak Gravity*

Wednesday 16 May 2018

Erik Verlinde	*Towards Non-AdSHolography and Emergent Gravity in de Sitter space*
Gui Pimentel	*Inflationary Correlators from the Boundary*
Richard Woodard	*Infrared Effects in Cosmological Quantum Field Theory*

"INFRARED PHYSICS:

Asymptotic & BMS symmetry, soft theorems, memory, information paradox and all that "

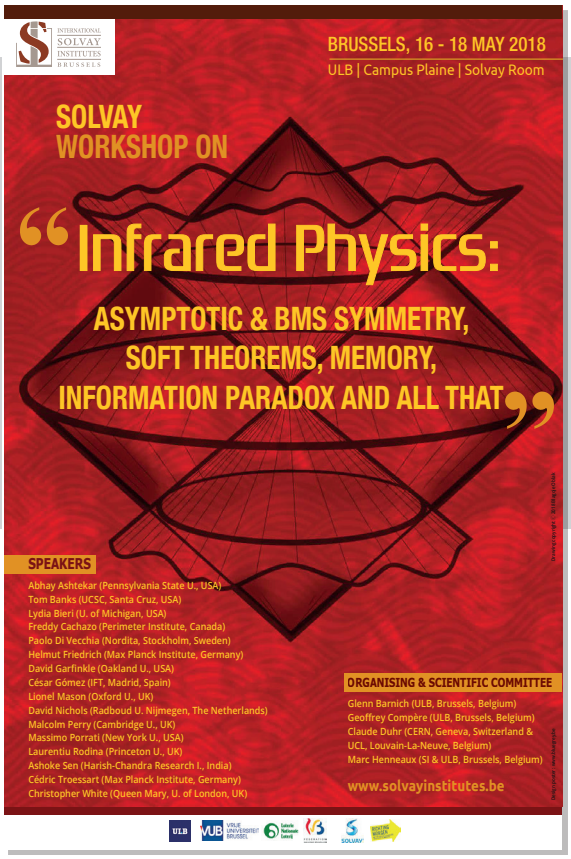
16 - 18 May 2018

Seemingly unrelated topics, such as the asymptotic structure of spacetime, infrared properties of massless particles in quantum field theory, or measurable effects related to gravitational waves, have been developed to some extent independently since the 1960s. Recent progress indicates that these subjects do admit an interesting intersection.

The purpose of the workshop was to give a snapshot of the advances in different communities (general relativity, both mathematical and observational, quantum field theory, string theory), with the hope to increase interactions transcending traditional subdivisions.

Organising and Scientific Committee

Glenn Barnich (ULB, Brussels, Belgium)
Geoffrey Compère (ULB, Brussels, Belgium)
Claude Duhr (CERN, Geneva, Switzerland & UCL, Louvain-La-Neuve, Belgium)
Marc Henneaux (SI & ULB, Brussels, Belgium)



Speakers

Abhay Ashtekar (Pennsylvania State U., USA)
Tom Banks (NHETC and Dept. of Physics and Astronomy, Rutgers U., USA)
Lydia Bieri (U. of Michigan, USA)
Miguel Campiglia (U. de la República, Montevideo, Uruguay)
Paolo Di Vecchia (Nordita, Stockholm, Sweden)
Helmut Friedrich (Max Planck Institute, Germany)
David Garfinkle (Oakland U., USA)
César Gómez (IFT, Madrid, Spain)
Lionel Mason (Oxford U., UK)
Prahar Mitra (IAS, Princeton U., USA)
David Nichols (Radboud U. Nijmegen, The Netherlands)
Malcolm Perry (Cambridge U., UK)
Massimo Porrati (New York U., USA)
Laurentiu Rodina (Princeton U., USA)
Ashoke Sen (Harish-Chandra Research I., India)
Cédric Troessaert (Max Planck Institute, Germany)
Christopher White (Queen Mary, U. of London, UK)
Ellis Yuan (IAS, Princeton U., USA)

Program

Wednesday 16 May 2018

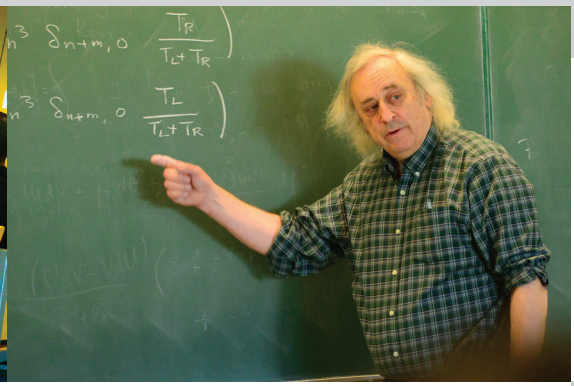
Ashoke Sen	*Soft theorem and its classical limit*
Ellis Yuan	*Scattering Equations and Soft Theorems*
Christopher White	*The many faces of (next-to) soft physics*
Lionel Mason	*From null geodesic to gravitational scattering: an alternative route from BMS to soft theorems via ambitwistor strings*

Thursday 17 May 2018

Paolo Di Vecchia	*Soft Theorems for Massless Particles from Gauge Invariance*
Laurentiu Rodina	*S-Matrix Uniqueness from Soft Theorems*
Malcolm Perry	*Black Hole Entropy from Soft Hair*
Tom Banks	*Currents on the Conformal Boundary and Gravitational Scattering Theory*
Prahar Mitra	*Asymptotic Symmetries and Soft Theorems in Effective Field Theories*
César Gómez	*Physics implications of the IR: A short journey through Von Neumann spaces*
Massimo Porrati	*A few applications of the infrared factorization of IR dynamics*

Friday 18 May 2018

Abhay Ashtekar	*The many faces of infrared issues: Some recent developments*
Lydia Bieri	*Gravitational Wave Memory and an Electromagnetic Analog*
Helmut Friedrich	*Hierarchies of asymptotic conditions and results*
David Garfinkle	*Gravitational wave memory and gauge invariance*
Cédric Troessaert	*The Hamiltonian description of BMS4*
David Nichols	*Gravitational-wave memory effects: Observables and prospects for measurement*
Miguel Campiglia	*Conserved charges at spatial infinity and an infinite set of soft photon theorems*



"MECHANICS OF SLENDER STRUCTURES

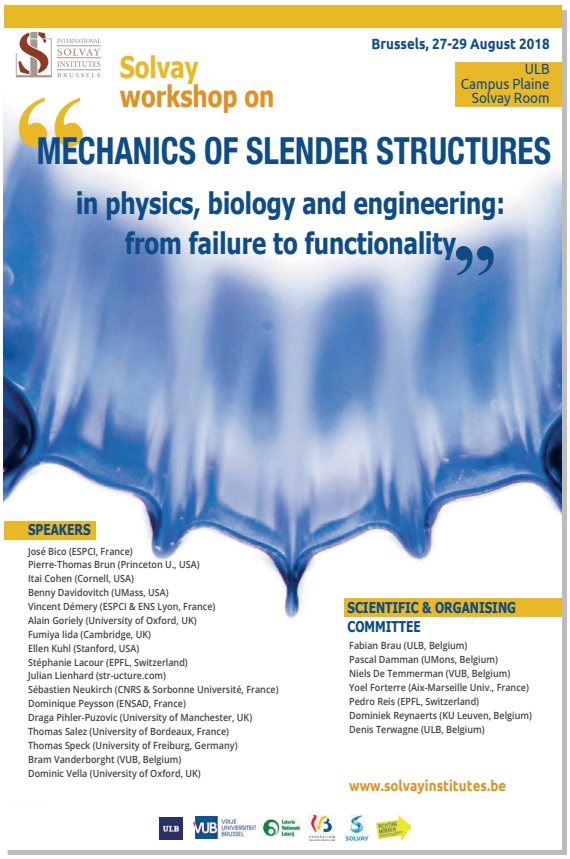
in physics, biology and engineering: from failure to functionality"

27 - 29 August 2018

The main ambition of this meeting was to bring together internationally acclaimed experts as well as young researchers in mechanics, biomechanics, biolocomotion, material science and architecture to address the current scientific challenges in these various fields. The workshop served as a platform to stimulate discussions, to start long-term scientific collaborations and to promote progress at the porous boundaries between research domains, such as elastic instabilities of slender objects, foldable structures /origamis/ kirigamis, elasto-capillarity/fluid-structure interaction, biomechanics, bio-inspired robotics /stretchable electronics, etc.

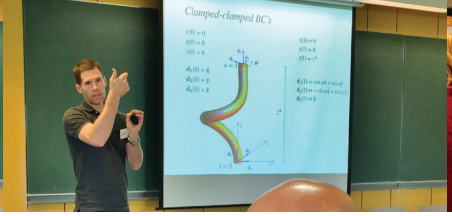
Organising and Scientific Committee

Fabian Brau (ULB, Belgium)
Pascal Damman (UMons, Belgium)
Niels De Temmerman (VUB, Belgium)
Yoel Forterre (Aix-Marseille Univ., France)
Pedro Reis (EPFL, Switzerland)
Dominiek Reynaerts (KU Leuven, Belgium)
Denis Terwagne (ULB, Belgium)



Speakers

José Bico (ESPCI, France)
Pierre-Thomas Brun (Princeton U., USA)
Itai Cohen (Cornell, USA)
Benny Davidovitch (UMass, USA)
Vincent Démery (ESPCI & ENS Lyon, France)
Alain Goriely (University of Oxford, UK)
Fumiya Iida (Cambridge, UK)
Ellen Kuhl (Stanford, USA)
Stéphanie Lacour (EPFL, Switzerland)
Julian Lienhard (str-ucture)
Sébastien Neukirch (CNRS & Sorbonne Université, France)
Dominique Peysson (ENSAD, France)
Draga Pihler-Puzovic (University of Manchester, UK)
Thomas Salez (University of Bordeaux, France)
Thomas Speck (University of Freiburg, Germany)
Bram Vanderborght (VUB, Belgium)
Dominic Vella (University of Oxford, UK)



Program

Monday 27 August 2018

Welcome by Marc Henneaux (Director of the Solvay Institutes, Brussels) and introduction

Session 1 - Elastic Instabilities of Slender Objects (Chairperson: Pedro M. Reis)

Alain Goriely	*Curves, strings, rods, filaments, and strips: elasticity, morphoelasticity, and configurational elasticity.*

Contributed talks

Tobias M. Schneider	*From turbulence transition to the buckling of a soda can*
David M. J. Dykstra	*Tensile instability in a thick elastic body*
Benny Davidovitch	*Geometrically incompatible confinement and generalized tension field theory: from Euler elasticato Gauss-Euler elastica*

Contributed talk

Derek E.Moulton	*Stable elastic knots with no self-contact*
Vincent Démery	*Geometric models for thin sheets at liquid interfaces*

Contributed talks

Douglas P. Holmes	*Elastogranular mechanics in fragile matter*
Yousra Timounay	*Wrinkle-to-crumple transition in thin films on curved surfaces*

Session 2A - Elasto-Capillarity/Fluid-Structure Interaction (Chairperson: Denis Terwagne)

Pierre-Thomas Brun	*Building with fluids, lazy design of functional materials*
Thomas Salez	*Elastohydrodynamics of an immersed particle near a soft wall*

Contributed talks

Andrej Kosmrlj	*Capillarity-induced folding of wrinkled skin*
Julien Chopin	*Dynamic wrinkling and strengthening of a filament in a viscous fluid*

Poster session

Tuesday 28 August 2018

Session 2B - Elasto-Capillarity/Fluid-Structure Interaction (Chairperson: Fabian Brau)

Dominic Vella	*Liquid drops on slender structures: From partial wetting to insect adhesion*
Draga Pihler-Puzovic	*Instabilities in blistering*

Session 3 - Foldable Structures/Origamis/Kirigamis (Chairperson: Andrej Kosmrlj)

Itai Cohen	*Atomic origami: a technology platform for nanoscale machines, sensors, and robots*

Contributed talk

Agustin Iniguez Rabago	*Finding the mechanical stable states of prismatic architected materials*

José Bico	*From 2D plates to 3D structures: playing with Carl Gauss*
Julian Lienhard	*Naturally integral*

Session 4A - Biomechanics (Chairperson: Derek E. Moulton)

Ellen Kuhl	*Instabilities in Soft Structures*
S. Neukirch/P. Grandgeorge	*Drops on fibers and liquid films on membranes*

Contributed talks

Tristan Gilet	*The elastocapillary adhesion of a wet beam: A model for the terrestrial locomotion of insects*
Amandine Lechantre	*Capture of viscous fluids in living organisms*

Wednesday 29 August 2018

Session 4B - Biomechanics (Chairperson: Douglas P.Holmes)

Thomas Speck	*Plant stems and ramifications: fibre-reinforced slender structures with mechanically highly efficient outer form and inner hierarchical structuring*

Contributed talks

Martin Brandenbourger	*Nonlinear low response of a channel with asymmetric valves inspired from the lymphatic system*
Nicolas Vandewalle	*Exploiting magnetocapillary interactions for swimming along liquid interfaces*

Session 5 - Bio-Inspired Robotics/Stretchable Electronics (Chairperson: Julien Chopin)

Stéphanie Lacour	*Engineering elasticity in thin films*

Contributed talk

Giorgio Oliveri	*Reprogramming the elastic properties of mechanical metamaterials by amplifying imperfections*
Fumiya Iida	*Embodied intelligence in soft deforming structures of robots*
Bram Vanderborght	*Self-healingsoft robots*

Contributed talk

Poincloux Samuel	*Plastic fluctuations in a knitted fabric*

Session 6 - Soft-Matter, Structures and Art (Chairperson: Pascal Damman)

Dominique Peysson	*Information & information in living materials*

MODAVE SUMMER SCHOOL

in Mathematical Physics

16 - 21 September 2018

The Modave Summer School in Mathematical Physics is a yearly summer school in topics of theoretical physics. Various topics ranging from quantum gravity and cosmology to theoretical particle physics and string theory. The school took place in Modave, a charming village in the Belgian Ardennes close to Huy. Modave School is organised by PhD students for PhD students, and this makes it rather unique. The courses are taught by Post-Docs or late PhD students, and they are all made of pedagogical, basic blackboard lectures about recent topics in theoretical physics. Participants and lecturers eat and sleep in the same place where the lectures are given. The absence of senior members, and the fact of spending day and night together in an isolated, peaceful place contribute to creating an informal atmosphere and facilitating interactions. Lectures of the fourteenth edition are centered around the following subjects: the weak gravity conjecture, AdS/CFT, QFT in curved spacetime, 2+1 dualities and fuzzballs.

Organising Committee

Pieter Bomans (KUL)
Marine De Clerck (VUB)
David De Filippi (UMONS)
Saskia Demulder (VUB)
Sibylle Driezen (VUB)
Adrien Fiorucci (ULB)
Kwinten Fransen (KUL)
Frederik Goelen (KUL)
Tom Lemmens (KUL)
Vincent Luyten (VUB)
Vincent Min (KUL)
Jesse van Muiden (KUL)
Daniel Naegels (ULB)
Kévin Nguyen (VUB)
Pierluigi Niro (ULB)
Antoine Pasternak (ULB)
Romain Ruzziconi (ULB)
Lucas Traina (UMONS)
Guillaume Valette (ULB)
Gerben Venken (KUL)

Lectures

- *Weak Gravity Conjecture*
  by Miguel Montero

- *Introduction to AdS/CFT*
  by Charles Rabideau

- *Fuzzballs*
  by Tom Lemmens

- *QFT in curved spacetime*
  by Guilherme Pimentel

I will review the basic features of quantum field theory in curved space, with a focus on spontaneous particle production by the curved background. After that, I survey the physics of some famous examples of backgrounds with particle production - black holes and electric fields;

The bulk of the lectures will focus on the calculation of spontaneous particle production from the early universe, in a hypothetical - but very plausible - period of inflation, and the predictions for late time evolution of these particles, which are currently being tested in experiments. I will show what has been measured, what has been constrained, and plan to get to the forefront of research in this area, describing some work in progress.

Finally, I will explain how certain aspects of particle production are universal, in particular, the crossover between stable and unstable background configurations.

- *2+1 dualities*
  by Carl Turner

In this course, we will look at recent progress in understanding the dynamics of non-supersymmetric quantum field theories in 2+1 dimensions. After orienting ourselves with several simpler examples of dualities in 2 and 3 dimensions, we will explore the rich network of proposed dualities governing the low-energy behaviour of a wide class of interesting, strongly-interacting QFTs. Along the way, we will discuss and gather evidence from anomaly matching, mirror symmetry, and even (time-permitting!) the lattice and large N physics. We will also look at applications to real-life condensed matter systems, and ponder a new outlook on the space of QFTs.

Participants

Marine De Clercq (VUB)
Lucas Traina (UMons)
Canberk Şanli (Boğaziçi University)
Kévin Nguyen (VUB)
Birses Debir (Boğaziçi University)
Vincent Luyten (VUB)
Aneesh Prema Balakrishnan (Chennai Mathematical Institute)
Vincent Min (KU Leuven)
Aravinth Kulanthaivelu (University of Oxford)
Frederik Goelen (KU Leuven)
Kwinten Fransen (KU Leuven)
Pieter Bomans (KU Leuven)
Gerben Venken (KU Leuven)
David De Filippi (UMons)
Antonio Rotundo (Universiteit van Amsterdam)
Miguel Montero (Utrecht Universiteit)
Carl Turner (Cambridge)
Guiherme Pimental (Universiteit van Amsterdam)
Charles Rabideau (VUB)
Tom Lemmens (KU Leuven)
Theresa Abl (Durham University)

DOCTORAL SCHOOL

Amsterdam-Brussels-Geneva-Paris

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

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

Organizing Committee Brussels

Riccardo Argurio I ULB

Ben Craps I VUB

Frank Ferrari I ULB

Participating institutions

- Institute for theoretical physics
  University of Amsterdam
- Laboratoire de physique théorique
  Ecole Normale Supérieure - Paris
- Physique théorique et mathématique
  ULB, Brussels
- Theoretical particle physics - VUB, Brussels
- SwissMap - ETH, U. Bern
  U. Geneva, CERN

Brussels Teachers

Adel Bilal I Ecole Normale Supérieure, Paris, France

Marco Billò I Università di Torino, Italy

Geoffrey Compère I ULB, Brussels, Belgium

Bernard Derrida I Collège de France, Paris, France

Stéphane Detournay I ULB, Brussels, Belgium

Zohar Komargodski I Weizmann Institute, Israel

Alberto Lerda I Università di Torino, Italy

Program

Brussels | 8 - 26 October

String Theory I
Alberto Lerda

String Theory II
Marco Billò

Advanced Quantum Field Theory
Adel Bilal

General Relativity and Black Holes
Geoffrey Compère & Stephane Detournay

Using Topology to Solve Strongly Coupled Quantum Field Theories
Zohar Komargodski (2018 New Horizons Lecturer in Physics)

The Importance of Large Deviations in Non-Equilibrium Systems
Bernard Derrida (2018 Solvay Chair in Physics)

Paris | 5 - 23 November

Introduction to supersymmetry
Ulrich Ellwanger

Introduction to supergravity
Antoine van Proeyen

Introduction to superstrings
Costas Bachas

Asymptotic properties of gravity
Marc Henneaux

Geneva | 3 - 21 December

Intro to AdS/CFT
Kyriakos Papadodimas

Applied AdS/CFT
Julian Sonner

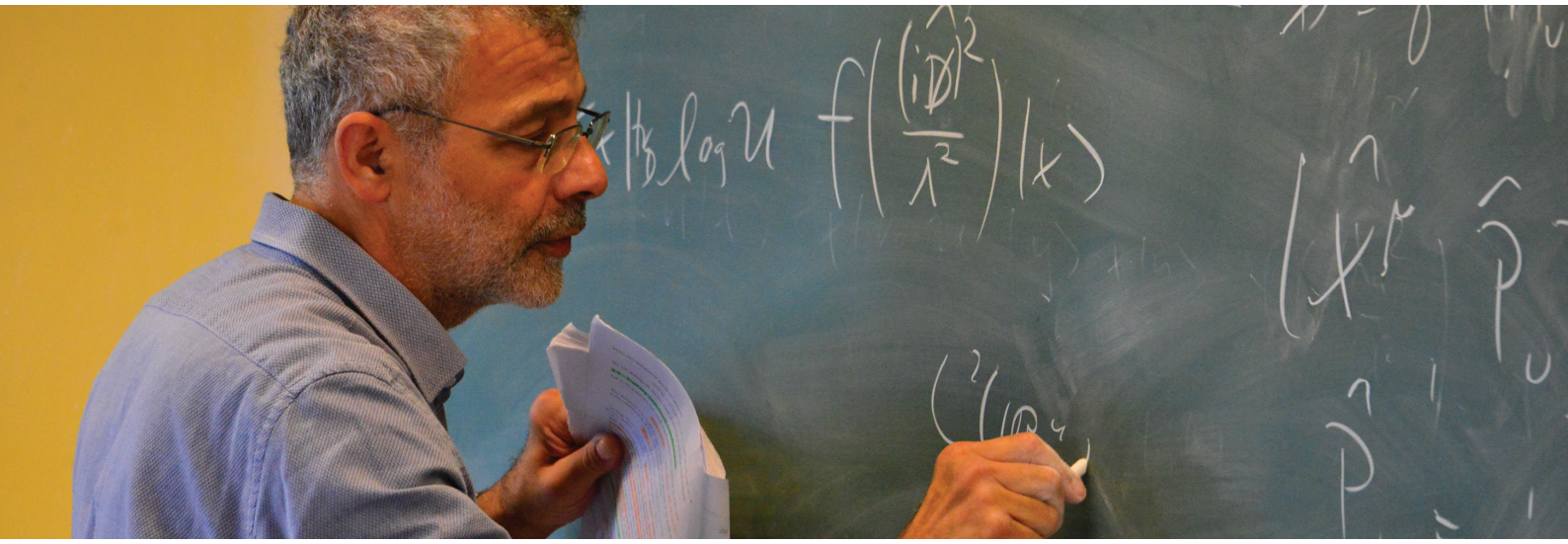
N=2 supersymmetric gauge theories in four dimensions
Francisco Morales

Introduction to topological string theory
Marcel Vonk

Large N
Marcos Marino

Participants

Aggarwal Ankit (ULB, Belgium)
Bonte Martin (ULB, Belgium)
Coudarchet Thibaut (Ecole Polytechnique, France)
Dimitrov Vasil (KU Leuven, Belgium)
Duaso Pueyo Carlos (University of Amsterdam, The Netherlands)
Eloy Camille (ENS de Lyon, France)
Espíndola Romero Ricardo (University of Amsterdam, The Netherlands)
Faraji Schokoufe (ZARM, Bremen, Germany)
Have Emil (University of Edinburgh, UK)
Holm Ingrid Angelica Vazquez (Institut de Physique Théorique, CEA-Saclay & University of Paris-Saclay, France)
Lahnsteiner Johannes (Groningen, The Netherlands)
Lara Kristiansen (Universidad de Santiago de Chile)
Liu Yan (ULB, Belgium)
Mougiakakos Stavros (Institut de Physique théorique - CEA-Saclay, France)
Nikolakopoulou Theodora (University of Amsterdam, The Netherlands)
Ohanesjan Vladimir (Leiden University, The Netherlands)
Oueslati Rami (ULiège, Belgium)
Reis Tomas (University of Geneva, Switzerland)
Sgroi Gabriele (University of Amsterdam, The Netherlands)
Stemerdink Koen (Utrecht University, The Netherlands)
Tielemans Rob (KU Leuven, Belgium)
van de Heisteeg Damian (Utrecht University, The Netherlands)
Van Hemelryck Vincent (KU Leuven, Belgium)
Vandermiers Quentin (ULB, Belgium)
Verheijden Evita (University of Amsterdam, The Netherlands)
Vermoortele Dylan (VUB, Belgium)
Yixuan Li (Ecole Normale Supérieure Paris-Saclay, France)



Student's opinion

> This school was a very useful and pleasant way to start my PhD

During my Master's thesis, I realized the difference between the topics taught in the Master's courses and the current subjects of research. The aim of the Solvay Doctoral School is precisely to fill this gap by organizing intense lectures on advanced and various topics in theoretical and mathematical physics.

There were three sessions of three weeks. The first one was held in Brussels and gave us complementary materials on field theories, gravitation and black holes, as well as an introduction to string theory. Those three first weeks in Brussels gave me the opportunity to meet all the other PhD students participating to the school.

Paris was the city of the second session. We were then introduced to Supersymmetry, Supergravity, Superstrings and to the asymptotic properties of gravity. During these three weeks in Paris, we had also some time to visit museums and famous places as the Palace of Versailles and the Eiffel Tower.

The third session took place in Geneva. We had there a deep insight in various subjects, such as the AdS/CFT correspondence, the large N physics and topological strings.

The three sessions of this doctoral school were also a great opportunity to meet other PhD strudents working in the same area as me, and sharing my interest for theoretical and mathematical physics. Moreover, there were students coming from a lot of different european countries, but also from China and Chile. This helps creating a scientific network, which could result in interesting future collaborations.

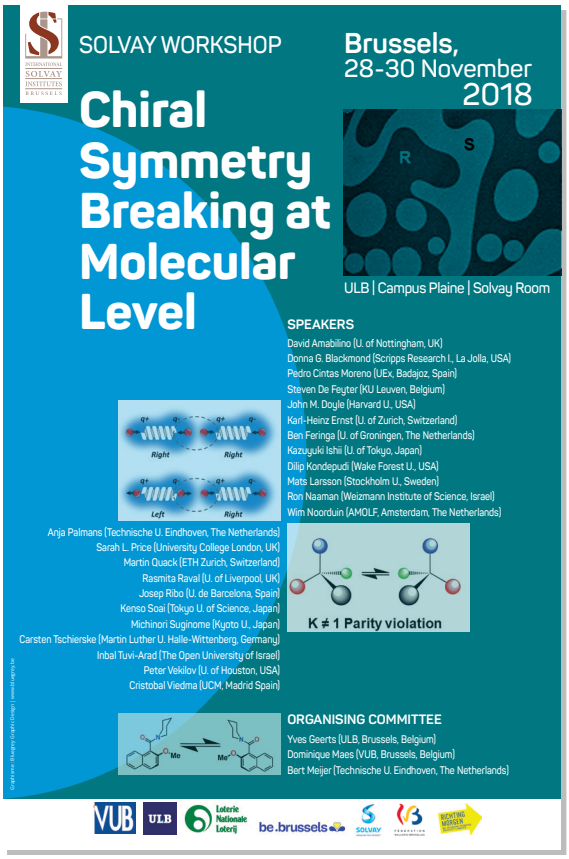
I was very pleased to attend this school, because of all I learnt about physics during the lectures, but also for the meeting with other young physicists! Of course, all of the materials covered in the lectures will not be directly useful for my research, but is more a part of the general knowledges in this field of physics. The lectures gave me at the same time a feeling of the broadness of all the subjects, as well as the keys to understand them.

This school was, in the end, a very useful and pleasant way to start my PhD.

Martin Bonte

"CHIRAL SYMMETRY BREAKING AT MOLECULAR LEVEL"

28 - 30 November 2018



Chiral Symmetry Breaking (CSB) is ubiquitous in chemistry and physics. For example, achiral molecules crystallize as chiral crystals. For which reasons, molecular systems break their symmetry? Under which conditions? How a tiny excess of one enantiomer lead to chiral amplification? What is the origin of homochirality on earth? The workshop intented to mix up ideas and people. Researchers working on CSB, but with very different background: theory, electromagnetism, non-equilibrium thermodynamics, crystallography, catalysis, nucleation, chemical engineering, liquid crystals, spectroscopy, organic synthesis, and quantum chemistry confronted their views.

Organising Committee

Yves Geerts (ULB, Brussels, Belgium)
Dominique Maes (VUB, Brussels, Belgium)
Bert Meijer (Technische U. Eindhoven, The Netherlands)

Speakers

David Amabilino (U. of Nottingham, UK)
Donna G. Blackmond (Scripps Research I., La Jolla, USA)
Pedro Cintas (UEx, Badajoz, Spain)
Steven De Feyter (KU Leuven, Belgium)
John M. Doyle (Harvard U., USA)
Karl-Heinz Ernst (U. of Zurich, Switzerland)
Ben Feringa (U. of Groningen, The Netherlands)
Kazuyuki Ishii (U. of Tokyo, Japan)
Mats Larsson (Stockholm U., Sweden)
Ron Naaman (Weizmann Institute of Science, Israel)
Wim Noorduin (AMOLF, Amsterdam, The Netherlands)
Anja Palmans (Technische U. Eindhoven, The Netherlands)
Sarah L. Price (University College London, UK)
Martin Quack (ETH Zurich, Switzerland)
Rasmita Raval (U. of Liverpool, UK)
Josep Ribo (U. de Barcelona, Spain)
Kenso Soai (Tokyo U. of Science, Japan)
Michinori Suginome (Kyoto U., Japan)
Carsten Tschierske (Martin Luther U. Halle-Wittenberg, Germany)
Inbal Tuvi-Arad (The Open University of Israel)
Peter Vekilov (U. of Houston, USA)
Cristobal Viedma (UCM, Madrid Spain)
Elias Vlieg (Radboud University, The Netherlands)

Program

Wednesday 28 November 2018

Chair: Bert Meijer

Yves Geerts	*Introduction and context*
Donna G. Blackmond	*Energy requirement for symmetry breaking in autocatalysis for the emergence of biological homochirality*
David Amabilino	*Emergence of morphological chirality in crystals*
Ben Feringa	*Exploring chiral space*
Karl-Heinz Ernst	*Cooperate chiral symmetry breaking in two dimensions*
Carsten Tschierske	*Chiral symmetry breaking in liquids and liquid crystals*
Martin Quack	*Parity violation in chiral molecules, biomolecular homochirality, and the fundamental symmetries of physics*
Ron Naaman	*Separation of enantiomers by enantio-specific interaction of chiral molecules with magnetic substrates*
Kazuyuki Ishii	*Chirality induced by aggregation of aromatic compounds*
Rasmita Raval	*Nanoscale viewpoints of mirror symmetry breaking at surfaces*

POSTER SESSION

Thursday 29 November 2018

Chair: Dominique Maes

Sarah L. Price	*Computer modelling insights into chiral separation by crystallization for organic molecules*
Wim Noorduin	*Physical chemical routes to single handedness*
Inbal Tuvi Arad	*Conformational chirality of protein building blocks and the chiral ramachandran plot*
Michinori Suginome	*Dynamic helical macromolecules for catalytic transfer, amplification, and up-conversion of molecular chirality in asymmetric synthesis*
Peter Vekilov	*Olanzapine crystal symmetry originates in preformed centrosymmetric solute dimers*
Elias Vlieg	*Deracemization of everything?*
Kenso Soai	*Asymmetric autocatalysis and the origin of homochirality*
Josep Ribó	*Chemical networks able to show spontaneous mirror symmetry in chemical evolution scenarios*

Solvay Colloquium

Cristobal Viedma	*Fighting fire with fire: racemization drives deracemization*

Friday 30 November 2018

Chair: Yves Geerts

John M. Doyle	*High-specificity spectroscopy and chiral detection using buffer-gas cooling and microwave three-wave mixing*
Mats Larsson	*Chiral-chiral interaction and symmetry breaking studied in low-energy collision experiments*
Pedro Cintas	*Mirror-symmetry breaking in prebiotic chemistry: Computer-aided insights*
Steven De Feyter	*Controlling chirality at the liquid-solid interface*
Anja Palmans	*Symmetry breaking and deracemisation in supramolecular polymeric systems*
Bert Meijer	*Conclusions & perspectives*

End of the conference

NEW HORIZONS LECTURES

NEW HORIZONS LECTURES

Upon recommendation of the Solvay Advisory Committee, the Board of Directors of the Solvay Institutes decided to launch a new project, the "New Horizons Solvay Lectures". The object of this program is to invite a brilliant young scientist (PhD + 12 years maximum) with already high visibility and well-established stature to give a series of lectures in Brussels and in other Belgian universities.

Through this program, the Solvay Institutes wishes to strengthen collaborations between Belgian research teams. Young researchers are the special target, and interactions between them and the Solvay lecturer are maximized.

This new program was launched in 2018 and will continue on a yearly basis.

2018 New Horizons Lectures in Chemistry

Professor Tkatchenko, University of Luxemburg

Professor Tkatchenko from the University of Luxemburg was the first "New Horizons Lecturer" in Chemistry. He is a world-leader in material sciences. His research group has successfully developed methods for quantum-mechanically modeling intermolecular interactions. He uses a combination of both physical intuition and machine learning to get new insight in complex molecular systems. The importance of his remarkable work has been recognized by the European Research Council, who awarded him two ERC grants, a Starting grant in 2011 and a Consolidator grant in 2017.

His lecture at the Solvay Institutes was devoted to a pressing question: "The Promise and Rise of Machine Learning in Chemistry and Physics". It was followed by visits to the University of Mons and Ghent University. Intense interactions with young researchers took place through seminars and poster discussions.

Professor Tkatchenko was hosted in the group of Professor Yves Geerts, who was instrumental in organizing Professor Tkatchenko's stay in Belgium (29 May – 1 June) and the scientific program of his visit.
The Solvay Institutes heartily thank him for his efficient help.

Alexandre Tkatchenko is a Professor of Theoretical Chemical Physics at the University of Luxembourg since 2015. He obtained his bachelor degree in Computer Science and a Ph.D. in Physical Chemistry at the Universidad Autonoma Metropolitana in Mexico City. In 2008–2010, he was an Alexander von Humboldt Fellow at the Fritz Haber Institute of the Max Planck Society in Berlin. Between 2011 and 2016, he led an independent research group at the same institute. He received a number of awards, including the Gerhard Ertl Young Investigator Award of the German Physical Society, and two flagship grants from the European Research Council: a Starting Grant in 2011 and a Consolidator Grant in 2017. His group pushes the boundaries of quantum mechanics, statistical mechanics, and machine learning to develop efficient methods to enable accurate modeling and new insights into complex materials.

Lectures and informal and spontaneous discussions with young scientists took place during Professor Tkatchenko's visit.

30 May at ULB

"The Promise and Rise of Machine Learning in Chemistry and Physics"

Learning from data has led to paradigm shifts in a multitude of disciplines, including web, text and image search, speech recognition, as well as bioinformatics. Can machine learning enable similar breakthroughs in understanding (quantum) molecules and materials? The main challenge is the disproportionately large size of chemical space, estimated to contain 10^60 molecules even when only counting small organic drug-like candidates. Aiming towards a unified machine learning (ML) model of quantum interactions, I will discuss the potential and challenges for using ML techniques in chemistry and physics. ML methods can not only accurately estimate molecular properties of large datasets, but they can also lead to new insights into chemical similarity, aromaticity, reactivity, and molecular dynamics. However, to do so one needs to carefully unify spatial and temporal physical symmetries with purpose-designed ML methods. While the potential of machine learning for revealing insights into complex quantum-chemical systems is high, many challenges remain. I will conclude my talk by discussing these challenges.

31 May at Mons University

1 June at Ghent University

"Bridging the accuracy of quantum mechanics with efficiency of machine learning in molecular modeling"

Professor Alexandre Tkatchenko's visit at the Center for Molecular Modeling at Ghent University

On June 1, 2018, Alexandre Tkatchenko, professor in Theoretical Condensed Matter Physics at the University of Luxembourg, visited the Center for Molecular Modeling as part of the New Horizon Lecture Series. This new initiative organized by the Solvay Institutes aims to welcome brilliant young scientists with already high visibility and well established stature to bring them into contact with early-career researchers and promote high-level international collaborations.

To further promote the open exchange of ideas between professor Tkatchenko and the young researchers at the Center for Molecular Modeling (CMM), ample time was reserved for small-scale meetings and discussions. The CMM, headed by professor Veronique Van Speybroeck (department of Applied Physics, faculty of Engineering and Architecture), is an interfacultary research team composed of about 40 researchers active in various branches of physics, chemistry, biochemistry, and materials science. Awarded with both an ERC Starting Grant and an ERC Consolidator Grant, the group focuses on the computational modeling of physical and chemical transformations in nanoporous materials. The interesting work discussions highlighted the possible synergies between both research groups.

2018 New Horizons Lectures in Physics

Professor Zohar Komargodski, Weizmann Institute, Israel and Stony Brook, USA

The 2018 New Horizons Lectures in Physics were delivered by Professor Zohar Komargodski, from the Weizmann Institute (Israel) and the Simons Center at the University of New York at Stony Brook (USA).

Professor Komargodski is a world-leading expert in quantum field theory and string theory. His remarkable contributions to the field are deep and far-reaching. In 2013, he received one of the most prestigious distinctions awarded to young scientists, the "New Horizons Prize ", for "his work on the dynamics of four-dimensional field theories. In particular, his proof (with Schwimmer) of the "a-theorem" has solved a long-standing problem, leading to deep new insights."

His lecture at the Solvay Institutes was delivered on October 16 and entitled: “Using Topology to Solve Strongly Coupled Quantum Field Theories”. It addressed profound concepts and methods, and was extremely insightful. A full day at the KUL was also organized, with seminars and intense interactions with young researchers.

The visit of Professor Komargodski (15-19 October) was organized by Professors Riccardo Argurio (ULB), Nikolay Bobev (KUL) and Frank Ferrari (ULB). It is a pleasure to thank them all.

Born in the USSR (Ukraine) in 1983, Prof. Zohar Komargodski earned his BSc in physics and mathematics from Tel Aviv University in 2004. He conducted his graduate studies in physics at the Weizmann Institute, earning an MSc in 2006 and a PhD in 2008. After carrying postdoctoral research at the Institute for Advanced Study in Princeton, where he was accepted as a long term member, Prof. Komargodski joined the faculty of the Weizmann Institute in March of 2011. In March of 2017, he became a Permanent Member of the Simons Center for Geometry and Physics at the University of Stony Brook.

Prof. Komargodski conducts research in theoretical high-energy physics, where he made central contributions to Quantum Field Theory, Conformal Symmetry, Supersymmetry, Quantum Gravity, and Particle Physics Phenomenology. He is the recipient of a number of prestigious fellowships and awards, including the New Horizons in Physics Prize in 2013, the Gribov Medal, for outstanding work by a young physicist in Theoretical Particle Physics and/or Field Theory in 2013, and the Philippe Meyer Prize in Theoretical Physics in 2014.

16 October at ULB

“Using Topology to Solve Strongly Coupled Quantum Field Theories” and discussions with young researchers.

I will begin by describing an interacting model in Quantum Mechanics where exact results about the ground state can be established by using tools from topology. I will then argue that such tools are also useful for tackling interesting problems in Quantum Field Theory. In particular, I will review Yang-Mills theory and argue that using topology one can make several predictions about its possible phases. We will then also extend the considerations to Quantum Chromodynamics and discuss possible connections with particle physics phenomenology and with condensed matter physics.

17 October at KU Leuven

“Phases of some 3D gauge theories and 4D domain walls” and discussions with young researchers.

We propose new quantum phases of some non-supersymmetric three-dimensional gauge theories. We show that these proposals pass highly nontrivial consistency checks and can be connected to the dynamics of domain walls in four-dimensional gauge theories. The new quantum phases include interesting symmetry breaking patterns as well as nontrivial Topological Field Theories. These proposals also lead to several new dualities.

COLLOQUIA

COLLOQUIA

Bottom up modelling of liquid crystals: from molecules to applications

Professor Claudio Zannoni | *Università di Bologna, Italy* | 6 February 2018

Liquid crystals (LC), with their unique combination of fluidity and anisotropic physical properties, continue to offer a number of novel fascinating applications, ranging from optical and haptic displays to organic electronics devices, sensors, etc... However, why some molecules form liquid crystals and other apparently similar do not and, more generally, the relation between molecular structure and features of the LC phases formed is still far from being understood. Modelling and computer simulations methods that address this problem at various length scales: mesoscopic, molecular, and atomistic have seen a huge development in the last few years, due also to the impressive increment in computer power. Thus, on one hand, coarse grained models, where molecules or molecular fragments are replaced by simple objects with similar shape endowed with attractive and repulsive interactions can now be employed to handle systems as complex as LC elastomers, explaining some of their unusual mechanical properties. On the other hand, atomistic molecular dynamics (MD) simulations have started to make detailed and fairly reliable predictions of phase transition temperatures, order and other properties of real liquid crystals starting from their chemical structure. An even more exciting development is the possibility of studying the interaction of liquid crystals with solid surfaces. This is particularly important since, for most practical applications, LC are not used in bulk quantities but in micro or nano thick films, where the LC is aligned along a specific direction with the help of surface interactions. In view of this it is somewhat surprising that surface effects are still being described only empirically, and that little is known on their molecular origin. In the talk we plan to show that atomistic MD can now shed some light also on the interfacial behavior of liquid crystals, separating various effects that contribute to alignment, e.g. chemical nature of the substrate, morphology, roughness, surface treatments like rubbing and possibly suggesting way of optimizing devices. A view of the perspectives for future developments of the field will also be briefly discussed.

Binary neutron stars: Einstein's richest laboratory

Professor Luciano Rezzolla | *Institute of Theoretical Physics Frankfurt, Germany* | 20 February 2018

I will argue that if black holes represent one the most fascinating implications of Einstein's theory of gravity, neutron stars in binary system are arguably its richest laboratory, where gravity blends with astrophysics and particle physics. I will discuss the rapid recent progress made in modelling these systems and show how the inspiral and merger of a binary system of neutron stars is more than a strong source of gravitational waves. Indeed, while the gravitational signal can provide tight constraints on the equation of state for matter at nuclear densities, the formation of a black-hole-torus system can explain much of the phenomenology of short gamma-ray bursts, while the ejection of matter during the merger can shed light on the chemical enrichment of the universe.

Wilson bases and gravitational waves

Professor Ingrid Daubechies | *Duke University, USA* | 27 February 2018

The talk will review the construction, in the early 90s, by Stephane Jaffard, Jean-Lin Journe and the speaker, of special orthonormal bases associated with the standard Weyl-Heisenberg unitary group representation in the Hilbert space of square integrable functions. An earlier argument by Balian and Low seemed to prevent the existence of such orthonormal bases, but a clever twist (using cosines and sines instead complex exponentials!) made it possible to circumvent this obstruction. In an interesting twist of fate, these constructions turned out to have interesting properties that made them especially appropriate for the celebrated LIGO detection of gravitational waves, a few decades later.

Decoding Molecular Plasticity in the Dark Proteome

Professor Edward A. Lemke | *EMBL, Heidelberg, Germany* | 27 March 2018

The mechanisms by which intrinsically disordered proteins (IDPs) engage in rapid and highly selective binding is a subject of considerable interest and represents a central paradigm to nuclear pore complex (NPC) function, where nuclear transport receptors (NTRs) move through the NPC by binding disordered phenylalanine-glycine-rich nucleoporins (FG-Nups). In the first part of my talk, I will present a combined single molecule, ensemble spectroscopy, solvation approach that paired with atomic simulations revealed that a rapidly fluctuating FG-Nup populates an ensemble of conformations that are prone to bind NTRs with diffusion-limited on-rates. This is achieved using multiple, minimalistic, low affinity binding motifs that are in rapid exchange when engaging with the NTR, allowing the FG-Nup to maintain an unexpectedly high plasticity in its bound state. Since site-specific labeling of proteins with small but highly photostable fluorescent dyes inside cells remains the major bottleneck for directly performing such high resolution studies in the interior of the cell, I will demonstrate an approach on how to overcome this limitation in the second part of my talk. We have now developed a semi-synthetic strategy based on novel artificial amino acids that are easily and site-specifically introduced into any protein by the natural machinery of the living cell. Expressed proteins only differ from their natural counterparts by very few atoms, constituting a ring-strained cyclooctyne or cyclooctene functional group. This allowed rapid, specific “click” labeling and even multi-color studies of living cells and subsequent super resolution microscopy.

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Nikic I, Plass T, Schraidt O, Szymanski J, Briggs JA, Schultz C, Lemke EA*. Dual-color super-resolution microscopy via genetic code expansion technology and tuned click reactions. Angew Chem Int Ed Engl, 2014, Feb, 53(8), 2245-2249 (2014)

Molecular Design of catalysts: From the fundamentals to the Industrial application

Professor Avelino Corma | *CSIC, Valencia, Spain* | 24 April 2018

Catalysis has very strong economic and strategic impact, since most industrial chemical process involve, at least, one catalytic step. While fundamental knowledge can be, relatively fast, transferred into the design of molecular catalyst, this is much straight forward in the case of solid catalyst. In fact, heterogeneous catalysis has mainly advanced by accumulated knowledge, trial and error and judicious interpretations of results.

However, today, catalysis by solids benefits from advances in nanomaterial synthesis, detailed catalyst surface, characterization under reaction conditions, and computational chemistry. This multidisciplinary approach allows a better approach to the molecular design of solid catalysts.

We will present how through the knowledge of reaction mechanisms by means of kinetics and isotopic studies, computational chemistry, and materials synthesis one may approach to the design and preparation of solid catalysts with well defined (or multiple) isolated, active sites. This molecularly designed solid can include single metal, metal nanoclusters and nanoparticles, acid and basic sites that can be introduced in confined species in an attempt to approach the behaviour of enzymes. We will present how the fundamental knowledge and materials developed can be transformed into industrial catalysts for chemical processes.

Quantum Field Theory and Duality

Professor David Tong | *Cambridge University, UK* | 8 May 2018

Quantum field theory is the framework that underlies much of the natural world, from particle physics to condensed matter physics. It is the natural marriage of quantum mechanics and special relativity. It is also quite hard.

In this talk, I will describe some recent, surprising advances in understanding dualities in quantum field theory. These advances required a convergence of ideas from disparate areas of physics, including the quantum Hall effect, higher spin holography, and supersymmetry.

Optimal decoding of cell identities in multicellular systems

Professor Thomas Gregor | *Princeton University, USA* | 12 June 2018

In a developing embryo, individual cells need to “know” where they are to do the right thing. How much do they know, however, and where is this knowledge written down? Here, we show that these questions can be made mathematically precise, using the framework of information theory and applying it to biological signaling networks. The same framework has been successfully applied to neural processing and under the name of “efficient coding” has been able to explain various non-trivial properties quantitatively from first principles. As such it has been able to make predictions “ab initio”, directly from data, rather than from fits to specific mathematical models. Here we’re building a similarly predictive theory for gene regulatory networks in the specific context of cell specification in the developing embryo. In this system, information about position is encoded by the molecular concentration of several types of effector molecules, and a cell’s position ultimately encodes its identity. Can the cellular process of decoding position and thus cell identity from a set of concentrations be made explicit? We present an approach that tightly integrates experiments and theory, and which allows us to generate a quantitative and simple predictive theory of how cells decode positional information in the patterning gene network of the early fly embryo. We construct a decoder from wild-type gene expression patterns and show that it correctly predicts, with no free parameters and 1% accuracy, the patterns of pair-rule expression in mutant backgrounds as well as their temporal changes. Information about precise cell identities is thus available at the earliest stages of development, and we argue that the way in which this information is distributed reflects an optimization principle, maximizing the information available from a limited number of molecules. Our results suggest that evolutionary pressures may have been strong enough to drive mechanisms that extract as much positional information as possible given the physical constraints.

Capturing light on the nanoscale

Professor Sir John Pendry | *Imperial College London, UK* | 19 June 2018

Conventional optics controls light on the scale of roughly a micron – approximately the wavelength of visible light. To control light in the world of nanoscience requires a new understanding in which we look inside the wavelength at the component electric and magnetic fields. Exploiting the new concepts we have designed devices that compress light into less than a square nanometer, thus enhancing the energy density by a factor of a million which opens the way to single molecule sensing and switching light with light – the optical transistor. Finally, I shall discuss negative refraction and how it leads to the construction of a lens whose resolution is unlimited by the wavelength of light.

Gravitational waves science from LIGO and Virgo to Einstein Telescope

Professor Jo van den Brand | *National Institute for Subatomic Physics, Nikhef and VU University Amsterdam, The Netherlands* | 27 November 2018

The LIGO Virgo Consortium achieved the first detection of gravitational waves. A century after the fundamental predictions of Einstein, we report the first direct observations of binary black hole systems merging to form single black holes. The detected waveforms match the predictions of general relativity for the inspiral and merger of a pair of black holes and the ringdown of the resulting single black hole. Our observations provide unique access to the properties of space-time at extreme curvatures: the strong-field and high velocity regime. It allows unprecedented tests of general relativity for the nonlinear dynamics of highly disturbed black holes. Last year the gravitational waves from the merger of a binary neutron star were observed. This discovery marks the start of multi-messenger astronomy and the aftermath of this merger was studied by using 70 observatories on seven continents and in space, across the electromagnetic spectrum.

The scientific impact of the recent detections will be explained. In addition key technological aspects will be addressed, such as the interferometric detection principle, optics, and sensors and actuators. Attention is paid to the largest challenges in the field, including plans for Einstein Telescope, an instrument that will allow us to observe black hole coalescence in the entire visible Universe. Einstein Telescope will be an underground observatory housing multiple (cryogenic) interferometers for gravitational waves science.

Fighting Fire with Fire: Racemization drives Deracemization

Professor Cristobal Viedma | *UCM, Madrid, Spain* | 29 November 2018

Life has chosen a single handedness, which manifests itself in D-sugars and L-amino acids, through the long and complex pathway of biological evolution. Probably, without that stereochemical constraint, crucial processes such as selective replication and transcription would have been difficult, if not impossible, to achieve. The origin of ho-mochirality in nature has puzzled and mesmerized scientists from Pasteur's times. Every theory and finding since shed light into the mystery. From a practical viewpoint, the ability of enzymes to selectively recognize chiral forms leads to the key consequence that, very often only one enantiomer (eutomer) of a chiral drug triggers the therapeutic effect, while the other (distomer) is no more than ballast to the biological action and may even be detrimental. Switch from racemates to unichiral compounds has become an imperative to the pharmaceutical industry in the search for more potent and selective drugs.

The way to chiral purity has traditionally viewed racemization as the biggest enemy to beat. A plethora of talented synthetic chemists have invented elegant asymmetric methodologies aided by enantiopure reagents and catalysts to overcome the undesirable isomer. In fact, the late William Bonner wrote, in one of the first reviews dealing with the origin of homochirality (1991): "all mechanisms for the origin and amplification of molecular chirality have racemization as their ultimate nemesis ..." Nearly two decades later (2007), we concluded however that "the molecular racemization in solution can be considered the driving force that guarantees chiral purity ...". What happened in between to move racemization from foe to friend?

This talk will summarize the experiments, hypothesis, results, and of course a touch of serendipity, which led us to exploiting racemization as the driving force for homochirality. Under certain conditions, one enantiomer nurtures the other in an autocatalytic fashion that evolves into single handedness.

Chemical Information Processing

Professor Christopher A. Hunter | *University of Cambridge, UK* | 4 December 2018

This presentation will describe two different projects dealing with communication of chemical information in molecular systems: synthetic information molecules and transmembrane signal transduction.

Transmission and amplification of chemical signals across lipid bilayer membranes is of profound significance in many biological processes, from the development of multi-cellular organisms to information processing in the nervous system. The ability to reproduce such processes in artificial systems has potential applications in sensing, controlled drug delivery and communication between compartments in tissue-like constructs of synthetic vesicles. We have developed a new mechanism for transmitting chemical information across membranes based on controlled translocation of a synthetic molecular transducer from one side of a lipid bilayer membrane to the other.[1]

The encoded recognition properties of nucleic acids are currently unrivalled in any other material. High fidelity sequence selective duplex formation is the molecular basis for replication of the genetic information encoded by DNA and is finding widespread applications in the programmed assembly of complex nucleic acid nanostructures. We have been investigating the sequence-selective duplex formation properties of synthetic recognition-encoded oligomers that bear no resemblance to the natural system.[2]

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Folding of Proteins Emerging From the Ribosome During Translation

Professor Marina V. Rodnina | *Max Planck Institute for Biophysical Chemistry, Germany* | 11 December 2018

Protein domains start to fold co-translationally, while they are being synthesized on the ribosome. Co-translational folding is vectorial; it starts in the confined space of the polypeptide exit tunnel of the ribosome and is modulated by the speed of translation. Defects in protein folding cause many human diseases; thus, understanding the co-translational folding is of eminent importance. We use rapid kinetics approaches to investigate co-translational folding of proteins and show that folding of the nascent protein proceeds through several compact, non-native conformations that forms within the peptide tunnel of the ribosome before exiting from the ribosome.

WORKSHOPS AND ACTIVITIES

sponsored by the Institutes

MEETINGS OF THE BELGIAN QUANTUM PHYSICS INITIATIVE

Académie Royale de Belgique, Brussels

The Meetings of the Belgian Quantum Physics Initiative (BQPi) are scientific meetings that are organized at the Royal Academy of Belgium on a monthly basis since November 2017. They aim to trigger and encourage interactions among physicists who are active in the many areas of quantum physics (such as condensed-matter physics, quantum optics, quantum information and quantum computing) in Belgium, in particular young researchers and phD students. Each meeting is structured in three parts: the meeting starts with a one-hour Colloquium, presented by an eminent scientist; then discussions take place over a long coffee-break; finally, two short presentations are given by young physicists. More informations on these meetings (e.g. the calendar and programs of previous meetings) are available on this webpage: https://www.nathan-goldman-physics.com/bqi-meetings.

Organising Committee

- Brussels (ULB): N. Goldman, J. Roland, S. Pironio and N. Cerf
- Antwerp (UAntwerpen): J. Tempere and M. Wouters
- Ghent (UGent): F. Verstraete and J. Haegeman
- Leuven (KU Leuven): C. Maes and W. De Roeck
- Liege (Univ. Liège): J. Martin, T. Bastin, P. Schlagheck

Program

18 January 2018
Tilman Esslinger (ETH Zurich) *Building quantum systems from scratch: supersolids and more*

1 February 2018
Steven H. Simon (Oxford Univ.) *Topological Matter and Why You Should be Interested*

15 February 2018
Rembert Duine (Utrecht Univ.) *Electronic spin currents and magnetization dynamics: from current-driven domain walls to black holes*

1 March 2018
Thierry Giamarchi (Geneva Univ.) *The bizarre one-dimensional quantum world*

26 April 2018
Klaus Mølmer (Aarhus Univ.) *The Ichtyosaur in the quantum laboratory*

17 May 2018
Wolfgang Schleich (Ulm Univ.) *The Riemann Zeta Function and Quantum Mechanics*

4 October 2018
Philipp Hauke (U. of Heidelberg) *Quantum simulation of high-energy physics with cold atoms*

8 November 2018
Eleni Diamanti (Sorbonne, Paris) *Demonstrating quantum advantage in security and efficiency with practical photonic systems*

13 December 2018
Ignacio Cirac (MPQ Garching) *Tensor Networks: Basic results and applications*

CERN

Masterclass for students in the 5th and 6th year of secondary school

Brussels, 28 February and 3 March 2018

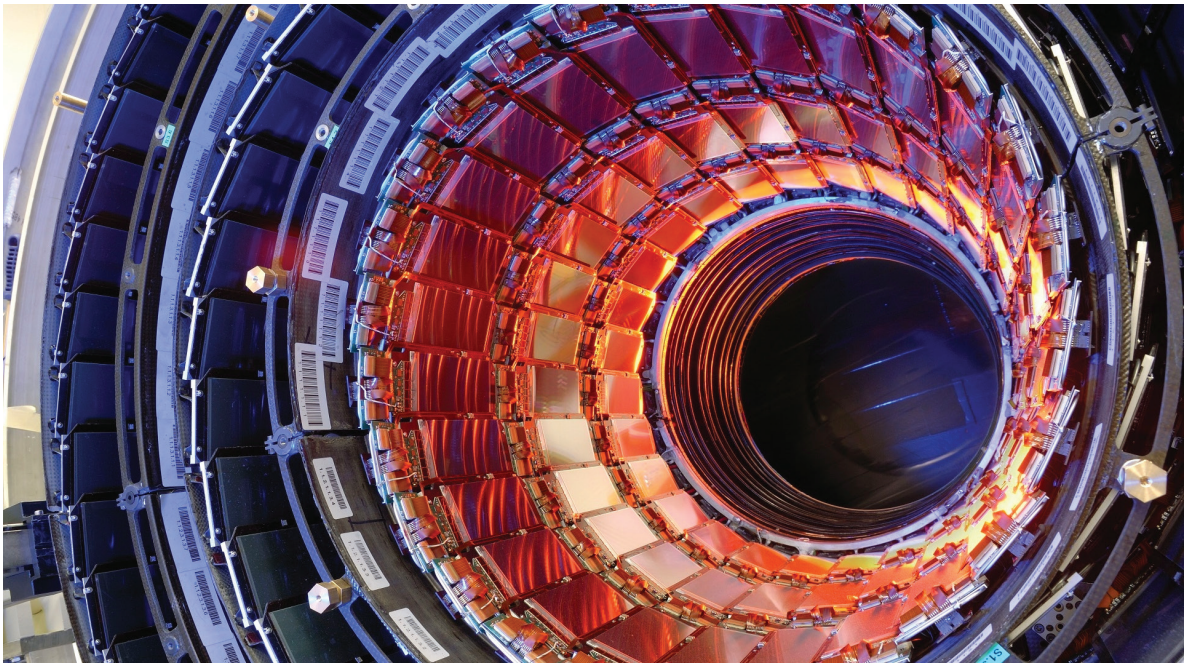
On February 28 and March 3, the Vrije Universiteit Brussel organised the only 'official' CERN masterclass in Belgium for students in the 5th and 6th year of secondary school.

This day was fully incorporated in the CERN masterclass program, including interaction with international students who are doing the same masterclass in other places world-wide, during a videoconferencing session at the end of the day, this year with students from exotic places such as Doha, Helsinki, Sao Paolo, Warsaw, Alexandria and Trieste. The masterclass was hosted by the I.I.H.E. (ULB-VUB, www.iihe.ac.be) and was organised in collaboration with the International Particle Physics Outreach Group (IPPOG), the world-wide organisation providing structured support for outreach activities.

These masterclasses received extremely positive feedback and also have historically been very successful at convincing strong students to choose physics as their university major, and is one of our more visible physics activities in particle physics at the IIHE, together with the IceCube masterclass (also supported by the Solvay Institutes) which has more of a focus of interaction between researchers and students while this activity focuses more on the interaction between students internationally. From 2011 onwards, we have received up to 30 students per year for these activities, with regular request for additional places, also by non-Flemish schools.

This is why this year, for the first time, we offered two masterclasses, one in Dutch (on the 28th this year, 55 attendees, 30 registered) and a new masterclass in English, specifically marketed towards the International community in Brussels but open to all interested parties (34 attendees and registered, ~80% of the attendees were associated with the European or International schools in Brussels, the rest were predominantly attending French language education, specifically from the better performing schools that offer English-language science courses).

Freya Blekman (Organising committee CERN masterclass)



STRINGS, COSMOLOGY AND GRAVITY STUDENT CONFERENCE 2018 (SCGSC18)

Brussels, 14 - 16 March 2018

The conference was designed to bring together young PhD and early stage postdoctoral researchers working in theoretical high energy physics, especially in the areas of string theory, cosmology, and gravity. One of our primary aims was to give attendants the opportunity to present their research via contributed talks and to form collaborations. The conference was open to all interested graduate students and postdoctoral researchers.

After a selection procedure, the interested attendees were invited to present their work in a 45-minutes or a 25-minutes talk, the latter in case of a parallel session.

Alongside the talks enough space was made for the young researchers to discuss their work and the future of research in theoretical high energy physics.

Organisers

Charles Cosnier-Horeau (EP)

Saskia Demulder (VUB)

Sibylle Driezen (VUB)

Daniel Klaewer (MPP)

Scott Melville (ICL)

Jesse van Muiden (KUL)

Daniel Naegels (ULB)

David Osten (MPP)

David Tennyson (ICL)

General Scientific Meeting 2018 of
THE BELGIAN PHYSICAL SOCIETY

Universiteit Antwerpen - 11 April 2018

This one-day conference aimed at bringing together physicists of different sectors and different scientific subdisciplines. A diverse program was 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
- Quantum physics, including atomic physics and quantum optics
- Biophysics and Medical physics
- Condensed Matter & Nanophysics
- Fundamental Interactions, Particle & Nuclear Physics
- Physics and Education

Organising Committee / Scientific Committee

Prof.dr. Jacques Tempere (Universiteit Antwerpen)

Prof.dr. Michiel Wouters (Universiteit Antwerpen)

Prof.dr. Jef Ongena (Royal Military Academy)

along with the chairpersons of the various sessions:

Prof.dr. Anitha Ethirajan (UHasselt): Biophysics and Medical Physics

Prof.dr. Francois Peeters (UAntwerpen): Condensed Matter and Nanophysics

Dr. Stefan Tinck (UAntwerpen): Astrophysics, Geophysics & Plasma Physics

Prof.dr. Pierre Van Mechelen (UAntwerpen): Particle & Nuclear Physics

Dr. Hilde Verheyen (Xaverius College): Physics and Education

Prof.dr. Michiel Wouters (UAntwerpen): Quantum Physics

Invited Plenary Lectures

Paolo Giubellino	*FAIR - The Universe in the Laboratory*
Lieven Vandersypen	*A "Spins inside" Quantum Processor*

Third ERC (HoloBHC) Solvay Workshop on

"HOLOGRAPHY"

Brussels, 22 - 25 May 2018

The holographic principle, which postulates dualities between quantum gravity and gauge theories without gravity, has led to tremendous advances over the past years in our understanding of gravity, gauge theories and string theory. This workshop aimed at gathering the community working on the topic of holography in relationship to black holes, lower dimensional models, entanglement and top-down string models. Short talks from the local Belgian holography community took take place in addition to the plenary talks of international speakers in order to encourage mutual interactions and transfer of knowledge.

Organising and Scientific Committee

Nikolay Bobev (KU Leuven, Belgium)
Geoffrey Compère (ULB, Brussels, Belgium)
Stéphane Detournay (ULB, Brussels, Belgium)
Frank Ferrari (ULB, Brussels, Belgium)
Marc Henneaux (SI & ULB, Brussels, Belgium)

Speakers

Dionysios Anninos (UvA, Amsterdam, The Netherlands)
Tatsuo Azeyanagi (ULB, Brussels, Belgium)
Marco Baggio (KU Leuven, Belgium)
Netta Engelhardt (Princeton U., USA)
Fridrik Gautason (KU Leuven, Belgium)
Monica Guica (IPhT, Saclay, France)
Michael Gutperle (UCLA, Los Angeles, USA)
Diego Hofman (UvA, Amsterdam, The Netherlands)
Jiang Long (ULB, Brussels, Belgium)
Dario Martelli (King's College London, UK)
Emil Martinec (Chicago U., USA)
Javier Matulich (ULB, Brussels, Belgium)
Mark Mezei (Simons Center, Stony Brook, NY, USA)
Joris Raeymaekers (I. of Physics, Prague, CR)
Max Riegler (ULB, Brussels, Belgium)
Gábor Sárosi (U. Pennsylvania, USA & VUB, Brussels, Belgium)
Fidel Schaposnik (ULB, Brussels, Belgium & IBS, Daejeon, Korea)
Wei Song (Tsinghua U., Beijing, China)
Julian Sonner (Geneva U., Switzerland)
Alberto Zaffaroni (Milan Bicocca U., Italy)

Symposium in honor of
PROFESSOR ROALD HOFFMANN

Brussels - 28 May 2018

A One Day Symposium in honor of Professor Roald Hoffmann, Nobel Laureate in Chemistry 1981, on the occasion of his visit to the Vrije Universiteit Brussel was organized at the Royal Academy of Belgium for Science and the Arts by the VUB Quantum Chemistry Group under the auspices of the FWO Research Network on Quantum Chemistry.

At the end of May 2018 Professor Roald Hoffmann, Frank H.T. Rhodes Professor of Humane Letters Emeritus at Cornell University and Nobel Laureate in Chemistry 1981, visited the Vrije Universiteit Brussel. On this occasion the Quantum Chemistry Group of the VUB organized a One Day Symposium around a theme that is central in Hoffmann's work: the chemical bond.

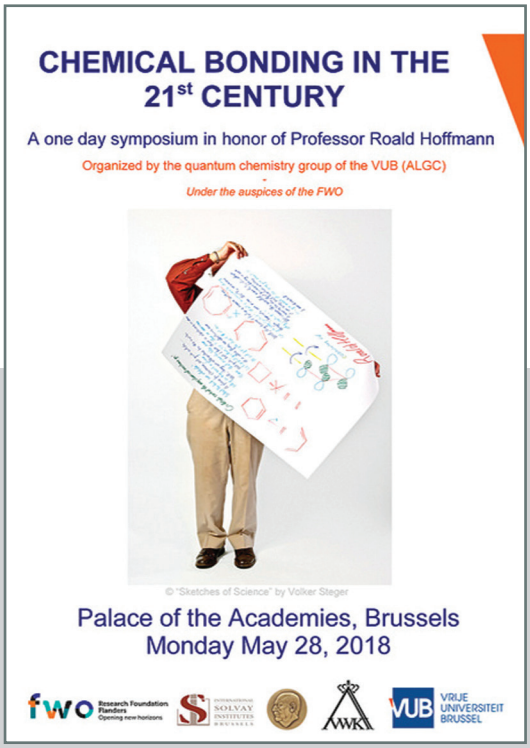
The aim of the Symposium was twofold; in the morning session the audience got an in depth impression of Hoffmann's work, ideas and vision on the chemical bond in a special two hours lecture with pedagogical perspective. Mathias Bickelhaupt (VU Amsterdam), a former postdoc with Hoffmann, closed the morning session discussing "Chemical Bonding in Transition States". In the afternoon session the context was different; six young but already renowned Belgian scientists (Jeremy Harvey, Mercedes Alonso, Geoffry Hautier, Benoît Champagne, Veronique Van Speybroeck, Jérôme Loreau) from six different Belgian universities highlighted their work, offering Roald Hoffmann and the audience an impression of the present status of Quantum Chemistry in Belgium. Given the many years behind us that Roald Hoffmann did not give a presentation on a conference in Belgium one could characterize the bottom line of this day as "Belgium meets Roald Hoffmann and vice versa".

The VUB Organizing Committee

Paul Geerlings (Chair)

Frank De Proft, Frederik Tielens, Mercedes Alonso

Freija De Vleeschouwer, Jan Turek, Thijs Stuyver



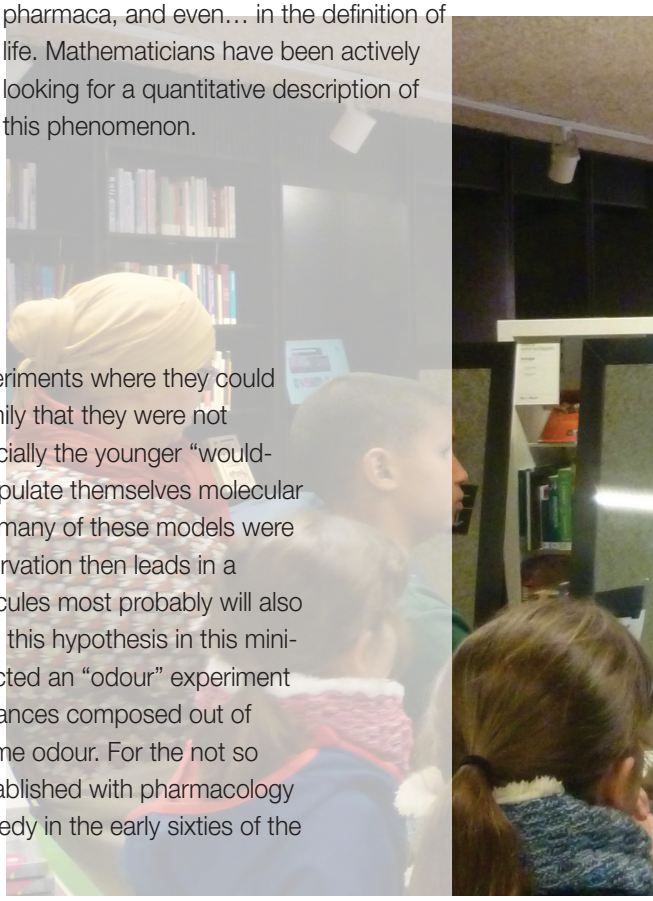

SCIENCE DAY

SCIENCE DAY 2018

The Solvay Institutes participated to the Science Days of the Flemish Community more precisely to the Science Festival, organized in the very center of Brussels, at Muntpunt, on Sunday November 25, 2018.

The Solvay Institutes presented information about their history, mission and organization, illustrated with many pictures of past and recent activities on three posters (roll-ups).

On the other hand an introduction was given to the visitors about an intriguing concept/phenomenon in science transcending its different subdisciplines: chirality: the remarkable fact that an object or process can be different from its mirror-image. The work by Louis Pasteur at the end of the 19th century gave a boost for the investigation of the "why and when" of chirality, which then first blossomed in chemistry. Later on it turned out that this concept also plays a fundamental role in describing processes in physics (e.g. at the level of elementary particles), in disentangling the activity of pharmaca, and even… in the definition of life. Mathematicians have been actively looking for a quantitative description of this phenomenon.



The visitors' interest was raised by mirror experiments where they could convince themselves and their friends and family that they were not identical to their mirror image, surprising especially the younger "would-be" scientists. They were encouraged to manipulate themselves molecular models and came to the conclusion that also many of these models were not identical with their mirror image. This observation then leads in a natural way to the hypothesis that these molecules most probably will also undergo different "chemical" reactions. To test this hypothesis in this mini-scientific research program the visitors conducted an "odour" experiment where they could smell themselves that substances composed out of mirror – molecules do not always have the same odour. For the not so young-any-more visitors the link was then established with pharmacology by refreshing their minds on the Softenon tragedy in the early sixties of the previous century.

The Solvay exhibition stand received all day long many visitors enthusiastically interacting with Paul Geerlings (Emeritus Professor Chemistry at VUB and Vice-President of the Solvay Institutes) and Tatiana Wöller (Assistant Chemistry at the VUB), and it was nice to see that children as well as adults got interested in this mini scientific excursion, and were, as we could witness, sometimes really amazed by these “tales and facts from the unexpected”.

In conclusion the participation of the Solvay Institutes to the Science Day of the Flemish Community was a success. The Solvay Institutes want to acknowledge the Flemish Community for the financial support they received for this activity.

SEMINARS

SEMINARS

The list below gives the joint inter-university weekly seminars co-organized by the Theoretical Particle Physics Group of the VUB, the Service de Physique Théorique and the Service de Physique Théorique et Mathématique, both of the ULB, the High Energy Physics and Relativistic Field Theory group of the KUL, the Groupe de Mécanique et Gravitations at UMons, and the International Solvay Institutes. It also gives the group seminars of the research team of the Director.

JANUARY

Deformation Quantization and Higher-Spin Theories
Eugene Skvortsov

FEBRUARY

BMS Supertranslations and Not So Soft Gravitons
Pujiao Mao

Kinematical Lie algebras and their homogeneous geometries
José Figueroa-O'Farrill

Effective field theories for hydrodynamics
Natalia Pinzani-Fokeeva

3d N=2 gauge theories on Seifert manifolds (or: how to localise on the Poincaré sphere)
Cyril Closset

Deep-Learning the Landscape
Yang-Hui He

MARCH

α'-corrected black holes in Heterotic String Theory
Pedro Ramirez

Handling Handles: Non-Planar AdS/CFT Integrability
Till Bargheer

Exactly deconstructing the (2,0) theory
Diego Rodriguez-Gomez

Towards an M5-brane model: A 6d superconformal field theory
Christian Saemann

Path integrals and trace anomalies
Fiorenzo Bastianelli

On exact solutions, boundary conditions and conserved charges in 4D higher-spin gravity
Carlo Iazeolla

APRIL

The infrared physics of 3d N=4 SQCD
Stefano Cremonesi

Exceptional Magic
Andres Braun

Puzzles of semi-classical inflation
Jean-Luc Lehners

Can a vector be a Goldstone boson?
Diederik Roest

Holographic Subregion Complexity from Kinematic Space
Raimond Abt (Wurzburg U.)

MAY

A new Matrix Model for latitude Wilson loops in ABJM theory
Silvia Penati

Nonlinear dynamics of gravity from entanglement in conformal field theories
Charles Rabideau

Bosonization in 2d and 3d
David Tong

Bootstrapping an Argyres-Douglas theory
Madalena Lemos

Gauge theories at finite density: an holographic perspective.
Anton Faedo

Supersymmetric AdS5 Black Holes with Squashed Boundary
Davide Cassani

JUNE

Proper Basis for Studying Amplitudes
Nabamita Banerjee

*Holographic phases of N=1**
Ben Niehoff

Quantum Gravity, or: Give me (more) observables!
Renate Loll

The fluid road to flat holography
Marios Petropoulos

JULY

Holographic dualities in non-perturbative 3D gravity: from spin chains to BMS characters
Bianca Dittrich (Perimeter)

OCTOBER

Higher-spin asymptotic symmetries, charges and soft theorem
Carlo Heissenberg (Scuola Normale Superiore, Pisa)

Deconstructing Defects
Vasilis Niarchos

The N=2 BMS3/GCA2 bootstrap
Ivano Lodato (Fudan U. Shanghai)

Counting massless matter in F-theory with CAP
Martin Bies (ULB)

Nonperturbative anomalies in particle physics
Miguel Montero

Renormalized volume and topological renormalization of Holographic Entanglement and Renyi Entropies
Ignacio Araya (Andres Bello Natl. U., Santiago)

5d partition functions with A twist and holography
Marcos Crichigno

Complexity and entanglement for thermofield double states
Michal Heller

Brussels sprouts, black hole mass and pre-holography
Rodrigo Olea (Andres Bello Natl. U.)

Soft theorems for the massless closed string and the hidden conformal symmetry of tree-level amplitudes in pure Einstein gravity
Matin Mojaza

Holographic Plasmons
Ulf Gran

NOVEMBER

Extended Gauge Theory Deformations from Flux Backgrounds
Yuta Sekiguchi (Bern U.)

E11 is the symmetry of the low energy effective action of strings and branes
Peter West

A unified geometric framework for YM charges and dressings in finite regions
Aldo Riello

Field theory on curved branes
Daniël Prins

Gravity and Holography between Newton and Einstein
Niels Obers

Tensionless strings: A perspective from the worldsheet
Pulastya Parekh (IIT Kanpur)

Quantum Null Energy Condition in two dimensions
Daniel Grumiller (TU Vienna)

Top-down holography and the Chern-Simons diffusion rate
Francesco Bigazzi

Stringy WZW models as integrable deformations
Alessandro Sfondrini

Hidden Symmetries in Gravity and Supergravity
Lars Brink

Graphene and Boundary Conformal Field Theory
Chris Herzog

Complexity for warped AdS black holes
Stefano Baiguera (Milan-Bicocca)

DECEMBER

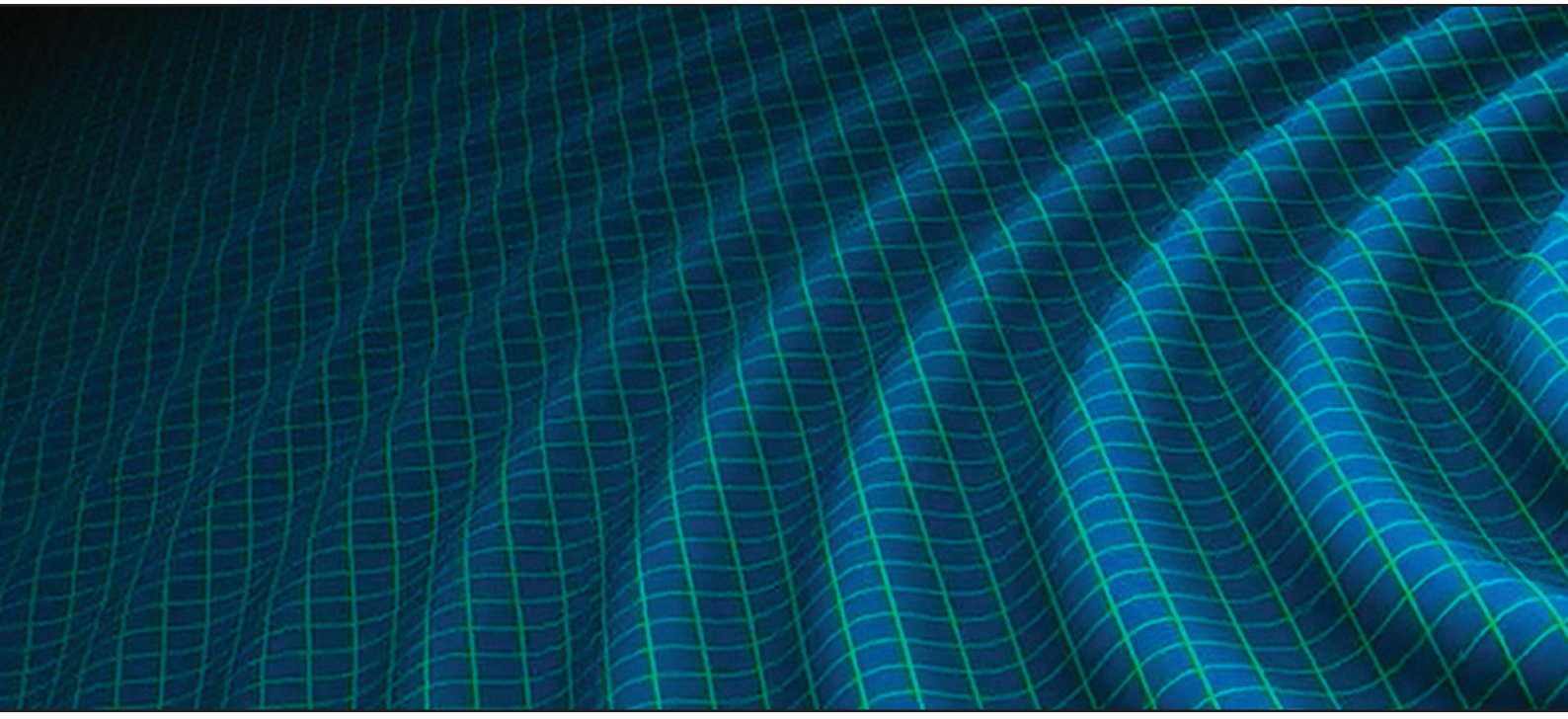
Open string T-duality and applications to non-geometric backgrounds
Fabrizio Cordonier (ASC, LMU München)

Conformal colliders, light ray OPE and General Relativity
Alexander Zhiboedov

Stueckelberg superfield in supergravity
Silvia Nagy

Superconformal index, Bethe Ansatz and holography
Paolo Milan (Sissa)

Quantum Gravity Amplitudes from CFT
Shai Chester



Gravitational Wave seminars

The Gravitational Wave seminars are organized to actively encourage Belgian research on Gravitational Wave Physics and other astrophysical observations that can make contact with fundamental physics.

FEBRUARY

LIGO, Virgo, and the Dawn of a New Era in Gravitational Wave Astronomy
Laura Cadonati (Georgia Tech and Deputy Spokesperson of Ligo Scientific Collaboration)

Extreme-mass-ratio inspirals and the second-order gravitational self-force
Adam Pound (Southampton)

Gravitational Waves and Cosmology: seven hints for primordial black hole dark matter
Sébastien Clesse (UCL and UNamur)

MARCH

Probing the electroweak scale via gravitational wave experiments
Germano Nardini (Bern & LISA)

Decoherence and the Black Hole Information Puzzle
Aidan Chatwin-Davies (Caltech)

SEPTEMBER

Oscillons and gravitational waves from preheating after inflation
Stefan Antusch (Basel U.)

Astrophysical background of gravitational waves: from cosmology to a new era of precision astrophysics
Giulia Cusin (Oxford U.)

OCTOBER

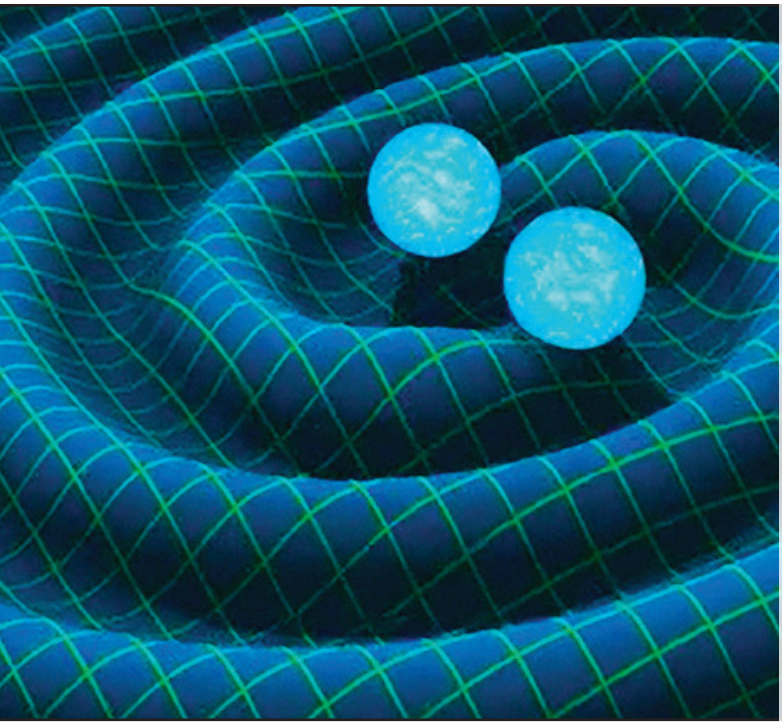
Imaging (and imagining) Black Holes
Sera Markoff (API/GRAPPA, University of Amsterdam)

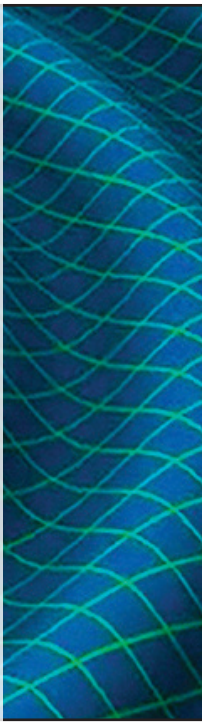
Shadows of 5D black objects
Tom Lemmens (KU Leuven)

NOVEMBER

Analytical self-force and Effective-One-Body approaches to extreme mass-ratio black hole binaries.
Chris Kavanagh (IHES, Paris on the move to AEI, Berlin)

New insights on the cosmic strings stochastic gravitational wave background
Christophe Ringeval (UCL)






Idea
Exploring
New
Frontiers
Research
Improvement
Concept

RESEARCH

CONTENTS

RESEARCH ON GRAVITATION, STRINGS AND COSMOLOGY

Groups of Professors Marc Henneaux I ULB and Alexander Sevrin I VUB

Researchers

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Riccardo Argurio I ULB
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Glenn Barnich I ULB
Andrès Collinucci I ULB
Geoffrey Compère I ULB
Ben Craps I VUB
Stéphane Detournay I ULB
François Englert I ULB, Honorary Member of the Institutes
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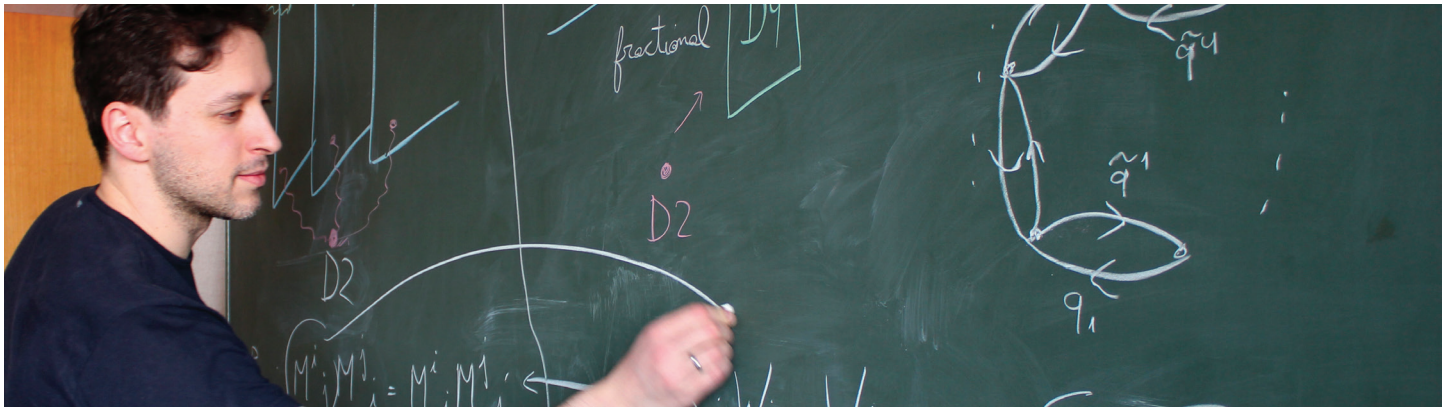

Research Summary

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. A major challenge of modern physics is to reconcile quantum mechanics and Einstein's gravity. This will undoubtedly need new developments that will go beyond Einstein's 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 can come to the front.

(i) Supersymmetry

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

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

(ii) Dualities

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

In nonlinear theories like Yang-Mills theories, dualities relate a strongly coupled regime to one at weak coupling, where standard perturbative computations may be performed. In supersymmetric situations, these dualities become tractable.

Finally, dualities between different string theories as well as holographic duality between gauge and gravity theories feature prominently in most of the recent developments. They have broadened the original scope of string theory by paving the way to applications to other fields of physics, including condensed matter theory and hydrodynamics.

(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 the algebras E_{10} and E_{11}.

(iv) Higher spin symmetries

Higher spin gauge fields (massless fields with spins greater than the spin 2 of the graviton) play a central role in many searches for a quantum-mechanically consistent formulation of gravity. For instance, they appear in the zero tension limit of string theory. High spin gauge field theories are described by a huge "higher spin symmetry".

The symmetries described in (i)-(iv) have strong but still somewhat mysterious connections with each other.

Research carried out in 2018

We have continued our research along the general directions outlined above. This has led to 129 published papers and preprints submitted for publication. These are listed on pages 135-141.

Specific achievements by some researchers from the group are described in the subsequent pages.

Support to the research of the director

The research of the director and of his group has benefited, as in the previous years, of gifts from the Solvay family and the Solvay Group. This generous support was precious to cover international collaborations, the organization of workshops as well as doctoral and postdoctoral grants to researchers. It is most gratefully acknowledged.

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 her or his career as a postdoctoral fellow in the group of "physique théorique et mathématique" of the ULB.

List of Marina Solvay fellows

Waldemar Schulgin (2012-2014)
David Tempo (2015)
Jelle Hartong (2016)
Adolfo Guarino (2017)
Charlotte Sleight (2018)

Dr. Charlotte Sleight was the fifth holder of the Marina Solvay fellowship, in 2018. She got her PhD degree at the University of Munich (Germany) in 2016 before joining the group of the Director at ULB. Her work deals with higher spin gauge theories, holography, and the connection with string theory. More recently, she applied her knowledge to cosmology.

Pull yourself up by the Bootstraps!

Almost all phenomena observed so far in Nature are neatly described within the framework of existing physical theories. Our physical experiments to date have accessed a tremendous range of phenomena, from the deep subatomic scales of ~10^{-19}m probed in the collisions of highly accelerated particles, to distances of ~10^{25}m captured by deep sky surveys - with a bounty of Condensed Matter systems, Chemistry and Biophysics in between.

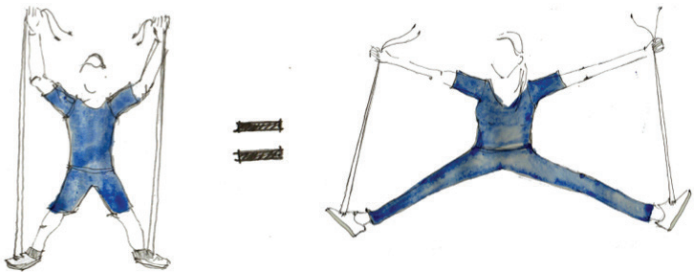

Figure 1: Adapted image from the Bootstrap 2017 meeting, http://bootstrap.ictp-saifr.org/

Quite remarkably, our current description of existing observations draws upon very few fundamental ideas. On the one hand, at subatomic scales, Nature becomes probabilistic and is described by *Quantum Mechanics*. Elementary Particles are regarded as Quantum Fields, and the list of all known Elementary Particles together with their interactions is elegantly encoded in just a few lines of the celebrated Standard Model Lagrangian. On the other hand, on the scale of Planets and Galaxies, *Einstein's Theory of General Relativity* postulates that space-time is a dynamical field, describing how matter affects geometry and vice versa. This principle forms the backbone of the Cosmological Standard Model, which provides a coherent framework describing the evolution of our Universe from Big Bang Nucleosynthesis up to the present day.

In spite of the incredible successes, our current description of our Universe is incomplete. Most strikingly, Quantum Mechanics and General Relativity are mutually inconsistent: In studying the gravitational effects at very small scales, if we apply the principles of Quantum Mechanics to our current description of Gravity, we get nonsensical answers. We therefore conclude that, at such scales, our current description must be substituted by a new, more fundamental, theory. This is known as the Quantum Gravity problem.

A major obstacle that we face in addressing the Quantum Gravity problem is the lack of experimental data. The scales at which Quantum Gravitational effects become significant are not directly accessible by our current experiments so, for now, the subject has been largely driven by thought <<Gedanken>> experiments: In the absence of experimental data, we have to develop our own guiding principles to extract consistent candidates for theories of Nature out of the swampland of possibilities.

Instead of aiming to develop a complete detailed framework for a consistent theory of Nature, which is known as the top-down approach, it can be advantageous to instead employ general consistency conditions and symmetries to constrain, or even fully determine, observables in Nature. These consistency conditions include the basic requirement that a particle's future does not affect its past (Causality), and that unphysical particles cannot be exchanged during the intermediate steps of a particle interaction (Unitarity). The resulting constraint equations can be regarded as closed circuits of particles, their masses, and interactions, so that from consistency alone the answers may pull themselves out of the equations -- like in the tall tales of Baron Münchhausen, who pulled himself and his horse out of the swamp just by his own Bootstraps!

The Conformal Bootstrap

The Bootstrap approach was first advocated in the 60s, in an effort to find order in the zoo of newly discovered particles. Despite early triumphs, this approach was largely neglected in favour of the Standard Model of Particle Physics, not to mention the lack of technical tools to implement the Bootstrap systematically beyond the simplest cases.

More recently, however, the Bootstrap has emerged as powerful method to understand theories with a special type of symmetry, known as Conformal Symmetry. Conformal symmetry is an enhancement of the usual symmetries we encounter (such as invariance under translations and rotations), to include invariance under transformations that preserve angles. Most importantly, this includes scale-symmetry: Things look the same no matter how far you zoom in or out.

Such theories, known as Conformal Theories, are significant as they serve as railway stations, or building blocks, in the space of all possible Quantum Theories. The constraint of Conformal Symmetry moreover makes them easier to study than a generic Quantum Theory. In spite of their simplicity, the utility of these theories is ubiquitous across physics: Among other things, they describe phase transitions in materials (e.g. the processes by which water boils and turns into steam) and play a central role in the definition of the String Theory paradigm – one of our current leading candidates for a consistent Quantum Theory of Gravity.

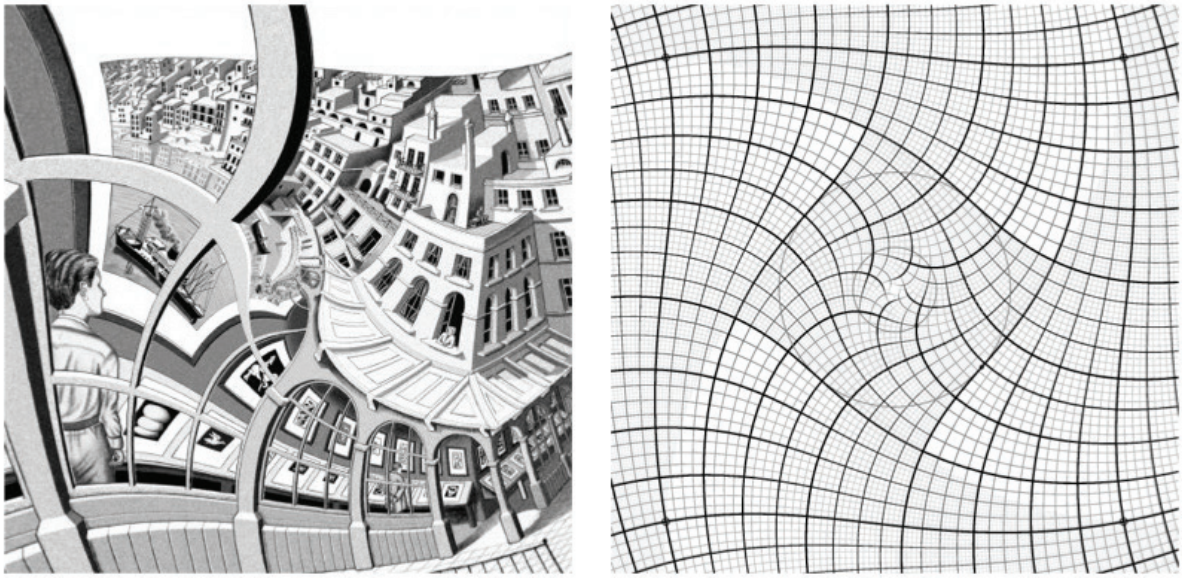

Figure 2: M.C. Escher's Print Gallery next to Escher's (hand-drawn) conformal grid

In the last two decades, Conformal Theories have risen to an even greater prominence owing to their conjectured equivalence to theories of Quantum Gravity on backgrounds of constant non-zero curvature. Observables of certain Quantum Fields in a Conformal Theory are equal to observables in the dual Quantum Gravity Theory, where the Quantum Fields in the Conformal Theory represent particles in the dual Quantum Gravity Theory. Such a duality, should it hold, is incredibly profound because it opens the possibility to translate the challenging questions that we face in Quantum Gravity into the language of Conformal Theories – which are much simpler and comparably better understood.

Accordingly, by Bootstrapping observables in Conformal Theories, we can constrain observables of consistent Quantum Theories of Gravity, and study their properties. This is the direction of my research at Université Libre de Bruxelles, in which I have focused on developing tools to Bootstrap Quantum Gravity observables generated by particles of high spin. Spin is an intrinsic form of angular momentum carried by particles. While elementary particles in the Standard Model of particle physics have a low spin, there are very good indications that the additional particles required of a complete, consistent, Quantum Theory of Gravity have increasingly high spins. These tools have allowed me to, via the Bootstrap, study interaction processes of high-spin particles, and in particular their interactions with Gravity. In the long term, these and subsequent results may be used to classify the signatures of such new particles in cosmological observations.

Andrea Amoretti
Postdoctoral researcher I ULB

Andrea Amoretti works on quantum field theory, Gauge/Gravity duality, Statistical Mechanics and strongly correlated systems. After holding postdoctoral positions at Cambridge and Würzburg, he visited ULB from January 2017 to September 2018, also as a postdoctoral fellow. In October 2018, he joined the faculty of the University of Genoa as Research Associate.

Research Interests of some other members

Stefan Prohazka*
Postdoctoral researcher I ULB

1. Spacetime symmetries

We live, at least to a good approximation, in a universe with three space dimensions and one time dimension. The three space dimensions are the three independent spatial directions “right”, “ahead” and “up”. “Left” is just the opposite of right and therefore not independent, as are “back” and “down”.

Time is the entity that governs the dynamics of our universe and can be seen as an additional coordinate parametrizing our three dimensional spatial slices, similarly to how a bread is sliced into pieces. In this analogy each bread slice would correspond to our spatial space and moving from one to the next slice would be the passing of time.

Having defined our universe one can now ask what kind of symmetries it permits. This means we look for transformations of our systems that do not change the physical outcome of our experiments. Symmetries are one of the most useful and fundamental concepts, helping us to find solutions of complicated theories, providing us with conservation laws and guiding us in our search for consistent theories. Some symmetries that seem to be known for a long time, therefore often called “aristotelian”, can be tested by dropping a rock. The time till the rock hits the floor seems to be independent of the place and the time our experiment is performed or if we rotate everything. A universe that governs this behavior is called a static spacetime, see S in Figure 1.

An observation, which goes back to Galileo Galilei, is that we can not recognize any difference between dropping the rock on a ship that sails with constant velocity or one that stands still. These additional symmetries, which one can call “galilean boosts” give rise to the galilean spacetime G. Ignoring these boosts brings us back to our static spacetime and is pictured by the arrow of G to S in Figure 1. Physically this can be understood as an approximation where we ignore the possibility of boosts, which basically means we look at systems with vanishing velocity.

The galilean spacetime underlies physics when the velocities are small compared to the speed of light and is important for, e.g., condensed matter physics, classical mechanics, and hydrodynamics. It was however realized that there is another possibility for these boosts to act on the spacetime. This led Einstein to propose the special theory of relativity which is based on Minkowski spacetime (M in Figure 1). The differences are relevant at high velocities and are therefore not easily recognized in our everyday experience. For fundamental physics where speeds, like at the LHC particle detector in CERN, are comparable to the speed of light this spacetime is crucial.

A last generalization is to allow for curved spacetimes, which gained popularity with Einstein’s theory of general relativity. Here it might happen that, even though we travel on a straight line in our spaceship we end, after some time, at the same place. This is similar to a bug which circles once around a balloon. Depending on the curvature of the spacetime, there are two options, Anti-de Sitter (AdS) and de Sitter (dS).

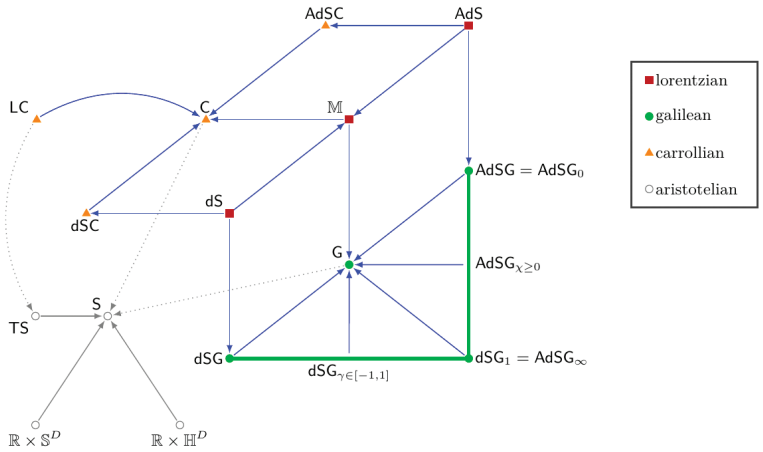

Figure 1: Homogeneous spacetimes in dimension D + 1 ≥ 4 and their limits. The arrows describe limits which start from a more “fundamental” spacetime to an approximation.

The difference in curvature can be envisioned as the difference between a valley and a mountain top. When straightened, we arrive again at the Minkowski spacetime, as can be seen by the two arrows from AdS and dS to M in Figure 1.

At this point one might wonder if we have missed any spacetimes that also allow for similar interpretations. This question was systematically analyzed by Bacry and Lévy-Leblond and ended in a classification of homogeneous spacetimes. However, the authors made a “by no means compelling” assumption and restricted to three space dimensions. Together with José Figueroa-O’Farrill I was able to drop these assumptions and we classified spacetimes for any space dimension. One result is that while three spacetime dimensions seems to be generic, lower dimensions allow for more intricate structure. But, also in three space dimensions we found novel spacetimes that naturally belong to the class of “maximally symmetric” spacetimes and have not been recognized as such so far. Our final result and their connections can be summarized as in Figure 1. All spacetimes that are not connected via arrows that originate from AdS and dS joined this structure through our work (e.g., the light cone LC cannot be reached using arrows starting at AdS).

2. Supersymmetry, higher spins and duality

Additionally to symmetries of the underlying spacetime there can be symmetries between physical fields. Fields are quantities that return one or more values for every space and time point. For example the temperature at every point and time in our universe is such a field. There can be symmetries between various fields, leading to theories with interesting properties.

One feature that distinguishes the various different fields is given by their spin. Particles with integer spin are called bosons and particles with half-integer spin are called fermions. Both types have been experimentally found. An example for a spin 1 boson is the photon which mediates electromagnetic radiation such as light. The electron is an example of a spin 1/2 fermion.

A conjectured symmetry between bosons and fermions is called supersymmetry and theories based on such a symmetry have interesting properties and could resolve various important open problems in physics. In a work with Marc Henneaux, Victor Lekeu and Javier Matulich we were able to write an action principle for the free N = (3, 1) theory, an exotic theory in five space dimensions. This theory is maximally supersymmetric, which makes it one of very few distinguished theories. The action principle we built provides not only the equations of motion which constraint the dynamics of the fields, but also gives additional information about the behavior of these field and is a first step to be able to quantize the theory.

Another symmetry, which influenced a work where were we were joined by Amaury Leonard, is duality invariance. Duality arises when we allow for the existence of, so far unobserved, magnetic monopoles. Completions of the current standard model of particle physics hint that magnetic monopoles should indeed exist at higher energies than we are currently able to procedure. Given such a symmetry it seems natural that our laws of physics should be manifestly duality invariant. In our work we provided such a duality invariant action principle for fermionic spin fields. Together with earlier work by Marc Henneaux, Sergio Hörtner and Amaury Leonard there now exists a duality invariant description for any half-integer or integer spin field. It is intriguing that the equations of motion look in this formulation, irrespective of their spin, uniform which might have interesting consequences for a universal description.

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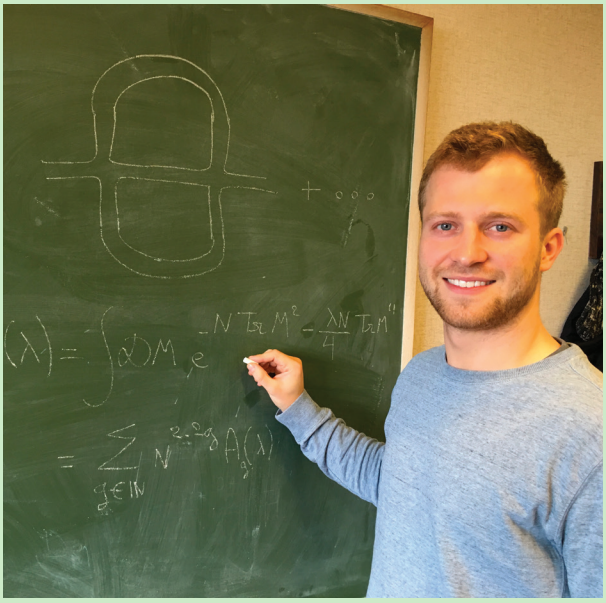
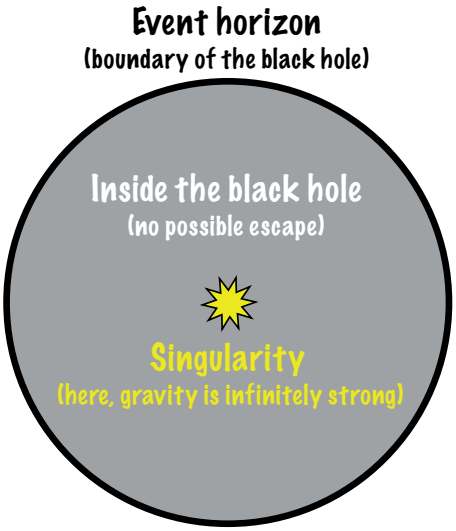
Guillaume Valette
Doctoral researcher I ULB

Black holes, what are they?

Black Holes are mysterious objects. In the last few years, they have caught people's attention thanks to remarkable observations made by LIGO. This kilometers-long laser interferometer announced in 2016 the first direct detection of gravitational waves—that is, oscillations of space-time itself—which were emitted after the collision of two black holes more than a billion light-years away. This detection seems to confirm that black holes are really part of our universe.



Nevertheless, black holes have been the center of conundrums in theoretical physics for a much longer time. They were first encountered in Einstein's theory of General Relativity; the theory that describes gravity on macroscopic scales. In 1915, Schwarzschild unravelled the existence of such objects into which anything can fall but from which nothing can espace, not even light. Theoretically, a black hole is a classical solution of General Relativity that consists in a curvature singularity, containing all the enormous mass of the black hole, together with an event horizon defining its no-escape boundary. The existence of a singularity, where mass density is formally infinite, first casted doubts about the validity of the theory. It was later realised that in such extreme conditions, quantum microscopic effects should actually be taken into account. In other words, one needs to reconcile classical gravity and quantum mechanics in order to wave away any doubts, which has not been possible to date.

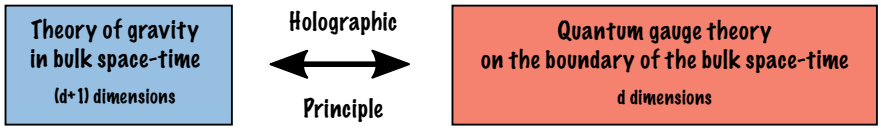


Black holes as thermodynamical objects

In the 1970s, Hawking discovered an interesting feature about black holes: the total area of the event horizon can never decrease. This result, known as the second law of black hole mechanics, is strikingly similar to the second law of thermodynamics, which states that the total entropy of a system can never decrease. This alike behaviour led Bekenstein to propose that black holes should have an entropy and that it should be proportional to the horizon area. This thermodynamical interpretation of black holes was further supported by Hawking, who realised that once quantum effects are accounted for, black holes also emit blackbody radiations at a constant temperature. Thus, black holes seem to behave like thermodynamical objects with a temperature and an entropy. However, this observation raises important questions: what is the microscopic origin of these properties? What is the microscopic structure of black holes? These are central issues in the understanding of how Einstein's theory of gravity can be reunited with the quantum world.

Black holes and holography

One puzzling consequence of black hole entropy is that it is proportional to the horizon area, whereas in usual statistical systems, it is proportional to the volume. This property would imply that the microscopic information about black holes is actually contained on the boundary horizon and not in the interior bulk. This insight was the first step towards a more general setting called holography. The holographic principle conjectures a complete equivalence between a theory of gravity in a bulk space-time and an ordinary quantum gauge theory, with no gravity, on the boundary of the bulk space-time. This duality makes an interesting connection between two *a priori* incompatible theories: on the one hand, a theory of gravity and on the other hand, a quantum theory living in a one-dimensional lower space. Holography could thus provide a new compelling way to study the microscopic properties of black holes. In fact, a large part of modern research in quantum gravity is currently working on this approach.



Toy models for quantum black holes

My center of interest consists in studying quantum theories that display interesting properties; some of them being similar to what is expected for describing black holes via the holographic principle. In a series of recent developments, a quantum mechanical model of fermions interacting randomly between each other has been shown to reproduce some features of black holes, such as the approximate scaling symmetry in the low energy regime, maximally chaotic behaviour and large degeneracy of states. The so-called Sachdev-Ye-Kitaev (SYK) model, inspired by a condensed matter model used to describe spin glasses, has a simple yet rich structure that emerges in the limit of a large number of fermions. The structure is simple because it allows one to carry out various computations explicitly, both analytically and numerically; yet rich because it exhibits non-trivial behaviours.

The structure observed in the SYK model is actually not entirely specific. Indeed, it is also found in different models based on random tensors. Random tensors generalise random matrices, which have an abundant history in mathematical and theoretical physics. Models based on random tensors were initially introduced for the study of discrete random geometry and quantum gravity, an alternative approach to string theory. Interestingly, they have an emergent structure in the limit of large dimensions which is the same as the one observed in the SYK model.

However, both models with random interaction and tensors remain rather exotic from the point of view of concrete string theory applications of holography, where matrix models are the favoured candidates for describing quantum black holes. Following my supervisor Ferrari's line of work, models based on a large number of matrices have been constructed in a such way that they display the same emergent structure, which may eventually capture the physics associated with quantum black holes.

In this context, my contribution has been to develop new theoretical tools based on graph theory and combinatorics in order to study the emergent structure in these models. Quite interestingly, these tools ended up to be useful in another field of mathematical physics. In collaboration with Dartois, Evnin, Lionni and Rivasseau, we were able to study turbulences in non-linear dynamical systems that have a highly resonant spectrum of frequencies. In particular, we showed that in a specific limit, the aforementioned emergent structure also appears and allows one to prove rigorously the emergence of turbulences, which is in general a hard problem.

Marine De Clerck
Doctoral researcher I VUB

"My research has been focused towards the understanding of the energy statistics of quantum systems and other indicators of chaos. The energy statistics analysis can for example be useful to discover more structure than expected in a system that is not integrable but does not follow the chaotic distribution in a naive first study. This topic is broad enough that it can be explored in quantum mechanical models like spin chains, but also in quantum field theories by using tools such as holography or conformal symmetry."

In the last decade, there has been a growing interest in the study of quantum chaos. This field aims at understanding the physics of chaotic behaviour at the quantum level. Classical chaos and non-linear differential equations had been studied for many decades already when quantum mechanics came along. When the world was understood to be intrinsically of a quantum nature, it became a natural investigation to unravel the underlying quantum origin of classical chaos.

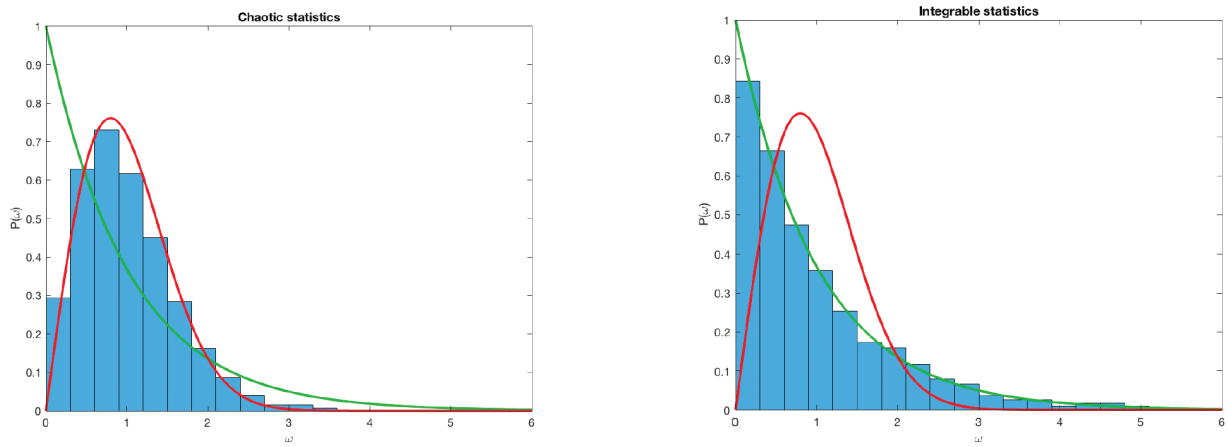
Although various definitions have been proposed and used over the years, a chaotic classical system is usually understood to exhibit strong dependence on initial conditions. One can imagine a particle following a trajectory as dictated by its equation of motion and some initial condition. For a chaotic motion, two nearby initial conditions (in phase-space) will generically diverge exponentially over time with some coefficient named the Lyapunov exponent. At a mathematical level, chaotic motions are known to be solutions to non-linear differential equations.

It became however quickly clear that the most straightforward attempts to incorporate chaos in the quantum realm fail. In a similar way that initial conditions diverge exponentially in a classical setting, one could study the time-evolution of the overlap of two quantum wavefunctions, that lie close to one another as defined by some measure. However, the Schrödinger equation is a linear differential equation, whereas non-linearities were a key ingredient in classical chaos. Moreover, such an overlap is constant in time by unitarity of the time-evolution and it can therefore never grow exponentially. Actually, the sole concept of a definite phase-space point cannot be associated to the motion in a quantum system because of the Heisenberg uncertainty principle. Over the years, arguments for indicators of chaotic or integrability properties of quantum systems (and their classical limit) have been put forward.

While chaotic systems are quite generic, their counterpart, integrable systems, are special in the sense that they possess more structure or symmetry, making them easier to solve exactly.

The statistics of energy eigenvalues

One indicator that was proposed to distinguish between integrable and chaotic quantum systems was to look at the statistics of the Hamiltonian describing the system. More precisely, the distribution of differences of neighbouring energy eigenvalues normalised by the local energy density is argued to follow some known distribution, different in the chaotic than in the integrable case.



Examples of the energy level spacing statistics for a chaotic (left) and an integrable (right) system.

Quantum chaos and black holes

Interestingly, a connection between quantum chaos and the field of black hole physics was recently discovered. In 2015, it was argued that in the quantum version of chaos, an upper bound should exist on the Lyapunov exponent, as a function of the temperature of the system. It was shown a few decades before that black holes were actual thermodynamical objects possessing a temperature. Further study, e.g. in the holographic context of AdS/CFT, revealed that black holes are systems that saturate the chaos bound. This, regarding the classical relation between chaos and thermalisation, drew a lot of attention to quantum chaos in the high-energy physics community.

Kévin Nguyen
Doctoral researcher I VUB

More than a century after its formulation, General Relativity still resists every single experimental and observational test that physicists have designed. However, this does not mean that it is a complete theory of gravity, but rather that observations are not accurate enough to falsify it yet. From the theory perspective, the simple fact that General Relativity is incompatible with the working principles of quantum mechanics calls for a deeper understanding and possibly signals its incompleteness.

The cosmological constant problem

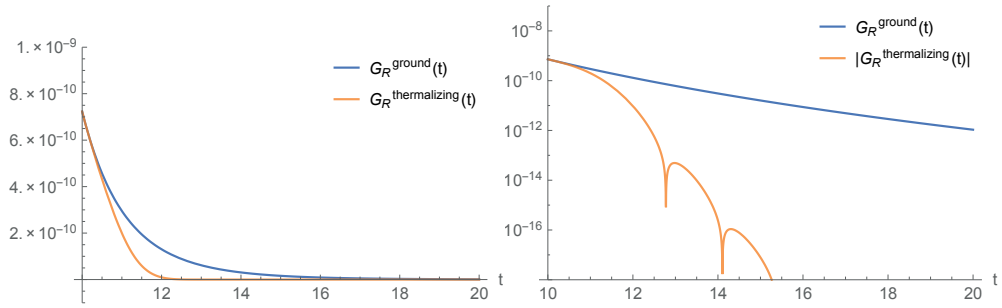
Although it is still unclear how the gravitational field satisfies the rules of quantum mechanics, Quantum Field Theory has been very successful in describing all other fundamental particles and interactions. However, when considered simultaneously to General Relativity, one encounters a series of intriguing puzzles, among which the cosmological constant problem is a striking one. Each fundamental quantum field is source of vacuum energy and hence contributes to the so-called cosmological constant. Observationally, the latter should manifest itself through the Hubble expansion rate of our Universe. “Why is the observed cosmological constant *unnaturally small* compared theoretical estimates for the contributing vacuum energies?”, is then the essence of the cosmological constant problem.

While some current theoretical developments such as String Theory or Loop Quantum Gravity attempt at a unification of quantum mechanics with the laws of gravity, an approach based on an effective field theory treatment of gravity is more likely to be testable in the near future. The idea behind such an approach is to parameterize possible corrections to General Relativity relevant to physics that can be probed through current observations. Part of my research explores the possibility of resolving the cosmological constant problem within an effective field theory approach to gravity. My co-advisor and I have proposed a theoretical model that dynamically reduces the Hubble expansion rate to the small observed value, irrespective of a *naturally large* cosmological constant. The model introduces an additional physical field, whose interactions with the gravitational field are restricted by the requirements of the effective field theory approach. In particular, these interactions are not sensitive to the precise microscopic details of the underlying quantum theory of gravity. The proposed solution being mathematically elegant, we plan to continue developing the model and study its various phenomenological implications.

Gauge/gravity duality

Also intriguing is the fact that General Relativity considered in asymptotically anti-de Sitter spacetimes (AdS) can be used to study certain classes of strongly interacting gauge theories equipped with *conformal symmetry* (CFT). This fruitful connection goes under the name of *gauge/gravity duality, AdS/CFT* or *holography.* It offers unprecedented tools to study these strongly coupled quantum field theories that are especially valuable in regimes where more conventional techniques fail.

Out-of-equilibrium processes in strongly coupled CFT are instances where conventional techniques fail to give accurate predictions. Using gauge/gravity duality, I have studied *thermalization* and *chaos*, two characteristic behaviors found in out-of-equilibrium systems. While chaos is a measure of sensitivity to initial conditions of the subsequent time evolution of a system, thermalization describes its approach to equilibrium. Through the holographic correspondence, these are related to the physics of black holes in AdS. As it turns out, thermalization can be understood as the gravitational collapse of disordered matter into a black hole, to which one can associate thermal properties such as temperature and entropy. Chaos, on the other hand, emerges from the gravitational acceleration of objects falling into a black hole and therefore creating strong gravitational fields capable of significantly disturbing the behavior of matter far away from the black hole.



(a) Comparison of the ground state and thermalizing out-of-equilibrium propagators in a holographic CFT. (b) Same quantities shown in logarithmic scale. In the thermalizing case, the damped oscillating behavior is reminiscent of the behavior of standing waves gradually absorbed by a black hole in anti-de Sitter. This correspondence is made precise through gauge/gravity duality.

Yet another possible use of holography is the study of strongly coupled quantum fields in cosmology. The importance of quantum fluctuations for cosmology is by now well appreciated, as they are known to be responsible for the formation of all structures – such as galaxies – in our present observable Universe, after having been amplified by the early inflationary expansion. The study of such quantum fluctuations on cosmological scales is mathematically very challenging though, as the Universe is curved and expanding. For that reason, I have contributed to developing the holographic correspondence between strongly coupled CFT in cosmology and gravitational physics in AdS. This might turn out useful in future studies of quantum fluctuations in a cosmological context, one of our best observational window into fundamental physics.

Appraisals and Prizes I Theses defended in 2018

Appraisals and Prizes

- Dr. Charles Rabideau (VUB) obtained a prestigious postdoctoral fellowship from the *Natural Sciences and Engineering Research Council of Canada* allowing him to extend his postdoctoral stay at the VUB.
- Sibylle Driezen (VUB) was awarded a 2-year extension of her FWO doctoral fellowship.

Theses defended in 2018

- Dries Coone (VUB) – "Inflation: generic predictions and nilpotent superfields"
  1 June 2018 (Promotors: Profs. Ben Craps and Diederik Roest; co-promotor: Prof. Alberto Mariotti).
- Céline Zwikel (ULB) – "Aspects of non-AdS holographic dualities in three dimensions"
  15 June 2018 (thesis advisor: Prof. Stéphane Detournay).
- Victor Lekeu (ULB) – "Aspects of electric-magnetic dualities in maximal supergravity"
  18 June 2018 (thesis advisors: Profs. Marc Henneaux and Geoffrey Compère).
- Tim De Jonckheere (VUB) – "Measures of correlation in holographic theories"
  4 July 2018 (Promotor: Prof. Ben Craps).
- Arash Ranjbar (ULB) – "String Dualities and Gaugings of Supergravity"
  11 July 2018 (thesis advisor: Prof. Marc Henneaux).
- Roberto Oliveri (ULB) – "Applications of space-time symmetries to black holes and gravitational radiation"
  31 August 2018 (thesis advisor: Prof. Geoffrey Compère).
- Paolo Gregori (ULB) – "Matrix models for holography and supersymmetric localization"
  5 September 2018 (thesis advisors: Profs. Frank Ferrari and Marco Billò – "cotutelle" with the University of Turin).

Talks at conferences, seminars and schools

Aqeel Ahmed

Clockwork perspective on BSM model building
EOS be-h WP1 meeting, VUB Brussels, Belgium
9 November 2018

Clockwork Mechanism: A 4D/5D perspective on BSM model building
MPIK, Heidelberg, Germany – 26 November 2018

Neutral Naturalness at the LHC
Winter Solstice meeting, ULB, Brussels, Belgium
20 December 2018

Tatsuo Azeyanagi

Aspects of large-D matrix models
Utrecht University, Netherlands – 25 January 2018

Warped Black Holes in Lower-Spin Gravity
Université Libre de Bruxelles, Belgium – 25 May 2018

Aspects of Large-D Matrix Models and SYK-like Physics
Institut d'Astrophysique de Paris, France
12 June 2018

Vijay Balasubramanian

The maps inside your head

- CERN, Geneva, Switzerland
  25 January 2018
- Inst. of Physics, Amsterdam, The Netherlands
  28 May 2018
- Scuola Normale, Pisa, Italy – 10 June 2018
- Simons Center, Stony Brook, USA
  12 September 2018

The life of Stephen Hawking
WBUR Radio Program, Boston, USA
10 March 2018

Dynamical self-organization and reorganization of grid cells
Univ. Texas, Austin, USA – 18 March 2018

Potential signatures of entanglement of the visible world with a hidden sector
ULB, Brussels, Belgium – 20 May 2018

From brains to black holes: information and emergent phenomena
DIEP Colloquium, Leiden, The Netherlands
29 May 2018

Random couplings from entanglement with dark matter
Galileo Galilei Institute, Florence, Italy – 18 June 2018

The brain distributes computation to function efficiently
Bio. Distributed Algorithms 2018, Egham, UK
21 July 2018

Dynamical self-organization of reorganization in the grid system
Google DeepMind, London, UK – 24 July 2018

The Physics of Smell
Aspen Center for Physics, Aspen, USA
10 August 2018

Momentum-space entanglement and the renormalization group
Brookhaven National Lab, Stony Brook, USA
10 September 2018

Glenn Barnich

Lectures on BMS symmetry
Wits University, Second Mandelstam Theoretical Physics School, Johannesburg, South Africa
16-17 January 2018

BMS current algebra and central extension

- Wits University, Second Mandelstam Theoretical Physics Workshop
  Durban, South Africa – 22 January 2018
- Scuola Normale Superiore, Pisa, Italy
  31 January 2018
- The joint meeting on quantum field theory and nonlinear phenomena
  Sinaia, Romania – 21 April 2018
- Perimeter Institute, Waterloo, Canada
  24 May 2018
- Université de Lyon, France – 25 June 2018

Electromagnetic edge modes and black hole entropy
Université du Luxembourg, Luxembourg
19 September 2018

Charged black body radiation

- Technical University Vienna, Austria
  16 October 2018
- Albert-Einstein-Institute, Golm, Germany
  23 October 2018
- IISER Thiruvananthapuram,
  Indian Strings 2018, India
  18 December 2018

Chris Blair

The Exceptional Sigma Model
Centro Atomico Bariloche, Bariloche, Argentina
January 2018

Unifying String and Brane Actions with Exceptional Groups
ENS Lyon, France – 9 July 2018

O-folds: Orientifolds and Orbifolds in Exceptional Field Theory
Corfu Summer Institute, Hellenic School and Workshops on Elementary Particle Physics and Gravity, Corfu, Greece – 14 September 2018

Andres Collinucci

Flops of length two, or the conifold 2.0
Universidad Autónoma de Madrid, Spain
7 March 2018

Geoffrey Compère

Analytic Signatures of High Spin Extreme Mass Ratio Inspirals and Mergers

- Conference venue Malta, Malta
  11 January 2018
- Max Planck Institute Potsdam, Germany
  19 February 2018

Gravitational Waveforms from Gargantua's lunch
Peyresq conference venue, Peyresq, France
14 June 2018

PhD School: *The Infrared Triangle of Gravity*
University Prague, Czech Republic
10-14 September 2018

PhD School: *Advanced General Relativity*
ULB, Brussels, Belgium – 1-31 October 2018

Ben Craps

Entwinement
AEI Potsdam, Germany – 27 February 2018

Holography and thermalization in optical pump-probe spectroscopy
University of Crete, Heraklion, Greece – 8 May 2018

Quantum Chaos, Thermalization and Black Holes
University of Crete, Heraklion, Greece – 9 May 2018

Quantum chaos, thermalization and holography
University of Groningen, The Netherlands
1 June 2018

Holography and thermalization in optical pump-probe spectroscopy
University of Würzburg, Germany – 2 August 2018

Saskia Demulder

Poisson-Lie T-duality from a doubled perspective
Theory at sea, Oostduinkerke, Belgium
7 June 2018

The YB-WZ model and Poisson- Lie T-duality
Conference Dualities and Generalized Geometries – Corfu, Greece – 12 September 2018

Integrable deformation and Poisson-Lie T-duality from a doubled perspective

- U. of Oviedo, Spain – 13 November 2018
- LMU and Max Planck Institute, Munich, Germany – 29 December 2018

Stephane Detournay

Warped but Simple: a simple dual for WCFT thermodynamics
Niels Bohr Institute, Copenhague, Denmark
20 March 2018

Of Black Holes and the Monster
UCL, Louvain-la-Neuve, Belgium
13 December 2018

Sibylle Driezen

Integrable D-branes in lambda-deformations

- Theory at Sea, Oostduinkerke, Belgium 8 June 2018
- Kyoto University, Japan – 13 July 2018
- CERN, Geneva, Switzerland 27 September 2018

Open strings in integrable deformations of sigma models
Corfu Summer Institute, Greece
11 September 2018

Oleg Evnin

AdS and Cold Atoms

- Albert Einstein Institute, Potsdam, Germany 21 May 2018
- University of Vienna, Austria 25 September 2018
- Jagiellonian University, Krakow, Poland 24 October 2018

Quantum resonant systems, integrable & chaotic

- HEPMAD18 conference, Antananarivo, Madagascar – 10 September 2018
- University of Vienna, Austria 26 September 2018
- Jagiellonian University, Krakow, Poland 22 October 2018

Quantum and classical resonant systems
Holographic Tensors mini-symposium, OIST, Okinawa, Japan – 2 November 2018

Large structured matrices and quantum chaos in resonant systems
National University of Singapore, Singapore
21 December 2018

Frank Ferrari

Introductory lectures on the melonic limit of models with disorder, tensor models and matrix models, and quantum black holes
Second Mandelstam Theoretical Physics School: Recent Advances in AdS/CFT, Witwatersrand University, Johannesburg, South Africa
15-16 January 2018

Phases of Matrix Quantum Mechanics and Quantum Gravitational Collapse from the new Large D Limit
Second Mandelstam Theoretical Physics Workshop: Recent Advances in AdS/CFT, Protea Edward Marriott Hotel, Durban, South Africa
23 January 2018

The New Large D Limit of Matrix Models, Phases of Matrix Quantum Mechanics and Quantum Gravitational Collapse
University of Southampton, United Kingdom
14 March 2018

On the New Large D Limit of Matrix Models and Phases of Matrix Quantum Mechanics and SYK Models
Perimeter Institute for Theoretical Physics, Waterloo, Ontario, Canada – 3 May 2018

On Melonic Matrix Models and Black Holes
Perimeter Institute for Theoretical Physics, Waterloo, Ontario, Canada – 4 May 2018

On Melonic Matrix Models and SYK-like Black Holes

- Institute for Advanced Study, Princeton, New Jersey, USA – 8 May 2018
- Instituto Superior Técnico, Lisbon, Portugal 4 June 2018

On the Melonic Limit of Matrix Models and Quantum Black Holes
Centro di Ricerca Matematica Ennio De Giorgi, Collegio Puteano, Scuola Normale Superiore, Pisa, Italia – 15 June 2018

Adolfo Guarino

Progress in massive IIA holography

- University Adolfo Ibáñez, Viña del Mar, Chile 8 January 2018
- Centro Atómico Bariloche, Bariloche, Argentina – 17 January 2018

Holographic RG flows from massive IIA
University of Granada, Spain – 25 January 2018

AdS_4/CFT_3 holography from massive IIA
University of Murcia, Spain – 24 May 2018

Accelerating Universes from String Theory

- University of Ghent, Belgium – 21 June 2018
- University of Palencia, Palencia, Spain 4 September 2018

How to get masses from Extended Field Theories
Institute for Theoretical Physics IFT UAM-CSIC, Madrid, Spain – 20 December 2018

Marc Henneaux

The BMS group at spatial infinity
NYU, New York, USA – 28 March 2018

Gravitational electric-magnetic duality and exotic theories of gravity
11th Workshop on "Quantum Field Theory and Hamiltonian Systems" Sinaia, Romania
19 April 2018

Gravité quantique et théorie des cordes
Collège de France/ Tel Aviv University Symposium, Paris, France – 7 juin 2018

Strings 2019 in Brussels
Conference "Strings 2018", OIST, Okinawa, Japan
25-30 June 2018

The Cosmological Singularity
Conference "15th Marcel Grossmann Meeting", Rome, Italy – 2-5 July 2018

Asymptotic Symmetries of Electromagnetism and Gravity
Four lectures given at the Summer School "The black hole information loss paradox" University of Bremen, Germany – 3-6 September 2018

Gravitational electric-magnetic duality and the (4,0) exotic theory in 6 dimensions
Workshop "Dualities and Generalized Geometries", Corfu, Greece – 10-14 September 2018

Topics in gravity: Hamiltonian formalism and asymptotic structure
International Amsterdam-Brussels-Geneva-Paris Doctoral School on Theoretical Physics (18 hours)
Paris, France – 14-20 November 2018

The BMS group at spatial infinity: the Hamiltonian approach
Universidad de la República, Montevideo, Uruguay
7 December 2018

The BMS group at spatial infinity
Universidad de Santiago de Chile, USACH, Chile
11 December 2018

Gravitational electric-magnetic duality and the missing (exotic) maximal supergravities in 6 dimensions
Universitad Católica, Santiago, Chile
13 December 2018

Yegor Korovin

Towards flat space holography
Bad Honnef, Germany – 15 March 2018

Holographic reconstruction of asymptotically flat spaces

- Wuerzburg, Germany – 31 July 2018
- Potsdam, Germany – 3 December 2018

Victor Lekeu

Exotic fields and maximal supersymmetry in six dimensions

- Université Libre de Bruxelles, Belgium
  14 March 2018
- Albert Einstein Institute, Potsdam, Germany
  26 November 2018

Supergravity gaugings and BRST cohomology
Corfu Summer Institute, Greece
10 September 2018

Laura Lopez Honorez

21cm and EoR window on DM
Laboratoire Univers et Particules de Montpellier, France – 16 January 2018

H-coupled minimal DM

- Rencontres de Moriond, La Thuile, Italy
  15 March 2018
- Latin America Webinars in Physics, web
  28 March 2018

A fresh look into interacting dark matter scenarios Dark side of the Universe
Annecy, France – 25 June 2018

EDGES observations of 21 cm line and possible implications for dark matter
RWTH Aachen, Germany – 23 October 2018

H portal to fermionic Dark Matter: from WIMP to FIMP
ECT workshop, Trento, Italy – 4 October 2018

H portal to fermionic Dark Matter: freeze-in vs freeze-out
UAM, Madrid, Spain – 26 November 2018

Vincent Luyten

A quantum hydrodynamical description for many-body chaos
Vrije Universiteit Brussel, Belgium – 25 January 2018

Conformal flow equations: toy models for AdS instability
Université Libre de Bruxelles, Belgium – 5 June 2018

Weak field regime of the cubic wave equation on AdS
Theory@sea conference, Oostduinkerke, Belgium
7 June 2018

Alberto Mariotti

Low mass diphoton resonances at the LHC
Rencontre de Moriond, La Thuile, Italy
13 March 2018

Singlet Doublet Dark Matter Freeze-in
CERN (LLP workshop) Geneva, Switzerland
17 May 2018

Dark matter at the LHC: status and new directions
University of Groningen, The Netherlands
31 May 2018

Dark Matter Freeze-in and LHC displaced signatures

- Durham University, UK – 12 July 2018
- Galileo Galilei Institute, Florence, Italy
  27 August 2018
- UCL, Louvain-La-Neuve, Belgium
  24 October 2018

Javier Matulich

Asymptotic dynamics of General Relativity on AdS_3 reconsidered
Université Libre de Bruxelles, Brussels, Belgium
24 May 2018

Revisiting the asymptotic dynamics of General Relativity on AdS_3

- Universidad de Santiago de Chile, Santiago de Chile, Chile – 28 August 2018
- Universidad de Concepción, Concepción, Chile – 24 September 2018

Wout Merbis

Supersymmetric GCA2 /BMS3 blocks
IPM, Teheran, Iran – 8 May 2018

Science of time travel: an unrealistic way to build a real time machine
Pint of Science festival, Ghent, Belgium
15 May 2018

Conformal blocks from the coadjoint orbit

- ULB, Brussels, Belgium – 22 November 2018
- Utrecht University, Utrecht, The Netherlands 30 November 2018

An unrealistic way to build a real time machine
Talk Cosmic to Me space café, Brussels, Belgium
19 December 2018

Saereh Najjari

EOS meeting WP1
IIHE, VUB, Brussels, Belgium – 9 November 2018

Exploring Twin Higgs Models via the Higgs and Hypercharge Portal
MPIK, Heidelberg, Germany – 27 November 2018

Kevin Nguyen

de Sitter-invariant states from holography

- Chulalongkorn University, Bangkok, Thailand 30 January 2018
- Université Libre de Bruxelles, Belgium 15 March 2018

Pierluigi Niro

QCD domain walls and holography
KU Leuven, Belgium – 17 October 2018

Stefan Prohazka

Kinematical (Higher-Spin) Chern-Simons Theories

- University of Edinburgh, Scotland 17 January 2018
- Johannes Gutenberg University, Mainz, Germany – 17 March 2018

Charles Rabideau

Holographic Entanglement and Poincare blocks in three-dimensional flat space
Princeton University, USA – 19 February 2018

Nonlinear dynamics of gravity from entanglement in conformal field theories

- University of Amsterdam, The Netherlands 27 March 2018
- Leiden University, The Netherlands 29 March 2018

Higher dimensional differential entropy: Towards the reconstruction of surface areas from entanglement
Johannes Gutenberg University, Mainz, Germany
29 May 2018

Max Riegler

Warped Black Holes in Lower-Spin Gravity

- Universiteit van Amsterdam, The Netherlands 30 January 2018
- ETH Zürich, Switzerland – 6 March 2018
- Kyoto University, Japan – 16 March 2018
- KAVLI IPMU, Tokyo, Japan – 5 April 2018
- Harvard University, Cambridge, MA, USA 1 May 2018
- Kyoto University, Japan – 30 July 2018
- University of Vienna, Austria 30 October 2018
- Tsinghua University, Beijing, China 29 November 2018
- KAVLI IPMU, Tokyo, Japan 4 December 2018

Holography and Entanglement in 3D Flat Spacetime
ULB, Brussels, Belgium – 24 May 2018

How General is Holography?
Kyoto University, Japan – 12 July 2018

Flat Space Holography and the Quantum Null Energy Condition

- Tsinghua University, Beijing, China
  27 November 2018
- Kyoto University, Japan – 14 December 2018

Gábor Sárosi

Boundary dual of the bulk symplectic form

- University of Minnesota, Mineapolis, USA
  6 May 2018
- ULB, Brussels, Belgium – 25 May 2018

Complexity and the bulk volume, a new York time story

- University of British Columbia, Vancouver, Canada – 1 October 2018
- MIT, Boston, USA – 7 November 2018
- Princeton University, Princeton, USA
  19 November 2018

Alexander Sevrin

Theoretical High Energy Physics after the LHC: Quo Vadis?
Theory at Sea, Oostduinkerke, Belgium
7 June 2018

Throughout the year, numerous presentations concerning the Einstein Telescope and the R&D facility ETpathfinder for decision makers and politicians, industrialists, scientists and lay people.

Charlotte Sleight

Lectures on Higher spin theories and holography
Benasque Center of Science, Benasque, Spain
23-30 September 2018

Dan Thompson

Generalised T-dualities and Integrable Deformation
Centro Atomico Bariloche, Bariloche, Argentina
17 January 2018

An Introduction to Generalised Dualities and Their Applications
Corfu Summer Institutes in Theoretical Physics, Corfu, Greece – 10 September 2018

O-folds: Orientifolds and Orbifolds in Exceptional Fields Theory
University of Oviedo, Spain – 19 September 2018

Exploring generalised dualities and integrable deformations

- U. Santiago de Compostela, Spain
  28 November 2018
- London Polygon Seminar, Imperial College, London, UK – 21 November 2018

Duality Integrability and Holography
U. of Athens, Greece – 21 December 2018

Matthias Vereecken

High energy neutrino emission from obscured sources through the pp channel
TeVPA 2018, Berlin, Germany – 31 August 2018

Hongbao Zhang

Dark Soliton and Quantum Wave Turbulence in Holographic Superfluids
Utrecht University, The Netherlands – 8 March 2018

Strong Cosmic Censorship: As Subtle As Ever
Tianjin University, Tianjin, China
17 September 2018

List of Publications

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NONLINEAR PHYSICAL CHEMISTRY UNIT

Group of Professor Anne De Wit I ULB

Researchers

Permanent Members

Fabian Brau

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Alexis Grau Ribes

Alexia Papageorgiou

Dimitra Spanoudaki

Reda Tiani

Valérie Voorsluijs

Research Summary

Convective dissolution of CO_2 in water and salt solutions

C. Thomas, S. Dehaeck and A. De Wit

In carbon sequestration techniques, dissolution of CO_2 into saline aquifers can lead to the development of buoyancy-driven convection in the brine which enhances the efficiency of CO_2 transfer. We have analyzed experimentally the onset, development and dynamic properties of such convective fingering of CO_2 into water, Antarctic water and in NaCl salt solutions of various concentrations to study the influence of varying the salt concentration on the buoyancy-driven convective dynamics. We have quantified the growth of convective fingers by performing, among others, a Fourier analysis of the pattern formation at early times and have qualitatively studied the nonlinear spatio-temporal dynamics at later times. In agreement with theoretical predictions, we find that increasing the salt concentration hinders the development of the instability as it delays the onset of convection, increases the wavelength of the convective pattern, decreases the growth rate and velocity of fingers as well as their interactions. Our experimental results provide quantitative data that should help the benchmarking of theoretical studies.

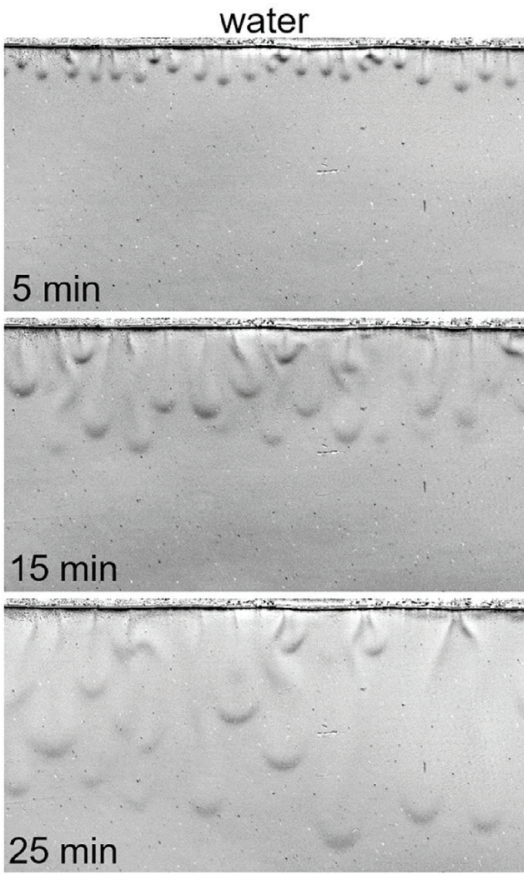


Figure: Convective dissolution pattern of CO2 dissolving in an aqueous salt solution, visualized with the help of a Schlieren imaging system sensitive to density gradients in the solution.

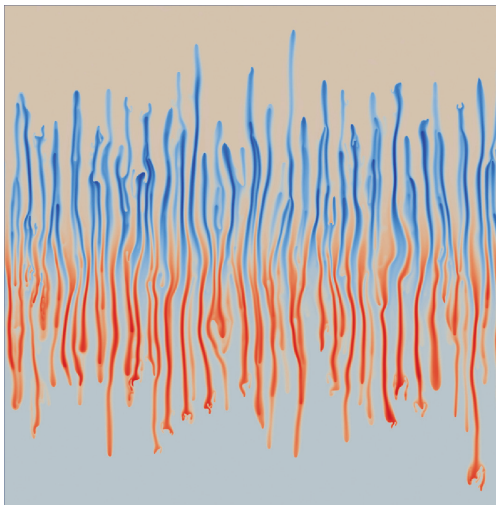


Figure: Numerical convective fingering pattern obtained when a denser solution lies above a less dense solution in the gravity field and differential diffusion effects are at play.

Control of convection velocity by differential diffusion effects

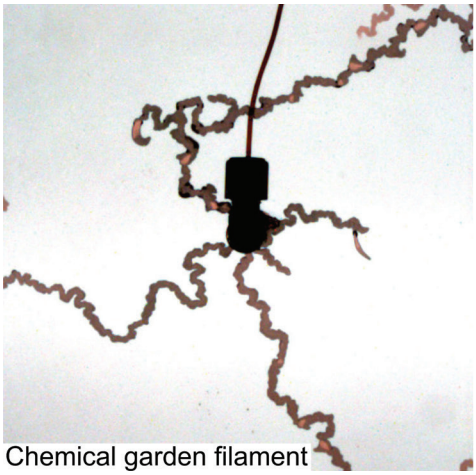
S. S. Gopalakrishnan, J. Carballido-Landeira, B. Knaepen and A. De Wit

Convective fingering instabilities of a miscible interface between two fluids in a gravitational field can develop due to adverse density gradients as in the well-known Rayleigh-Taylor (RT) and double-diffusive (DD) instabilities. In the absence of differential diffusion, the mixing rate and the onset time of the RT instability developing when a denser solution of a given solute A overlies a less dense solution of a solute B are respectively proportional and inversely proportional to the initial density difference $\Delta\rho_0$ between the two superposed layers. We have shown both experimentally and theoretically for porous media flows that, when the mechanisms of RT and DD instabilities are combined, the properties of the convective growth of the fingers are controlled by the dynamic density jump $\Delta\rho_m$ of the nonmonotonic density profile induced by the differential diffusion effects.
In particular, the onset time and mixing rate can be controlled by varying the ratio of the diffusion coefficients of the solutes.

Filament dynamics in confined chemical gardens and in filiform corrosion

F. Brau and A. De Wit

Two reaction systems that are at first sight very different produce similar macroscopic filamentary product trails. The systems are chemical gardens confined to a Hele-Shaw cell and corroding metal plates that undergo filiform corrosion. Using experiments and theoretical analysis, F. Brau and collaborators have revealed numerous similarities that had not been noted earlier between these different systems. The filament dynamics obey similar scaling laws in both instances: filament motion is nearly ballistic and fully self-avoiding, which creates self-trapping events. Chemical similarities include the product composition, basically a metal oxyhydroxide that, in the case of silicate chemical gardens, typically also includes an outer layer of amorphous silica. They both form filamentary reaction products at macroscopic length-scales and belong to the large class of self-organizing far-from-equilibrium systems.



Chemical garden filament

Filiform corrosion

On the possibility of spontaneous chemomechanical oscillations in adsorptive porous media

Y. De Decker

We derive general conditions for the emergence of sustained chemomechanical oscillations from a non-oscillatory adsorption/desorption reaction in a gas/solid porous medium. The oscillations arise from the nonlinear response of the solid matrix to the loading of the adsorbed species. More particularly, we prove that, in order for oscillations to occur, adsorption of the gas must in general cause a swelling of the solid matrix. We also investigate the prototypical case of Langmuir kinetics both numerically and analytically.

Reconstructing stochastic attractors from nanoscale experiments on a non-equilibrium reaction

Y. De Decker

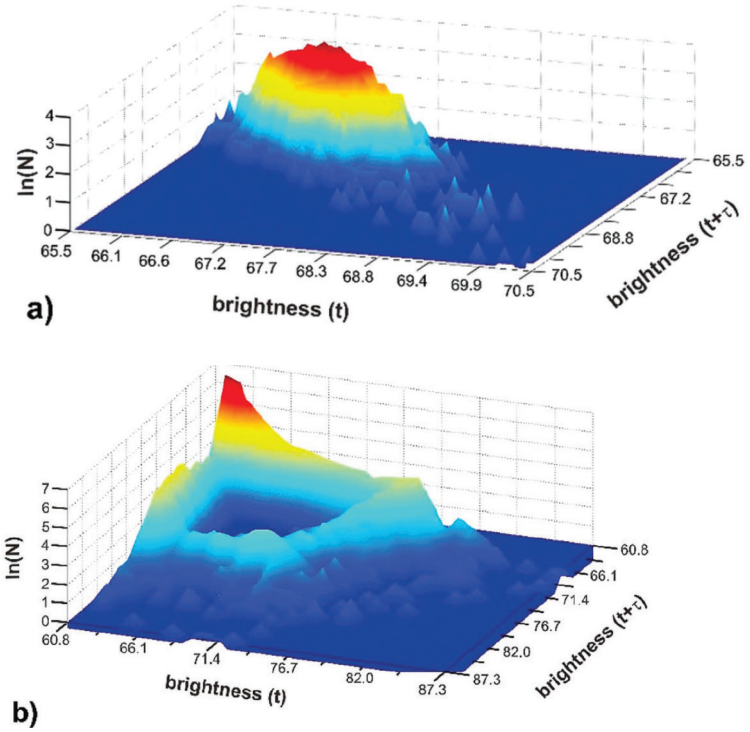


Fig 1 : Histograms reconstructed from time series of the FEM brightness (a) for a steady state just before a bifurcation point and (b) in the presence of oscillations. Highly probable states are represented in red, and low-probability states are in blue.

We studied the catalytic $NO_2(g) + H_2(g)$/Pt system on model platinum catalysts with nanoscale spatial resolution by means of field emission microscopy (FEM).
While the surface of the catalyst is in a non-reactive state at low H_2 partial pressure, bursts of activity are observed when increasing this parameter. These kinetic instabilities subsequently evolve towards self-sustained periodic oscillations for a wide range of pressures. Combining time series analyses and numerical simulations of a simple reaction model, we clarify how these observations fit in the traditional classification of dynamical systems.
In particular, reconstructions of the probability density around oscillating trajectories show that the experimental system defines a crater-like structure in probability space (see Fig.1).

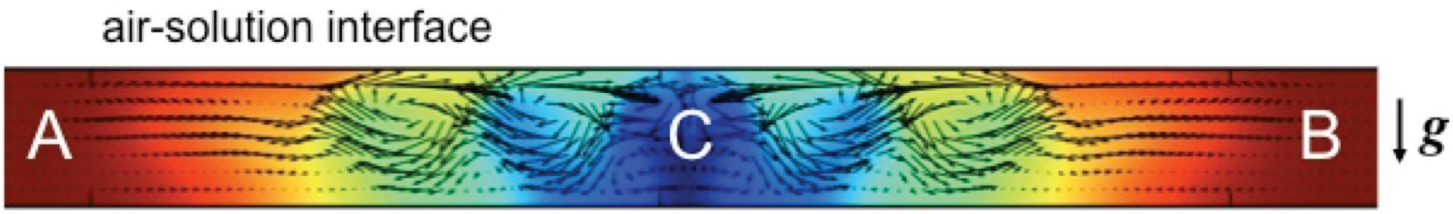
The experimental observations thus correspond to a noise-perturbed limit cycle emerging from a nanometric reactive system. This conclusion is further supported by comparison with stochastic simulations of the proposed chemical model.
The obtained results and simulations pave the way towards a better understanding of reactive nanosystems.

Oscillations of simple A + B → C reactions through the coupling between reactive Marangoni and buoyancy-driven convection

M. A. Budroni, V. Upadhyay, L. Rongy

Chemical oscillations and waves have long been known to emerge when complex chemical reactions are maintained out-of-equilibrium. However, they seem to be restricted to exotic classes of kinetics such as autocatalysis. In order to extend the possibilities for oscillations to the realm of ubiquitous bimolecular reactions, we have found a new mechanism through which self-sustained chemical oscillations and waves can be maintained in batch conditions with a simple A + B → C reaction, in the absence of any nonlinear chemical feedback or external trigger.

When two miscible reactants A and B, initially separated in space, react upon diffusive mixing, the product C can generate convective flows by locally changing the surface tension of the solution or its density. By means of numerical simulations, we have shown that, if the surface tension increases sufficiently during the reaction, a transient Marangoni oscillatory flow can be observed. The antagonistic coupling with buoyancy-driven convection, arising from density changes during the chemical reaction, can enhance the oscillatory instability, leading to self-sustained oscillations.



Fluid velocity field superimposed on the density field (red: high density, blue : low density). Upon reaction between A and B, C is produced in the middle of the system, increasing the surface tension and inducing thereby a convergent Marangoni flow at the surface and hence a vertical down-flow. By decreasing the local density of the solution, C generates an antagonistic vertical up-flow opposing the Marangoni-induced flow. This competition induces sustained oscillations.

Research interest of some other members

Chinar Rana
Postdoctoral fellow

Viscous fingering in reactive systems

In a porous medium, the interface between two fluids can deform into finger-like patterns because of a viscous fingering instability when a less viscous fluid displaces a more viscous one. Reactive systems are able to trigger this instability as soon as the chemical reaction changes the viscosity of the interplaying fluids.
In processes like polymer or chemical flooding for oil recovery, viscous fingering affects the efficiency of the oil production. Similarly, this fingering is dramatic for the performance of chromatographic separation techniques as it contributes to peak broadening and distortions.
The goal of my research is to understand theoretically how the fingering instability dynamics is affected by chemical reactions. Specifically, I investigate numerically how the reaction-diffusion specificities of chemical fronts can be used to tune the viscous fingering pattern. The properties of this reactive fingering can be obtained by computing onset times, mixing lengths and characteristics of the nonlinear fingering dynamics as a function of the viscosity ratios. The theoretical investigation aims at predicting the optimal conditions for transport of reactive solutions in porous media.

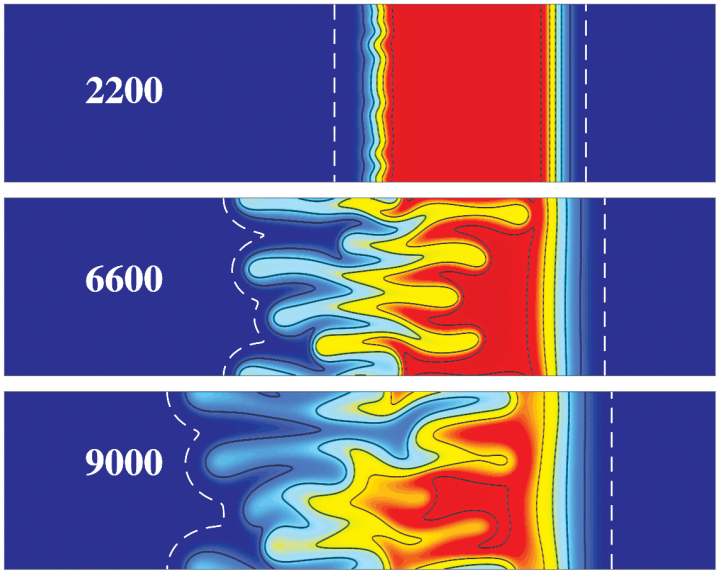
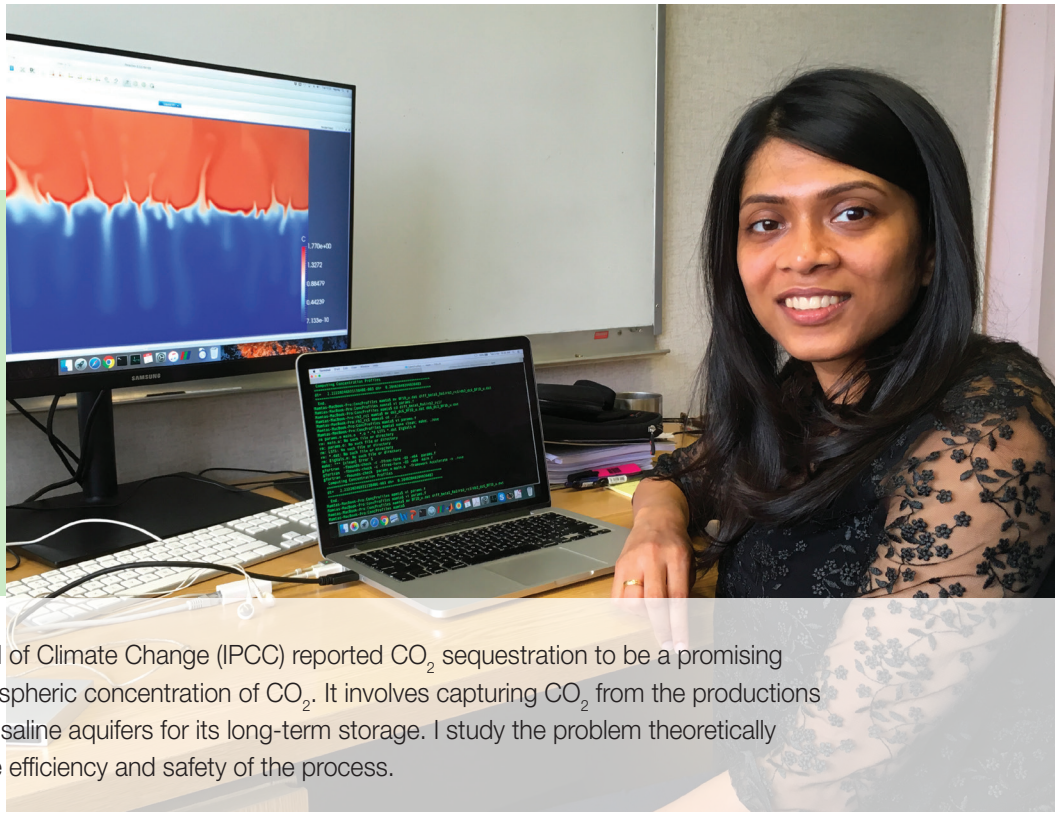


Figure: Simulation of reactive fingering

Publications:

1. Rana, C., Mishra, M., and De Wit, A. (2018) Effect of anti-Langmuir adsorption on spreading in porous media. Europhysics Letters 124, 64003.
2. Rana, C., De Malsche, W., and De Wit, A. (2019) Decreased peak tailing during transport of solutes in porous media with alternate adsorption properties. Chemical Engineering Science (in press).
3. Rana, C., and De Wit, A. (2019) Oscillating viscous fingering dynamics. Chaos (accepted).

Mamta Jotkar
Post-doctoral research fellow



"I am deeply passionate about environment and my current position as a post-doctoral researcher at the Nonlinear Physical Chemistry Unit (NLPC) is directly related to investigating negative emission techniques to combat global climate change."

In 2005, the International Panel of Climate Change (IPCC) reported CO_2 sequestration to be a promising technology to reduce the atmospheric concentration of CO_2. It involves capturing CO_2 from the productions sites, and injecting it into deep saline aquifers for its long-term storage. I study the problem theoretically and numerically to optimize the efficiency and safety of the process.

Upon injection into deep saline aquifers under a cap rock, a layer of less dense CO_2 is formed over the brine. When CO_2 dissolves in the underlying brine, a buoyantly unstable stratification of denser CO_2-rich brine lying on top of the less dense resident brine is typically formed. A buoyancy-driven fingering instability then develops resulting in denser CO_2-rich fingers sinking towards the bottom (see figure).
The convective motion facilitates further transfer of CO_2 to the host phase and increases mixing, which leads to a faster and safer storage of CO_2.

Recently, it has been demonstrated that chemical reactions can accelerate convective fingering. In this context, my objective is to quantify the onset time for convection and asymptotic dissolution fluxes in reactive host phases. My results are useful in predicting the long-time fate of CO_2 during its sequestration and in selecting the storage sites with optimal geochemical composition for improving the efficiency and safety of the process.

Figure: Numerical convective dissolution of CO_2-rich fingers in a reactive host phase.

Appraisals and Prizes

Anne De Wit has been elected as member of the Congress Committee of the International Union of Theoretical and Applied Mechanics (IUTAM).

Anne De Wit and Laurence Rongy will be the Belgian representatives in the management committee of the new COST action “Chemobrionics” (2018-2022).

Delora Gaskins has been awarded a prestigious postdoctoral fellowship of the Belgian American Educational Foundation to join NLPC at ULB.

Valérie Voorsluijs has received:

- the Lepouse Prize 2018 for her doctoral thesis entitled “Emergent properties of nonlinear compartmentalized dynamics”;
- the ChemCYS 2018 3rd prize for her oral presentation in the Physical and Theoretical Chemistry session;
- a Postdoctoral fellowship of the Philippe Wiener and Maurice Anspach Foundation;
- a Research Membership of Common Room, Wolfson College, University of Oxford.

PhD thesis defended in 2018

- V. Voorsluijs – “Emergent properties of nonlinear compartmentalised dynamics” - Supervisor: Y. De Decker.

Master thesis defended in 2018

- S. Gokalp – “Étude expérimentale de l’influence d’un flux sur la sélection de polymorphes de ROY” Promotors: A. De Wit, F. Brau and D. Maes.

Talks at conferences, seminars and schools

Fabian Brau

- Talk at the 10th European Solid Mechanics Conference, Bologna, Italy, July 2-6, 2018
- Invited seminar, Oxford Centre for Industrial and Applied Mathematics (OCIAM), Oxford, UK 18 October 2018

Yannick De Decker

- Invited talk at the Gordon Research Conference "Oscillations and Dynamic Instabilities in Chemical Systems, Les Diablerets, Switzerland 9 July 2018

Jean-François Derivaux

- Poster at the conference "Stochastic Thermodynamics: Experiment and Theory", Max Planck Institute for the Physics of Complex Systems, Dresden, Germany 9-14 September 2018

Anne De Wit

- Invited Seminar in the Chemistry Dept, Instituto de Ciencias, Universidad Nacional de General Sarmiento, Argentina – March 2018
- Invited talk at the ESA Topical Team meeting on Crystallization and Nucleation, Brussels, Belgium March 2018
- Invited plenary talk at the International Interpore 2018 Conference, New Orleans, USA – May 2018
- Oral talk at the XXII Edition of Computational Methods in Water Resources (CMWR 2018), St Malo, France – June 2018
- Invited plenary talk at the Gordon Conference on Flow and Transport in Permeable Media, Newry, USA – July 2018
- Invited talk at the LabEx Tec21 "Engineering of complexity" Day, Grenoble, France – September 2018
- Talk at the ESA Physical Sciences Working Group Meeting, ESTEC, The Netherlands October 2018
- Talk at the 71st Annual Meeting of the Division of Fluid Dynamics of the American Physical Society, Atlanta, USA – November 2018
- Invited talk, Symposium on Patterns and Dynamics in Multiphase and Interface Flow, Gainesville, USA – November 2018

Delora Gaskins

- Poster at the Gordon Research Conference on Oscillations and dynamical instabilities in chemical systems, Les Diablerets, Switzerland 7-13 July 2018

Mamta Jotkar

- Poster at the summer school on 'Flow and transport in porous and fractured media', Cargese, France – 25 June - 7 July 2018
- Poster at the Gordon Research Seminar and Conference "Flow and Transport in Permeable Media", Newry, Maine, USA – 7-13 July 2018
- Participation to the workshop on the numerical code YALES 2 and visit of the CORIA, CNRS University of Rouen, France 19-22 November 2018

Alexia Papageorgiou

- Poster at the Gordon Research Conference on "Oscillations and Dynamic Instabilities in Chemical Systems", Les Diablerets, Switzerland 8-13 July 2018
- Poster at the 69th Annual Meeting of the International Society of Electrochemistry, Bologna, Italy – 2-7 September 2018

Chinar Rana

- Oral talk at the 10th International Interpore Conference on Porous Media, New Orleans, USA 15 May 2018
- Seminar at the Laurentian University, Sudbury, Canada – 16 July 2018

- Poster at the workshop Young Women in Mathematical physics, Department of Mathematics, University of Bonn, Germany 24-26 September 2018

Laurence Rongy

- Invited Seminar in the Área Química, Instituto de Ciencias, Universidad Nacional de General Sarmiento, Argentina – 13 March 2018
- Talk at the Interpore 10th Annual Conference on Porous Media, New Orleans, Louisiana, USA 17 May 2018
- Invited Seminar at the University of Bremen (Germany), Research training group MIMENIMA on Micro-, meso- and macroporous nonmetallic Materials: Fundamentals and Applications 28 May 2018
- Talk during the conference Computational Methods in Water Resources (CMWR 2018), Saint-Malo, France – 6 June 2018
- Talk during the Gordon Research Conference on Oscillations and Dynamic Instabilities in Chemical Systems, Les Diablerets, Switzerland 12 July 2018
- Talk at the APS American Physical Society Division of Fluid Dynamics 71st Annual Meeting, Atlanta, Georgia, USA – 19 November 2018

Dimitra Spanoudaki

- Poster at the Gordon Conference on Oscillations and Dynamic Instabilities in Chemical Systems, Les Diablerets, Switzerland – 8-13 July 2018

Reda Tiani

- Poster at the Gordon Research Seminar and Conference "Oscillations and Dynamic Instabilities in Chemical Systems", Les Diablerets, Switzerland 7-13 July 2018

Virad Upadhyay

- Oral talk at the Gordon Research Seminar on Oscillations and Dynamic Instabilities in Chemical Systems (GRS), Les Diablerets, Switzerland 7-8 July 2018
- Poster at the Gordon Research Conference on Oscillations and Dynamic Instabilities in Chemical Systems held, Les Diablerets, Switzerland 8-13 July 2018

Valérie Voorsluijs

- Talk at the Chemistry Conference for Young Scientists (ChemCYS2018), Blankenberge, Belgium – 19-21 February 2018
- Talk at the conference Analysis and Modeling of Complex Oscillatory Systems (AMCOS), Barcelona, Spain – 19-23 March 2018
- Poster at the 1st Casign Symposium, Leuven, Belgium – 1 September 2018

Scientific stays

Fabian Brau

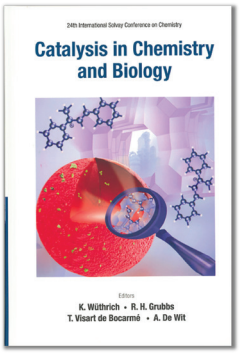
Visit to Prof. Benny Davidovitch, Physics Department, University of Massachusetts, USA
16-28 April 2018
Visiting Professor at ESPCI, Chaire Joliot, Paris, France – 22 October - 8 November 2018

Organized Conferences

Solvay workshop "Mechanics of slender structures in physics, biology and engineering: from failure to functionality", 29-31 August 2018, Université libre de Bruxelles (ULB), Belgium.

Fabian Brau (ULB), Pascal Damman (UMons, Belgium), Niels De Temmerman (VUB, Belgium), Yoel Forterre (Aix-Marseille Univ., France), Pedro Reis (EPFL, Switzerland), Dominiek Reynaerts (KU Leuven, Belgium), Denis Terwagne (ULB, Belgium).

Publications



K. Wüthrich, R.H. Grubbs, T. Visart de Bocarmé and A. De Wit
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Proceedings of the 24th Solvay Conference on Chemistry (2018).

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Effect of anti-Langmuir adsorption on spreading in porous media,
Europhys. Letters 124, 64003 (2018)

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Differential Diffusivity Effects in Reactive Convective Dissolution,
Fluids 3, 83 (2018)

S.S. Gopalakrishnan, J. Carballido-Landeira, B. Knaepen, A. De Wit
Control of Rayleigh-Taylor instability onset time and convective velocity by differential diffusion effects,
Phys. Rev. E 98, 011101(R) (2018).

C. Barroo, V. Voorsluijs, T. Visart de Bocarmé, P. Gaspard, Y. De Decker
Reconstructing stochastic attractors from nanoscale experiments on a non-equilibrium reaction,
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P. Bába, L. Rongy, A. De Wit, M. J. B. Hauser, Á. Tóth, D. Horváth
Interaction of Pure Marangoni Convection with a Propagating Reactive Interface under Microgravity,
Phys. Rev. Lett. 121, 024501 (2018).

F. Haudin, F. Brau, A. De Wit
La chimie génératrice de forme : végétation métallique et jardins chimiques,
Open Science 1, (2018).

R. Tiani, A. De Wit, L. Rongy
Surface tension-and buoyancy-driven flows across horizontally propagating chemical fronts,
Adv. Colloid Interface Sci. 225, 76 (2018).

C. Thomas, S. Dehaeck, A. De Wit
Convective dissolution of CO_2 in water and salt solutions,
Int. J. of Greenhouse Gas Control 72, 105 (2018).

F. Brau, F. Haudin, S. Thouvenel-Romans, A. De Wit, O. Steinbock, S. S. S. Cardoso, J. H. E. Cartwright
Filament dynamics in confined chemical gardens and in filiform corrosion,
Phys. Chem. Chem. Phys. 20, 784 (2018).

P. M. Reis, F. Brau & P. Damman
The mechanics of slender structures,
Nature Physics 14, 1150 (2018).

V. Voorsluijs
Emergent properties of the compartmentalised Belousov-Zhabotinsky reaction,
Chimie Nouvelle 128, 7 (2018).

D. Bullara, Y. De Decker, and I. R. Epstein
On the possibility of spontaneous chemomechanical oscillations in adsorptive porous media
Phil. Trans. R. Soc. A 376, 20170374 (2018)

The mechanics of slender structures

Modern physics edged mechanics out into the wilds of engineering. But multidisciplinary interest in pattern formation has moved it back into the mainstream, bringing with it interest from other fields — as this summer's Solvay Workshop demonstrated.

Pedro M. Reis, Fabian Brau and Pascal Damman

At the turn of last century, the Belgian chemist, industrialist and philanthropist Ernest Solvay organized a conference to enable the most prominent scientists of the time to meet and address contemporary challenges in physics and chemistry. The first Solvay conference took place in Brussels in 1911 and is still considered a turning point from classical to modern physics. Subsequent meetings have continued this tradition, catalysing significant advances in solid-state, particle, chemical and biological physics. In August this year, a cohort of leading experts and young researchers from physics, mechanics, biomechanics, locomotion, materials science, engineering, architecture and art converged in Brussels for a Solvay workshop to explore new opportunities in understanding the mechanics of slender structures — from their failure to their functionality[1].

Within the new paradigm of modern physics, the mechanics of fluids and solids slipped away from the physics mainstream and moved closer to the realm of engineering. But the new field of pattern formation was quietly gaining prominence in the physics community, with the realization that order, form and function can emerge spontaneously from a featureless or disordered system. Early examples, including the Liesegang ring precipitation patterns[2], Rayleigh–Bénard convection[3], Turing patterns[4] and the Belousov–Zhabotinsky reaction[5,6], revived concepts from classical physics, powered by novel analysis tools rooted in nonlinear dynamics and statistical mechanics. Efforts to rationalize pattern formation in these systems eventually led to the emergence of a new paradigm based on far-from-equilibrium thermodynamics and dissipative structures[7] — recognized in Ilya Prigogine's 1977 Nobel Prize in Chemistry.

As the understanding of pattern-forming systems evolved, it became apparent that systems in equilibrium can also generate complex patterns. Instead of energy dissipation, complex structures can result from the interplay of competing physical ingredients. Elastic deformation, fluid flow, electromagnetic forces and surface energy, together with geometric confinement, can often pair to generate patterns in solids and fluids. Pattern-forming systems, involving thin layers of fluids or slender solid objects, for example, tend to require a delicate balance of the various, often antagonistic, forces at play, so as to prevent the domination of bulk energy terms. Within this paradigm, mechanical instabilities in thin elastic sheets emerged rapidly as a canonical system to investigate how geometry can couple to nonlinearities to produce intricate patterns[8–10].

Participants of the Solvay workshop on the 'Mechanics of slender structures in physics, biology, and engineering: from failure to functionality' that took place at the Université libre de Bruxelles (ULB), from 27–29 August 2018. Credit: Victor Levy

The formation of wrinkles in bilayers is now considered an archetypal process for illustrating this pattern-formation mechanism; the buckling of the thin sheet is balanced by the deformation of the soft foundation to produce regular patterns[11]. In the realm of materials science, these buckling instabilities, previously considered the first route toward failure in engineering structures, are now being used to functionalize materials and structures[12]. For example, wrinkles are used to tune the wetting[13] and adhesion[14] properties of a surface; to improve OLED light extraction[15] and increase the efficiency of photovoltaics[16]; or to impart flexibility in otherwise rigid materials, as in stretchable electronics[17] and soft implantable prosthesis[18].

We organized a Solvay workshop this year with the central goal of providing a platform for exchange, discussion, cross-pollination and synthesis for this growing community. The multidisciplinary footprint of the attendees demonstrates how active and porous the boundaries are within this community, but also highlights the common themes that traverse seemingly disparate fields.

The workshop was organized in a series of topical sessions, covering the elastic instabilities of slender objects; elastocapillarity and fluid–structure interaction; foldable structures, origami and kirigami; biomechanics; bio-inspired robotics and stretchable electronics; and soft matter, structures and art. The presentations and discussions during the workshop highlighted the following challenges, which will doubtless keep the community active, vibrant and engaged for years to come.

RESEARCH HIGHLIGHTS OF OTHER SCIENTISTS CONNECTED WITH THE INSTITUTES

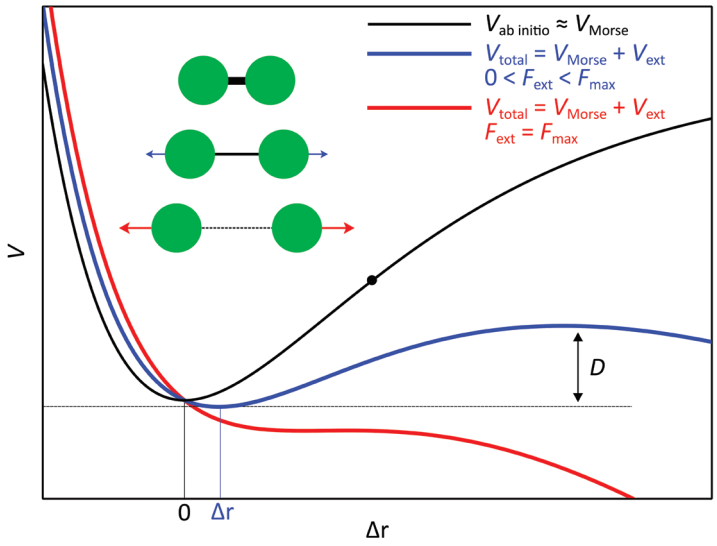
ALGC RESEARCH GROUP I VUB

Group of Professors Frank De Proft, Frederik Tielens, Mercedes Alonso, Freija De Vleeschouwer and Professor Emeritus Paul Geerlings

In recent years the ALGC Research Group has been extending its long-standing research interest in Conceptual Density Functional Theory [1] in a natural way along new research lines on the basis of the experience gained in various aspects of Density Functional Theory. Research Lines have been launched on Molecular Electronics, on Molecular Switches, on Inverse Design and on the study of molecular behaviour in the molecules' real environment upon reactions, i.e. in most cases a solution, requiring ab initio Molecular Dynamics and Metadynamics Simulations. Beyond and along these lines various applied quantum chemical studies are performed applying DFT based concepts on a variety of substrates most often carried out in direct interaction with experimentalists. Recently, as of the appointment of Prof. Frederik Tielens, a new applied research line has been opened into the field of Materials Modeling, characterizing, at the atomic level, inorganic, organic and biological solid materials, especially at the interphases.

In this 2018 Report attention is paid to fundamental work in Conceptual DFT, Molecular Electronics, Molecular Switches, Applied Quantum Chemistry and Materials Modelling illustrating the broadening of the scope of the research activities of the ALG group with combined attention to both fundamental and applied aspects of Quantum Chemistry.

Conceptual DFT



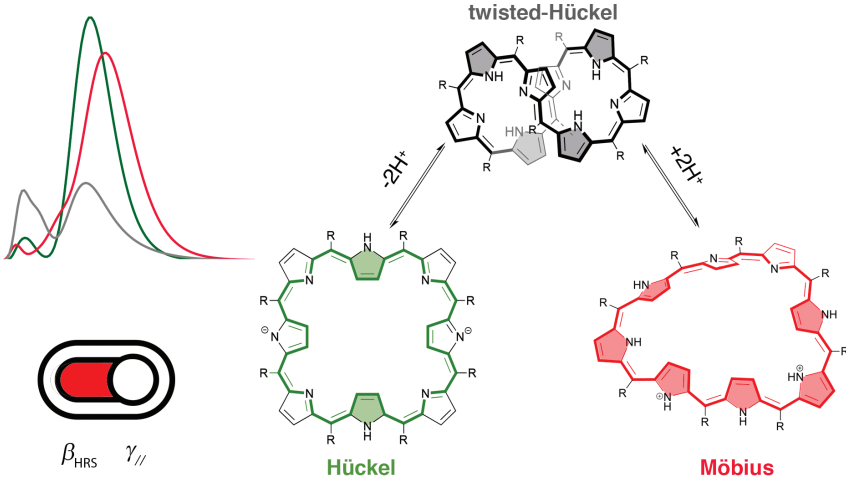
Concerning the Conceptual DFT part particular attention was paid to extending the scope of Conceptual DFT to the vibrant field of Molecular Mechanochemistry [2] by introducing mechanical forces in the energy functional, thus creating a formal and computational framework to test the sensitivity of molecules to external mechanical forces leading, after introductory studies on diatomics, already to an order of magnitude estimate of the variation of molecular electrophilicity under the influence of stretching forces as occurring in biomolecules [3].

As a second example in this line of research the collaboration with Dr. Robert Balawender (Polish Academy of Sciences) should be mentioned, deepening and exploiting the concept of alchemical derivatives, i.e. derivatives of the energy of a molecule when one nucleus is replaced by another. This ansatz was previously shown to be a step forward in the exploration of the huge Chemical Compound Space. In recent work in a walk through the Periodic Table, we composed a table of isolated atom alchemical derivatives which could be a basic instrument in a navigation toolbox [4]. This work also fits into a broader context of our ongoing investigation of the Linear Response function [5][6], for which recently analogies between the four different DFT response kernels and derivatives of Thermodynamic state functions were scrutinized [7].

Molecular Switches

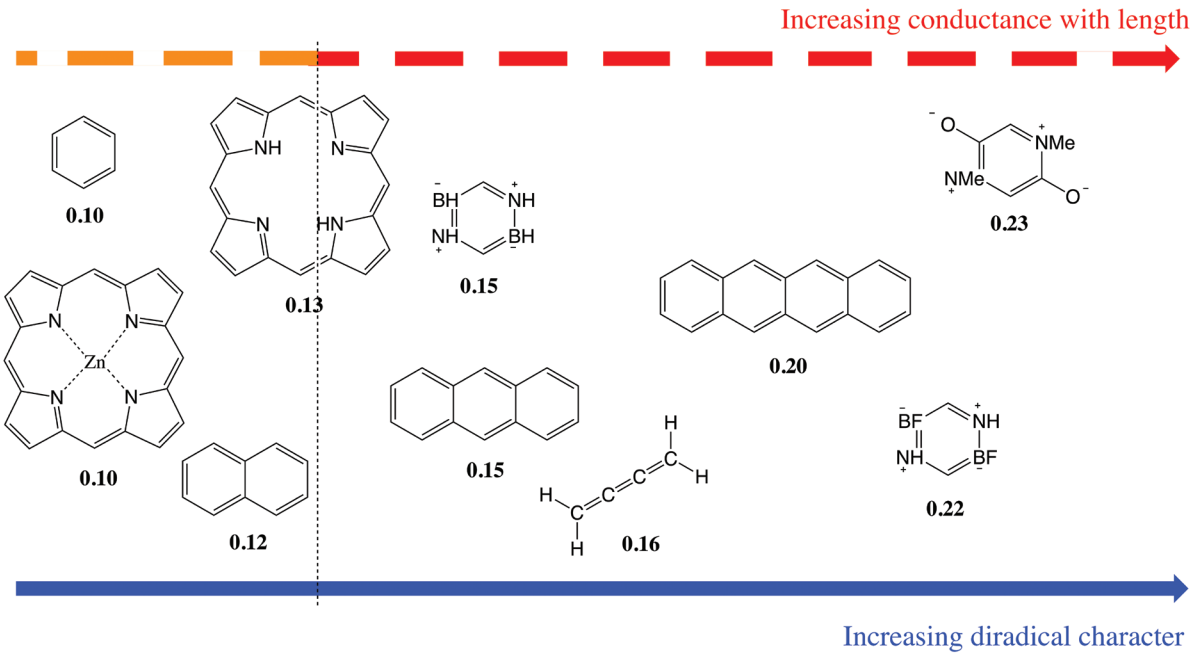
Molecular Switches based on expanded porphyrines have now been explored in ALGC for some years in the case of extended porphyrins under the impetus of Prof. Mercedes Alonso [8], with particular attention to topological switches from Hückel to Möbius rings under the influence of external stimuli.
As a prelude to the use these unique building blocks in non- linear optical switches photophysical properties (e.g. Non Linear Optical properties as βHRS and $\gamma_{//}$) porphyrinoids and octaphyrins were studied with varying molecular topology in collaboration with Prof. Benoît Champagne (UNamur) [9][10].

A particular type of switch has been investigated on the road to the design of thermo-electric switches,combining our knowledge on molecular switching devices, expanded porhyrins and conductance: a topology switch between the Hückel and Möbius form of heptaphyrins was shown to change the sign of the thermopower, indicating their potential as bithermoelectric switches at the molecular scale [11] .

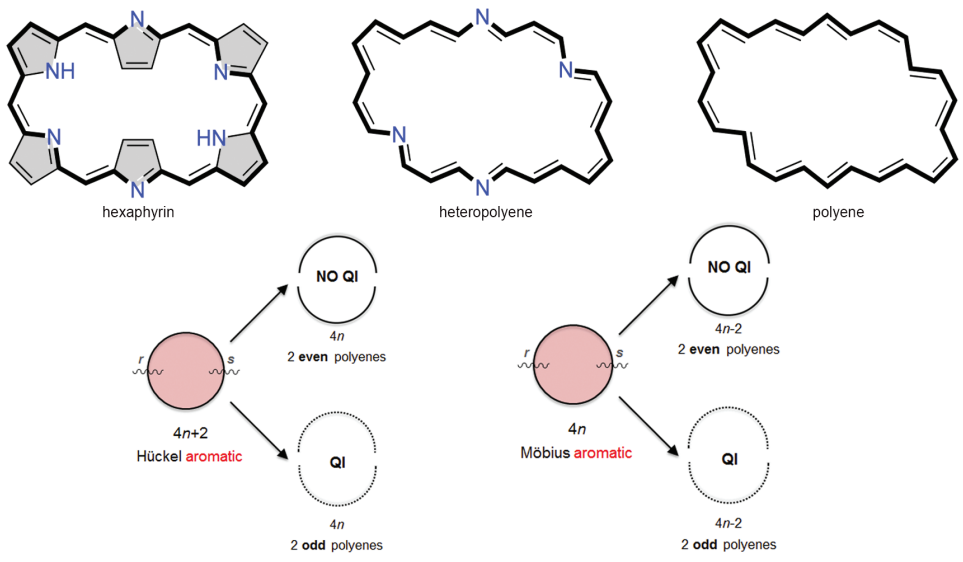


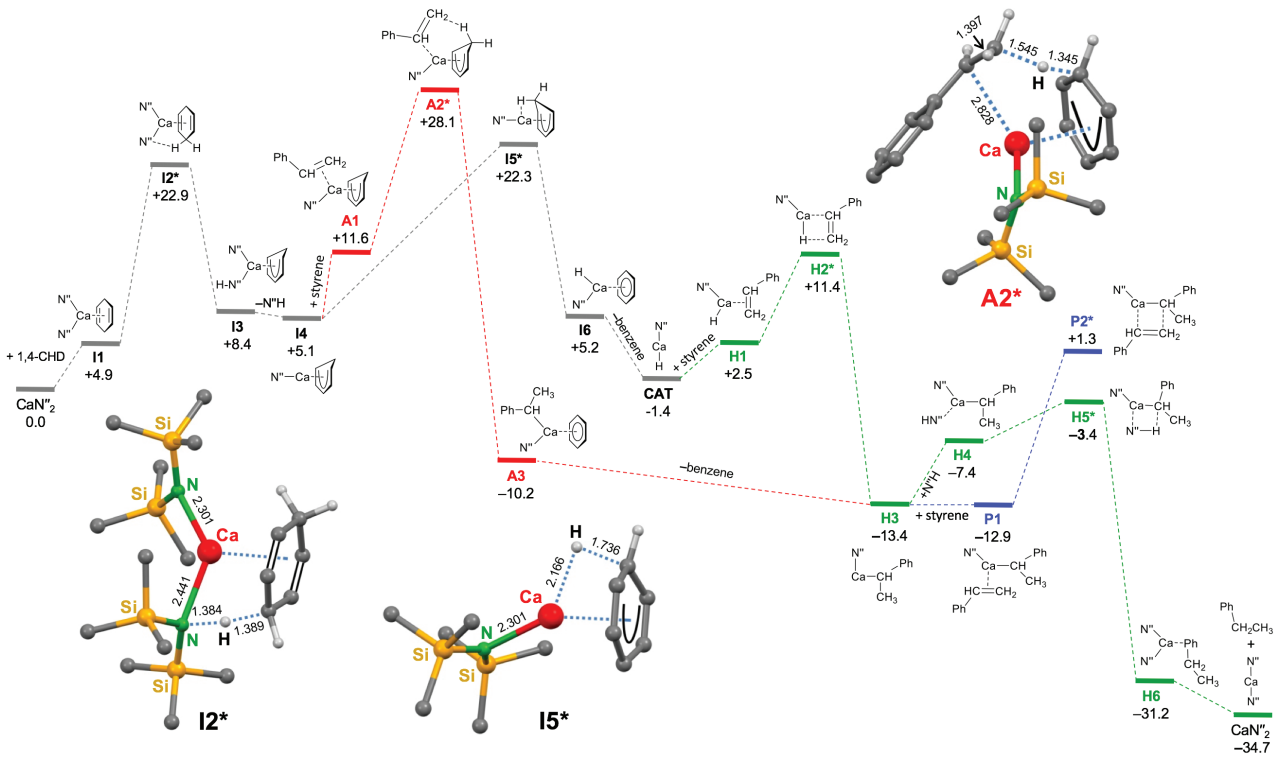
Molecular Electronics

In the Molecular Electronics research line, initiated with Dr. Thijs Stuyver and Dr. Stijn Fias, later on involving a close collaboration with Prof.Hoffmann from Cornell University [12], we earlier arrived at the conclusion that conductivity of molecules can be tuned by “pushing” them towards more or less diradical character as exemplified in our studies on the captodative effect [13]. This road has been exploited by invoking the diradical character as a guiding principle for insightful design of molecular nanowires with an anti-Ohmic increasing conductance with length [14].



In a series of expanded porphyrins (cf. previous item) a study on the relationship between conductance and aromaticity / topology was undertaken starting from a simple back-of-the- envelope Hückel type based counting rule on the parent polyacenes, to predict the occurrence of Quantum Interference at the Fermi level. The different approximations were gradually lifted enabling us to explore step by step the influence of each structural feature on the transport properties of expanded porphyrins [15]





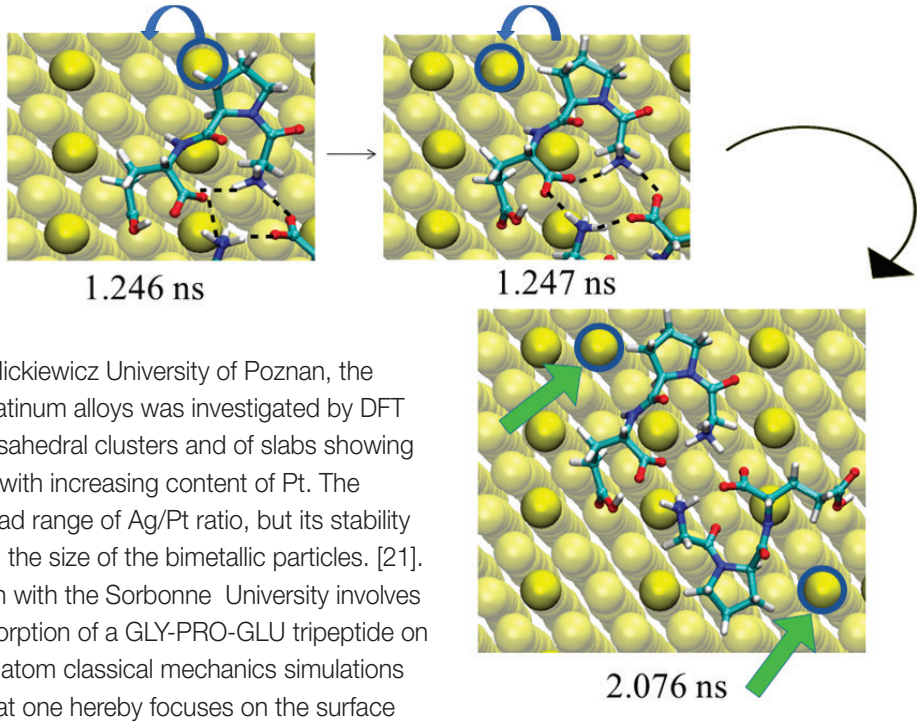
Two prototype examples of applied quantum chemistry are presented, the first one in direct interaction with experimental chemists.

In 2018 a collaboration with Prof.Harder from the Inorganic Chemistry Department of the University of Erlangen-Nürnberg was set up on the catalytic activity of early (group 2) main group metals (Mg, Ca, Sr, Ba) [16] in search for replacing transition metal elements by early main group metals as catalysts driven by both economic and environmental profit. In our recent studies on alkene direct and alkene transfer hydrogenation, DFT calculations were adopted to elucidate the catalytic cycles in both cases by studying the reaction profiles of styrene with H_2 and styrene with 1,4 cyclohexadiene, both catalyzed by CaN"$_2$ with N"= N(SiMe$_3$)$_2$, in the latter case involving for example the formation of a metal hydride species by deprotonation of 1,4 cyclohexadiene followed by hydrogen transfer [17][18]

As a sequel to previous studies on refining / reconsidering classical textbook reaction mechanisms in solvent using metadynamics simulations [19], the electrophilic aromatic chlorination has been scrutinized on its solvent and autocatalytic effects [20]. A new chlorine addition mechanism was revealed highlighting solvent and autocatalytic effects on the stability and lifetime of a charged σ- complex as reaction intermediate.

Materials Modelling

In this research line two examples of the subfields and systems that are addressed are the stability of alloys and the adsorption behaviour and concomitant reconstruction of a metallic surface.



In a collaboration with the Adam Mickiewicz University of Poznan, the stability of nanostructured silver-platinum alloys was investigated by DFT calculations on Ag-Pt 13-atom icosahedral clusters and of slabs showing decreasing stability of the clusters with increasing content of Pt. The Ag-Pt alloy can be formed in a broad range of Ag/Pt ratio, but its stability depends on the metal content and the size of the bimetallic particles. [21]. The other example, in collaboration with the Sorbonne University involves a detailed investigation on the adsorption of a GLY-PRO-GLU tripeptide on the Au (110) surface combining all atom classical mechanics simulations and DFT. A particular issue was that one hereby focuses on the surface reconstruction for which a mechanism is proposed both for the neutral and zwitterionic form of the peptide at room temperature. [22]

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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.

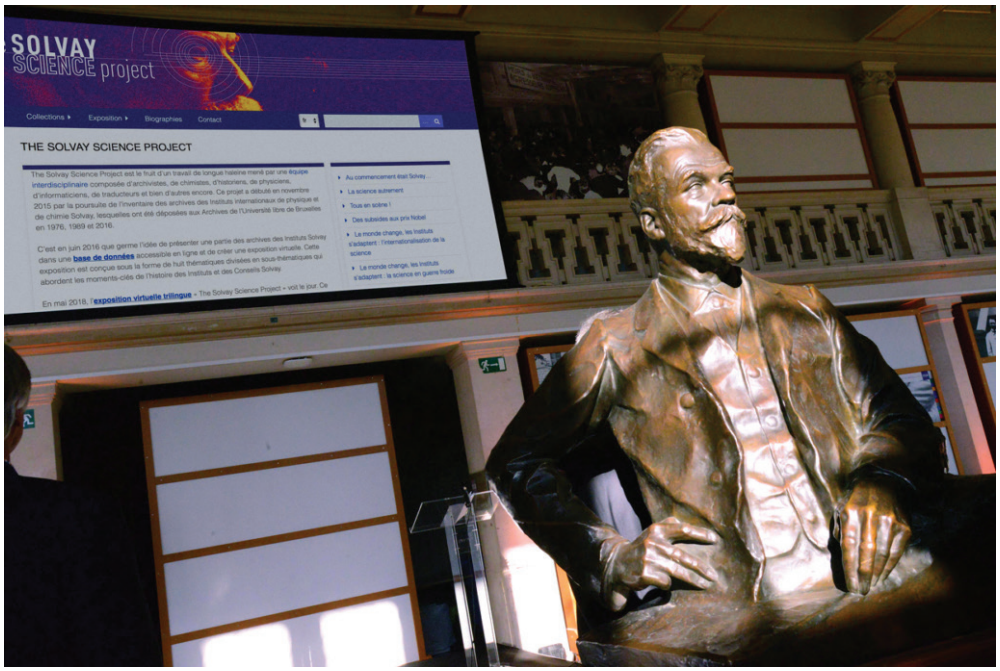
In 2018, the prizes have been awarded to:

- Babette Deckers and Kevin Van Holsbeeck (Ilya Prigogine Prize VUB)

- Aidan Wastiaux (Robert Brout Prize ULB)

SOLVAY SCIENCE PROJECT

THE SOLVAY SCIENCE PROJECT



The “Solvay Science Project” was launched on May 7th with simultaneous physical and virtual expositions in the grandiose “Hall of Marble” on the ULB campus in presence of Mrs Caroline Pauwels, Rector of the VUB, Mr Yvon Englert, Rector of the ULB and the Solvay family.

The launch of the “Solvay Science Project” consisted of a presentation of some twenty archives that document the first 1911 Solvay conference that is represented on the famous picture of Ernest Solvay surrounded by scientific icons such as Hendrik Lorentz, Max Planck, Albert Einstein and the other famous contributors to that first conference.

The virtual exposition presents to the world the digital archives that narrates the creation of the first conference and another 8 themes that outline the history of the conferences and their influence on the evolution of modern science.

The Solvay Institutes are very grateful to the ULB for its support in caring for the archives, digitalizing them and structuring the website. They are thankful for the support of the ULB and the VUB for translating the site to make it accessible to the public across communities.

Scientific Committee

Kenneth Bertrams | Nicolas Coupain | Anne De Wit | Franklin Lambert | Jean-Marie Solvay | Marina Solvay | Brigitte Van Tiggelen | Yoanna Alexiou | Didier Devriese until September 2018, replaced by Renaud Bardez.

Editorial Committee

Yoanna Alexiou | Kenneth Bertrams | Nicolas Coupain | Anne De Wit | Franklin Lambert | Brigitte Van Tiggelen.

Jean-Marie Solvay
President of the Solvay Institutes

Mrs Caroline Pauwels
Rector of the VUB

Mr Yvon Englert
Rector of the ULB

The Project

The Solvay Science Project is the fruit of the long-term labours of an interdisciplinary team made up of archivists, chemists, historians, physicists, computer scientists, translators and many other specialists.

This project began in November 2015 with an inventory of the archives of the International Solvay Institutes for Physics and Chemistry, which were lodged with the Archives of the Université Libre de Bruxelles (ULB) in 1976, 1989 and 2016.

It was in June 2016 that the idea arose of presenting part of the archives of the Solvay Institutes in a database (the database holds more than 400 archive documents illustrating key moments in the history of the Institutes, selected from among the 20 000 documents in the Institutes' collection) that was accessible online, thereby creating a virtual exhibition.

This exhibition was designed in the form of eight topics, divided into subtopics, covering the key moments in the history of the Solvay Institutes and Conferences. The exhibition may be consulted via a desktop or laptop computer or smartphone.

UNESCO Memory of the World Project

The next step is to gather as much digitalized records as possible about the Solvay Council that have been scattered from all over the world and propose to register four Councils of Physics or four Councils of Chemistry at the UNESCO Memory of the World in March 2020.

For example, the French physicist Paul Langevin took with him to Paris all records concerning his work as president of the Institute. Part of these records are not personal or professional records of Paul Langevin as professor but administrative and scientific records of the Institute's secretary. Before 1976, these documents were preserved by members of the Councils or Institutes or the scientific secretaries on their own. This explains why we can still find today records of the Solvay Institute in Paris or in Austin, Texas, for example.

We are trying now to digitalize some of these documents with the help of these other archives centers to complete our collection and bring the most scientifically interesting selection of records together on our website: http://thesolvaysciencepproject.be

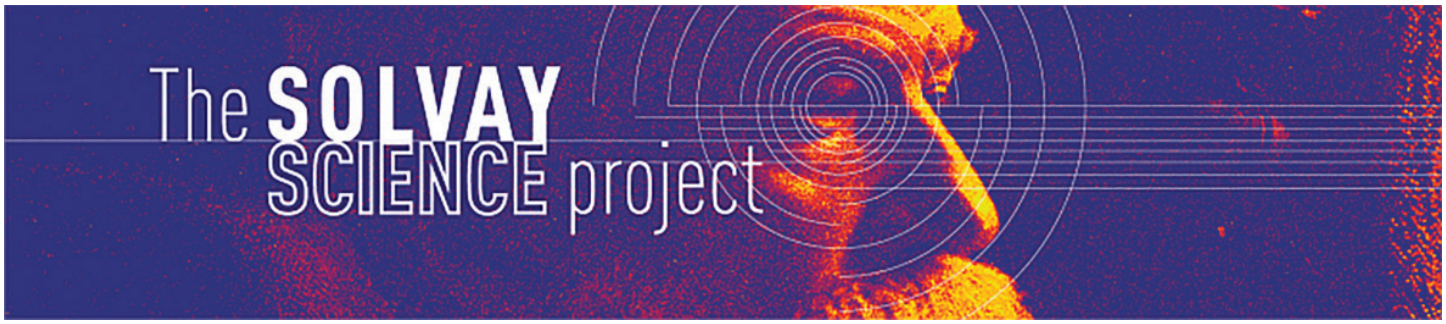
Conclusion

The institutes keep producing scientific knowledge and the records to witness that process. The scientific heritage of the Institute is huge and we have still many records to discover, select and digitalize, as well as many stories to uncover in this particularly impressive collection.

The results of the Solvay Science Project show how much work we still have to preserve, to share and write the modern history of Chemistry and Physics, but also to what extent we can use new tools for archiving and sharing these records of the scientific endeavour.

We hope to complete this research in the years to come.

Yoanna Alexiou



The importance of the Solvay Sciences Project lies in its history. Science has become very complex and may seem hermitic to students who turn away from it. By telling its story, we step through each and every phase until the final discovery, which seems more understandable.

Council after Council, Science grew according to the lives of their participants, the politics of their different countries and the wars in Europe and the United States. Documents and testimonies are numerous in the archives of the Solvay Institutes of Physics and Chemistry and they belong to the History of Humanity. This Project is designed to share it.

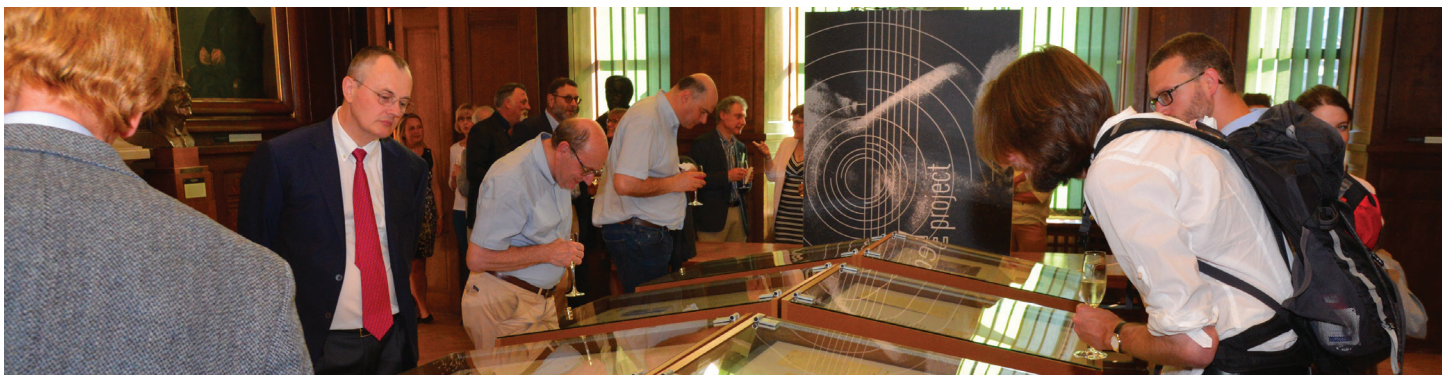
I have had the honor and the pleasure to interview some of these scientists and two of them, who both became Nobel Prizes, were not believed during the councils in which they had presented their theories. Their stories were most amusing! One of them went off skiing and became a ski teacher, and met his wife…

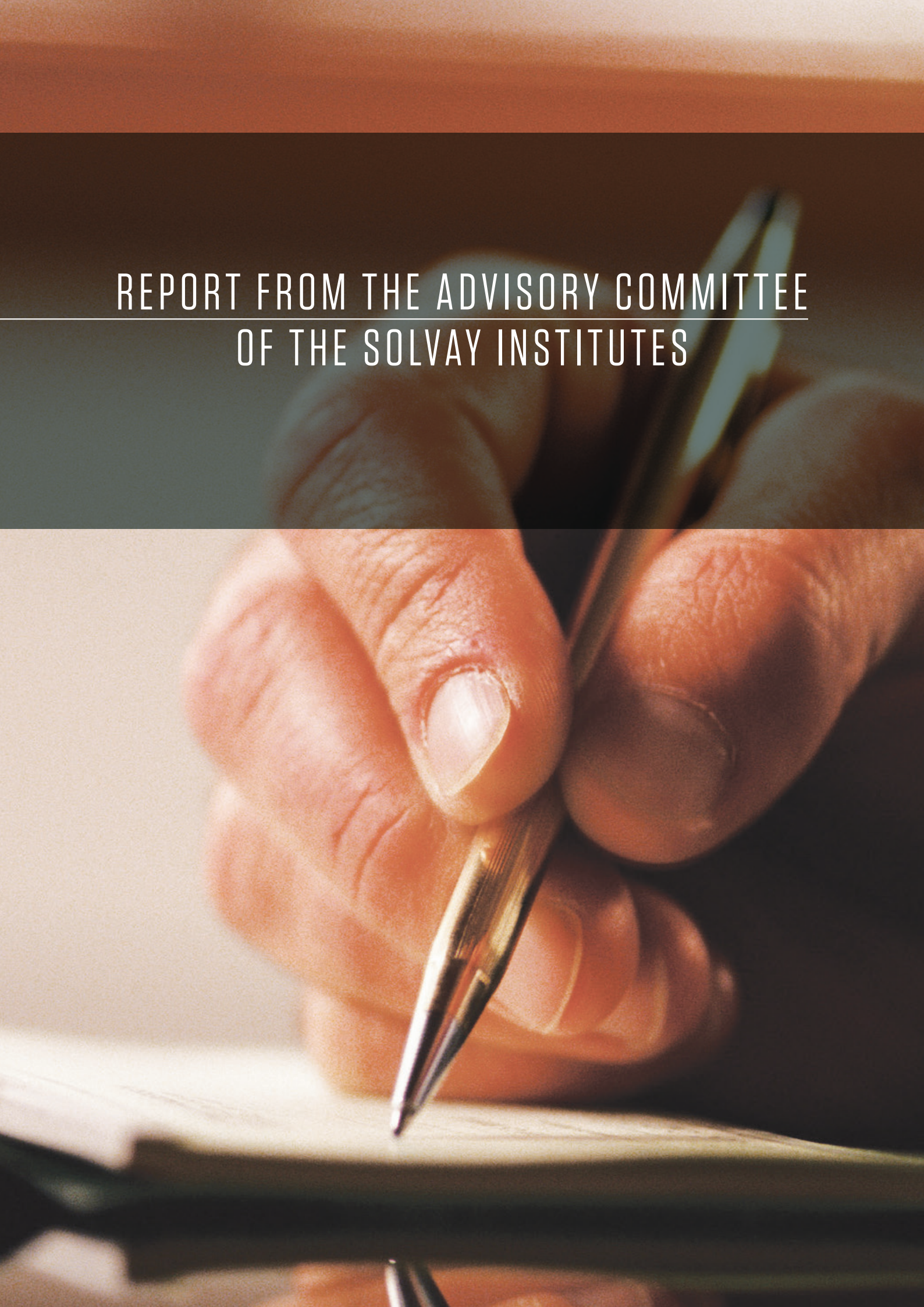
These Councils started with the encounter between two or three Physicists and my great- great-grandfather's wish to obtain some answers to questions he could not solve himself. They became hugely important because at the time, communicating between scientists was mainly by post and reading publications from two newspapers in two different languages.

To bring together these researchers during a few days in Brussels was a powerful catalyser to each of their fields. Today, too much communicating and too many publications render the Solvay Councils into a safe haven where the participants are happy to meet and discuss their topics.

And the scientific advances are still remarkable.

Marina Solvay





REPORT FROM THE ADVISORY COMMITTEE OF THE SOLVAY INSTITUTES

REPORT FROM THE ADVISORY COMMITTEE OF THE SOLVAY INSTITUTES

Executive Summary We will this time not discuss much the existing activities which all work very well. We would like to emphasise the following points.

- The Solvay Institutes make the ULB and VUB leading universities in Europe in natural sciences as compared to corresponding universities in Europe.
- The Solvay Institutes are run in a most impressive, efficient and competent way.
- Within the existing organisation and budget we find that the activities have reached an optimal stationary level.
- The Solvay institutes have now reached a balance between the activities in physics and chemistry.
- The Solvay Conferences are the pearls in the activities. Every effort should be spent to uphold this level. We support the planning of a conference in biology/life sciences in 2021.
- The Solvay Workshops, the Solvay Chairs and the Solvay Colloquia are activities of highest rank and quality. They have been established as key activities to further Belgian science and play a huge role both nationally and internationally.
- The creation of the New Horizons Lectures in physics and in chemistry for young scientists has started out very well and the programme for the future years is quite impressive.
- The Solvay Public Lectures are of utmost importance to foster interest in the most modern, fundamental science within the public mind. It is very impressive to gather some 800 people on a Sunday afternoon.
- The efforts to bring in the young scientist in the planning and attendance of the colloquia have been successful and should be continued.
- The strong and steady support from the Solvay family and the Solvay group provides the basis for the institutes and the committee appreciates a lot the introduction of the sixth generation to the activities.
- The strong support from the two universities both economically and morally is also very important for the institutes.
- The establishment of national committees including all the relevant Belgian universities to discuss and propose the programmes has been very successful and is establishing the Solvay institutes also as national institutes.
- The Solvay Institutes build an important bridge between the two language groups in Belgium.
- A substantial increase in the endowment is necessary if the institutes will branch out into biology/life sciences.
- The discussion about the future successor as director should investigate both possible persons suitable for the position as well as possible constructions for the position.
- The Institutes should interact with the two universities if they contemplate to introduce new research directions. This could be done by organising workshop or lectures in such fields.

Also this time we like to emphasise that it is very rewarding for the Committee to see our recommendations in the past being so seriously considered.

Introduction

The Committee that consists of Prof:s Lars Brink (Göteborg), chair, Leticia Cugliandolo (Paris), Karen Goldberg (Philadelphia), Gunnar von Heijne (Stockholm), Hermann Nicolai (Potsdam), Bert Meijer (Eindhoven), Hirosi Ooguri (Pasadena and Tokyo) and Jacques Prost (Paris) met in Brussels on November 26-28. Unfortunately, Prof. Hermann Nicolai (Potsdam) could not attend the meeting due to illness. In order to prepare ourselves we had obtained a report on the activities in 2017 as well as various information about the institutes. We have also had the report from 2015 as a reference for the work.

On November 28 the Committee met with the Director and the Deputy Directors, Prof:s Marc Henneaux, Alexander Sevrin and Lode Wyns together with the President of the Board of Directors Jean-Marie Solvay and Prof. Paul Geerlings from the executive group for an informal dinner. On November 29 the Committee had discussions with Prof:s Henneaux, Sevrin, Glenn Barnich and Irina Veretennicoff and a meeting with Prof. Jan Danckaert, Vice rector VUB, Prof. Gino Baron VUB representative on the Board of Directors, Lode Wyns, Paul Geerlings and Alex Sevrin together with Jean-Marie Solvay. Then followed a lunch together with Prof. Koen Debackere (KUL Professor and KUL General Manager). In the afternoon the committee met with Jean-Marie Solvay, Marina Solvay and three members of the sixth generation of the Solvay family, Diane Thibaut de Maisières, Valériane Moyersoen and Daisy-Anne de Selliers de Moranville . After that we had a long discussion with Baron Daniel Janssen together with Jean-Marie Solvay. Much of the day was devoted to discussions about the future.

On November 30 the Committee met with the scientists engaged in the institutes, Prof:s Yves Geerts, Anne De Wit, Ben Craps, Pierre Gaspard and Lode Wyns. The committee also had a brief interview with the secretariat, Dominique Bogaerts and Isabelle Van Geet. This was followed by a lunch meeting with Prof. Yvon Englert, the ULB Rector and Prof. Oberdan Leo, the ULB vice-Rector for research and Eric De Keuleneer, former director of Générale de Banque and ULB representative on the Board of Directors of the Solvay Institutes together with Jean-Marie Solvay. Between and after the interviews and at the dinners the Committee had its deliberations.

The Committee found that all interviewees were very enthusiastic about the Solvay Institutes like at previous times. They are all committed to the cause to run the various activities and to uphold the excellence stamp that the name Solvay carries. Everyone was very content with the progress during the last three years when the activities in chemistry has reached the level of the one of physics and the Belgian universities outside Brussels have been engaged in a very meaningful way. Apart from the secretariat, the work behind the activities is performed on a voluntary basis within the academic positions. The Committee very much appreciates that the two universities allow and support this. It puts, however, a limit as to how much work the staff can do for the Solvay Institutes. We will comment more on this fact later.

The Committee appreciates that the recommendations from previous reports have been given such strong considerations and are very happy to see how well they have been implemented.

Scientific Activities

The Committee is again very pleased to see how well all activities are working. They are all of highest rank and quality. The organisation behind, which is partly based on a voluntary basis, is done with great enthusiasm. We can only congratulate the Institutes for these achievements. The creation of the New Horizons Lectures in physics and in chemistry for young scientists has started out very well and the programme for the future years is quite impressive. Also the initiative to involve the younger scientists in the colloquia seems to work very well and we urge the Institutes to follow up and gauge the progress. We strongly believe that the broadening of the horizons that the colloquia can give is ever more important for all scientists especially the younger ones, but that story has to be told over and over again.

The Committee finds that the activities of the Institutes are at an optimal level given the economic and personal resources. We understand that there might be more proposals than there is room for activities. This will only make the programmes better, but they have to be balanced such that people do not get too upset if they cannot organise the activity they have intended to do.

We understand like last time that it could be difficult to get someone for a Solvay chair be present in Brussels for the whole month. Even so the chairs have been filled with world-class scientists and the programme is very successful. We find it advantageous like last time that she/he also extends the activity to visit and make contacts with other universities in the country. This visit program seems to be working well.

Gender Balance

The committee highly appreciates the continued efforts by the institutes to improve the gender balance. The progress - especially in chemistry is seen as first steps and the committee strongly recommends to make gender balance an important topic for all activities. It should not be done by introducing quotas but by making sure that the programme committees always try to invite female speakers and participants if there is a choice between equally important persons on an invitation list. As long as the programme committees also have an imbalance they have to make extra efforts to improve that imbalance among invitees. The Director and the executive group have the overall responsibility to make sure that the imbalance among the programme committees and the invitees is continuously improved.

Staff and Support for the Director and plans for the future

Like at the previous times the Committee has understood that the success of the Solvay Institutes rests heavily on the tireless and excellent work that the Director and the staff perform. The appreciation for them is remarkable from all persons interviewed and very well deserved. Also the enthusiasm of the other persons involved is necessary for the success. The role of the director is very demanding. It is then very important that he is not burdened with some of the very time-consuming chores ordinary university professors have to deal with such as massive applications to secure research funds. This is now taken care of by support from the Solvay family which we find very considerate and appropriate. However, it would be advantageous for the future if such funds could be part of the chair. That would facilitate the future appointment of a new director.

The two deputy directors play a vital role for the success of all the activities. We will especially note this time the work of Lode Wyns during the last three years who together with his colleagues from the executive group have managed to bring the chemistry activities up to the level of the physics one. We understand that he wants to scale down his activities. We sincerely hope that a suitable successor be found. These positions are keys to a successful organisation and every effort should be made to have the right people for them. We are also very impressed with the devotion of the assistants to the director. We would like to introduce the name members of the executive group for them. Let us especially commend Anne De Wit who has served in the organisation for quite some time now and who showed a particular maturity to all the issues we discussed with her. Like in previous years we can only commend the secretariat with Dominique Bogaerts and Isabelle Van Geet, which is extremely efficient, knowledgeable and professional. Like in so many of the positions discussed here the specific persons play a vital role and if anyone will leave every effort has to be made to secure a replacement of the same calibre.

Marc Henneaux' present term as director ends in 2021. We have understood that he is willing to continue for another six-year period. It is vital for the institute that he can stay on as long as possible. We do not need to further stress his importance for the Institutes. He will be able to continue even when in two years he will start as Professor of Collège de France. Even if it might be nine years before a successor will be appointed it is time to ponder all the options. The committee thinks that all doors should be open. It is true that the director moves in a very difficult landscape with the two language groups and needs to know this landscape, but she/he will also need to know how to direct Institutes in a university milieu and a Belgian society that is complex. Ideally one would find a successor within the faculties of ULB and VUB, but if that is not possible one has to look further towards the horizons. To prepare for this the Committee suggests that a particular chair is created which is shared by the two universities which can be in any of the fields that the Institutes are working in, and which has extra fundings such that the conditions of the present director can be uphold. Even though this is hopefully nine years away the work for creating such a chair should start in the near future.

Documentations

A very important aspect of all the activities is the documentation on internet. We notice that the normal running of the web pages is performed very expertly by the staff. The web pages are very instructive and is continuously being upgraded with new material and new functions that streamline the activities. More and more of the archives are coming on line and it is very instructive. This was discussed in the last report and the progress is again quite good. The Committee has urged the secretariat to set up a Facebook page and a Twitter account to promote information about the activities. This has been done but has not drawn many followers. Perhaps this is a venue where younger members of the faculties could be asked to help. They are much more involved in the latest trends of the internet and could be very useful setting up the right channels for information. The committee suggests, however, that access to the social network accounts should be limited to the Director and the administrative staff and should not be shared by anybody else. Only the Director can speak on behalf of the Solvay Institutes, even over Facebook or twitter, and this responsibility should not be delegated to others.

We are very pleased to see the Solvay Science Projects being set up with material of utmost importance for the history of science. In some respects they are unique in the world containing correspondences between some of the most important figures in the history of science. The project is supplemented with lots of material about the individuals who have been engaged over the years. The project has been resting earlier to a large extent on Prof. Franklin Lambert, with very deep knowledge about the Institutes engaged in this matter. We are very pleased to learn about the involvement of both Marina Solvay and Jean-Marie Solvay in the project. We argued in the last report to open up the archives to some chosen graduate students of the history of science. They could do the bulk of the work while at the same time getting unique material for their theses. This has been started and a student in documentation has been hired. Here some strategic cooperations could be set up with University departments or institutes. This issue was not much discussed this time but every effort to make the historic developments available to interested persons should be considered. Also the lectures and discussions at the Solvay meetings but also of the deliberations to organise these meetings today are of course of utmost value. The Institutes should try to save these for a posteriori. We are very pleased to see that more and more material from the conferences and workshops such as proceedings and pictures are coming on line.

There is a modern trend that scientific documents of historic value are auctioned with a risk that they will disappear from the scholars. It is very important that the Institutes are aware that such things can happen and make every effort to safeguard documents of value.

Extensions into biology/life sciences

The physics conference in 2017 was in the subfield of biophysics. It gathered world experts in both biophysics but also in biology. It was a great success and the idea came up that the Solvay Institutes should have a third branch also in biology/life sciences, making the three-year cycle with conferences complete with one every year.

The committee finds this a very interesting proposal and appreciates the initiative by the Solvay family to fund such a conference in 2021. We believe that such a conference should be a check-point to see if such conferences could be as unique as the physics and chemistry ones. There are many more conferences and meeting in this broad field, but as far as we know no one of the same character as the Solvay conferences. It is very important that the first conference in a series is a success that will be remembered many years in the future, so special efforts should be made to find a topic that is deep and important enough. It must focus on fundamental scientific issues, not on more applied areas. There are two venues to follow. Either one invites the most famous and established scientists in the field or one tries to identify young stars that will be the famous ones in a near future. We would recommend the second one but of course with participations also of older generations. We would also recommend a smaller size than the standard size of about fifty participants. One key point is to find a chairman of the committee to organise the meeting. She/he should be at the same level as the chairs of the physics and chemistry committees. We would favour a smaller committee to start with and if the programme gets established to fill it up to a full size later. The chair and the initial committee should have full freedom to choose the subject, but they should know how the other two committees work. The Solvay Institutes might have to play a more active role in guiding the choice of the subject and the character of the invitees than they do for the other conferences.

After the meeting the conference has to be evaluated and checked that it is of the level as the ordinary ones, and if there is room for these conferences and if so to continue, and set up the full programme. However, an extension of the programmes can only be proposed if is not interfering with the existing programmes.

Finances

The Committee is very pleased to see that the Institutes can be run on the existing budget. For an outsider the existing funding seems to be low, but one has to keep in mind the support of the two universities and of the scientists involved in the programmes. Even so the committee is worried for the future. We understand that the support of the National Lottery which constitutes almost 20 % of the budget is not to be taken for granted in the future. There is always a temptation for such an organisation to seek to spend money on other, for the public, more visible events. There is also a risk that they will argue that they have supported the Institutes at a point of building them up, and that they like to seek other upstarts. We have understood that the contributions from the regions is now fairly stable so there does not seem to be any immediate threat to substantial cuts from other contributors. The contributions from the two universities are also stable and should probably be kept at the present level, in order not to be too dependent on the universities.

However, the weak point in the financing is the endowment. The present level is 6 M Euro, and it has increased steadily since the new start of the Institutes. It does now give a substantial part of the running costs and together with the generous support of the Solvay family and the Solvay Group it provides a steady source for the expenses. However, even if there are no extensions in the activities, the Institutes would benefit from having a larger endowment. It would provide a further stability and independence. We understand that much efforts have been spent to find new donors and we appreciate the difficulty for institutes so intimately connected with the Solvay name and the Solvay group.

The introduction of a new programme in biology/life science might be a door opener to new donors. We would urge the Institutes to use the decision to launch the 2021 conference in this field to approach new possible donors. If such a programme should be permanent the Institutes need to increase the endowment by a sizeable amount. The introduction of a new programme will not only draw new costs for the conferences. There will be more administrative costs. Even though the secretariat told the committee that they believe that they can handle the extension, we believe that more administrative help will be needed to let the secretariat handle the important issues with the conferences. In the long run if such a programme gets established there will be a need also to enlarge the existing activities into biology and to set up both local and national committees for that field. This will mean a substantial increase in the local costs to run the Institutes. It must be kept in mind though that in no way new initiatives should jeopardise the quality and size of the already existing activities.

Conclusions

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

The Committee is also very pleased to see that the imbalance between physics and chemistry and also about the weak participation of Belgian scientists and institutions outside the Brussels area is now being remedied. We find that the organisation works at an optimal level and have no concrete new proposals to put forward apart from the biology/life science initiative.

The Committee supports the idea to organise a Solvay conference in biology/life sciences in 2021 to see if the activities can be extended also to that field making the engagement in natural science more complete. This will by necessity demand a substantial increase in the budget, and a new programme can only be set up if the endowment is substantially increased.

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

APPENDIX

NEWSPAPERS AND PUBLICATIONS

HORIZON recherche ULB
septembre 2018 N° 54

- Youtube

Contacts | Archives | Imprimer

Le dossier à la Une

L'Europe, moteur de recherches de pointe

La recherche *made in Europe*, **Marc Henneaux** la connait bien. Chercheur au **Service de Physique Théorique et Mathématique** de la **Faculté des Sciences**, il est lauréat de deux bourses ERC – dont une ERC Advanced Grant toujours en cours. « Les ERC ont certainement fait progresser mes recherches de manière significative », explique-t-il, « Notamment grâce à la grande liberté accordée aux lauréats : la gestion est plus souple et plus légère que d'autres projets ou réseaux internationaux, ce qui permet de suivre plus facilement de nouvelles pistes de recherche si nécessaire ».

Le directeur des Instituts Solvay insiste également sur la dimension internationale de ce type de projet : « Le financement ERC nous permet d'inviter des scientifiques prestigieux à venir donner une conférence, par exemple. Cela favorise les interactions, influence positivement le travail de toute l'équipe et nous permet d'inscrire notre laboratoire sur la carte du monde ».

Autre manière de booster la dynamique à l'échelle internationale : le recrutement de jeunes talents. Le laboratoire de Marc Henneaux accueille actuellement plusieurs lauréats de bourses Marie Sklodowska-Curie : Charlotte Sleight et Massimo Taronna ont obtenu une bourse « outgoing », qui leur permet d'effectuer un séjour dans des institutions de recherche de référence à Princeton, aux Etats-Unis. « Le fait d'aller aux Etats-Unis, parmi les meilleurs équipes de notre discipline, est un élément qui comptera certainement pour leur future carrière », commente Marc Henneaux, « Ce programme est donc un soutien important pour la mobilité des jeunes chercheurs et l'acquisition d'une expérience internationale indispensable ».

L'Europe, moteur de la recherche et de l'innovation ? « J'en suis convaincu », conclut Marc Henneaux « Les initiatives de ce type, soutenant la recherche fondamentale et le développement de la recherche à l'international, sont indispensables et à encourager ».

"L'Europe comme moteur" de la recherche: découvrez tous les financements européens de la recherche sur http://europe-connaissance.ulb.be/fr/l-europe-comme-moteur

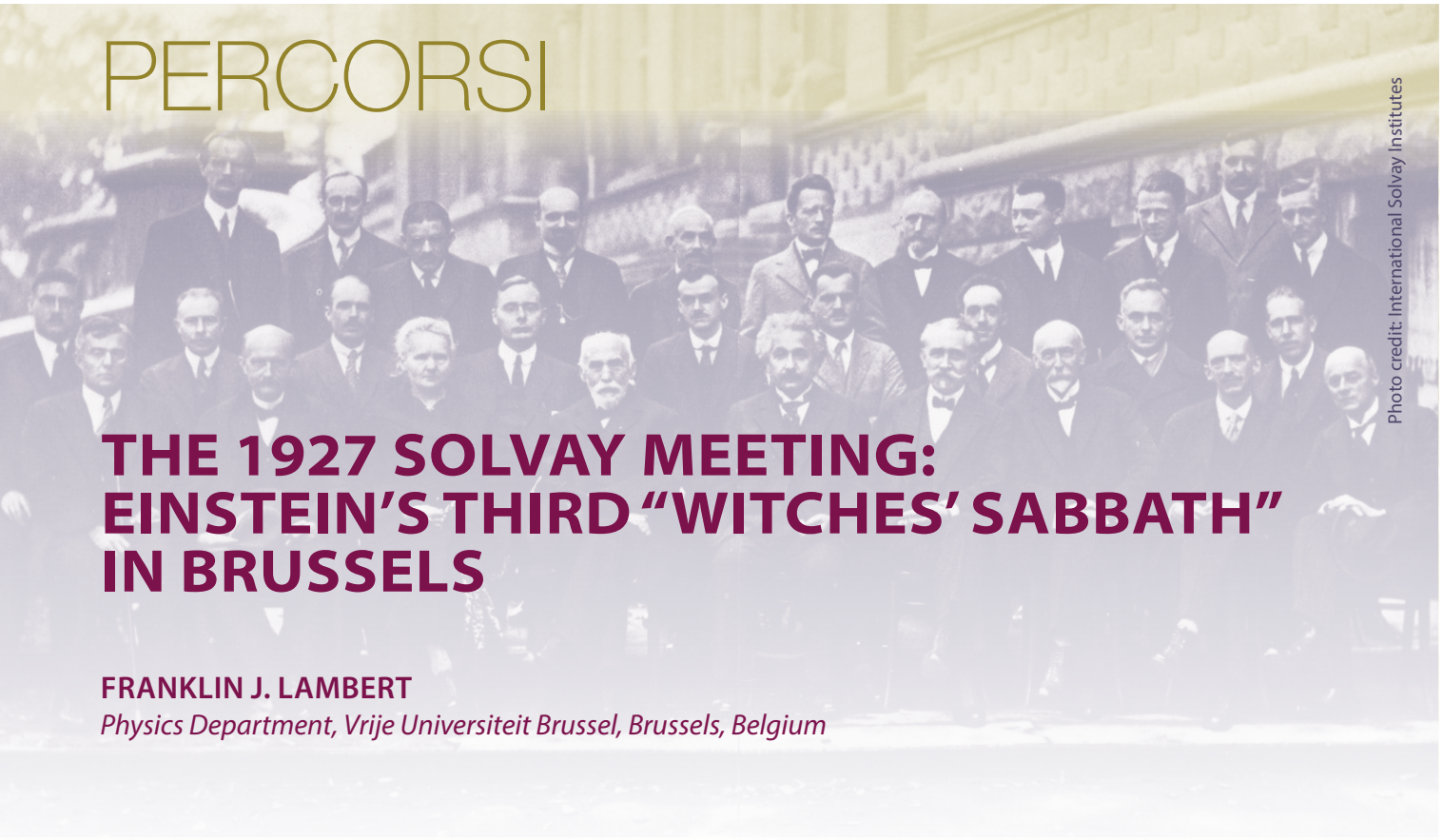


Photo credit: International Solvay Institutes

THE 1927 SOLVAY MEETING: EINSTEIN'S THIRD "WITCHES' SABBATH" IN BRUSSELS

FRANKLIN J. LAMBERT
Physics Department, Vrije Universiteit Brussel, Brussels, Belgium

A comprehensive analysis of the 1927 Solvay Council was published five years ago by Bacciagaluppi and Valentini. This paper aims at providing some additional information on particular facts that took place during this legendary meeting, recognized today as a milestone in the development of quantum theory. A short survey of the main steps in the planning and the proceedings of the Council is followed by a report on some surprising elements, such as the absence of Sommerfeld and the presence of Langmuir. The paper also deals briefly with the role of Einstein at the meeting: his famous but often misrepresented debate with Bohr, and his encounters with two personalities: Georges Lemaître and Queen Elisabeth.

Foreword

As they reconsidered the 1927 Solvay Council in 2013, Guido Bacciagaluppi and Antony Valentini [1] made the following statement:

"Remarkably, the proceedings of the fifth Solvay Conference have not received the attention they deserve, neither from physicists nor from historians of science, and the literature contains numerous misunderstandings about what took place there".

One of the authors' main claims is that the proceedings do not contain any trace of the famous Bohr-Einstein debate about the status of quantum theory, so that the nature of their disagreement at that time can only be inferred from testimonies (such as Ehrenfest's and Heisenberg's), or from Bohr's tardy recollections [2]. Being not in a position to add anything meaningful to this claim[1], nor to produce new archival elements in support of it[2], I will briefly recall some salient elements in the planning and the proceedings of the Council (referring to the work of the above authors for details), while focusing on lesser known features of this legendary meeting which, according to Heisenberg, "*contributed extraordinarily to the clarification of the physical foundations of the quantum theory, and formed so to speak the outward completion of the quantum theory* [3]".

1 Planning of the Council

The first steps towards the fifth Solvay Council were taken in Brussels during the meetings of the Scientific Committee (SC) of the International Solvay Institute for Physics (ISIP) on

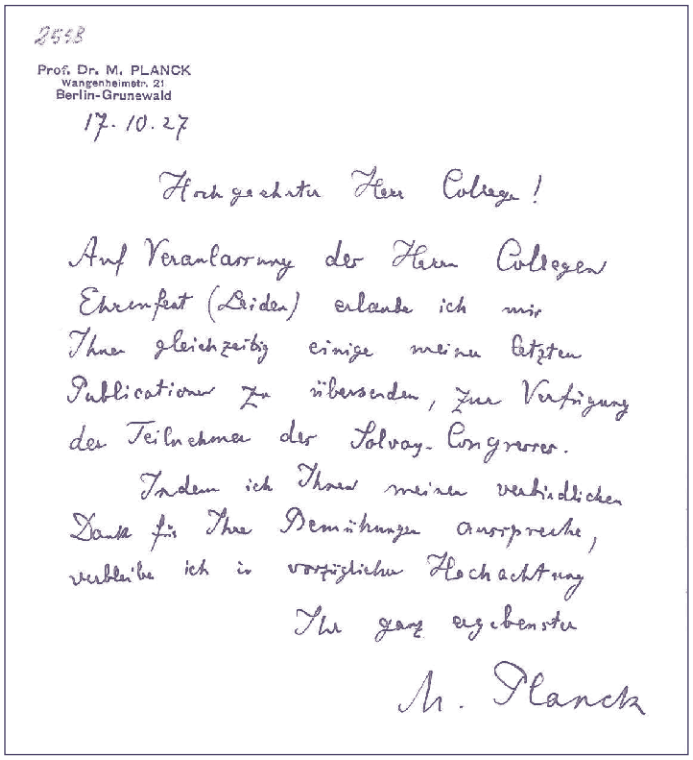
[1] In contrast with the first Solvay Council, the proceedings of which were orderly recorded by Maurice de Broglie (*Registre* offered in 1951 to the Archives of the Paris Academy of Science), we cannot rely on a similar archival source for the 1927 Council (see appendix of ref. [1]).

[2] A major problem is that the archives of the International Solvay Institute for Physics are scattered over several centres, such as the ESPCI in Paris, the NHA in Haarlem, the Niels Bohr Archive in Copenhagen –an unfortunate consequence of the Institute's multinational way of functioning. An additional drawback is that the documents which remained in the custody of the ULB in Brussels have not been open to research for a long period of time.

1 and 2 April 1926. This Committee comprised the following members: H. A. Lorentz (chairman), M. Knudsen (secretary), Marie Curie, P. Langevin, O. Richardson, Ch. E. Guye, and E. van Aubel (the Belgian representative[3]). A Dutch member, H. Kamerlingh Onnes, had died on 21 February 1926, leaving his chair vacant.

According to Lorentz, the 1927 Council would be in line with Einstein's *Witches' Sabbath* of 1911, which had been convened to address the failure of molecular kinetic theory but had finally switched to the more fundamental questions regarding quanta and the theory of radiation. On 8 April 1926 he informed the secretary of ISIP's administrative commission, Ch. Lefébure, of the results of the Committee's meeting[4]:

- Einstein's unanimous election as Kamerlingh Onnes' successor in the SC.
- Decision to concentrate the next Council on *The quantum theory and the classical theories of radiation*.
- First proposal for reports:
  1. New tests of the classical radiation theory (by W. L. Bragg).
  2. Compton effect and its consequences (by Compton or Debije).
  3. Observations on photoelectrons and collision electrons by the condensation method (by Wilson).
  4. Interferences and light quanta (by L. de Broglie).
  5. Short note on the theory of Bohr-Kramers-Slater (if Kramers considers it useful).
  6. New derivations of Planck's law and applications of statistics to the theory of quanta (by Einstein or Ehrenfest).
  7. Adaptation of the foundations of dynamics to the theory of quanta (by Heisenberg or Schrödinger).
- First list of invitees: 1 Danish member (N. Bohr); 2 Dutch members (H. A. Kramers and P. Ehrenfest); 3 German members (Planck and 2 physicists to be chosen among M. Born, W. Heisenberg and W. Pauli); 3 British members (R. Fowler, W. L. Bragg, C. T. R. Wilson); 3 French members (L. de Broglie, L. Brillouin, H.-A. Deslandres); 1 American member (A. H. Compton); 1 Austrian member (E. Schrödinger); 1 Swiss member (P. Debije). With the following substitutes: M. de Broglie or J. Thibaut for W. L. Bragg; P. A. M. Dirac for Brillouin, C. Fabry for Deslandres; P. Kapitza for Wilson; Darwin or Dirac for Fowler; Bergen Davis for Compton; H. Thirring for Schrödinger.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Prof. Dr. M. PLANCK
Wangenheimstr. 21
Berlin-Grunewald

17. 10. 27

Hochgeehrter Herr Collega!

Auf Veranlassung der Herrn Collegen Ehrenfest (Leiden) erlaube ich mir Ihnen gleichzeitig einige meiner letzten Publicationen zu übersenden, zur Verfügung der Teilnehmer der Solvay-Congresses.

Indem ich Ihnen meinen verbindlichen Dank für Ihre Bemühungen ausspreche, verbleibe ich in vorzüglicher Hochachtung

Ihr ganz ergebenster

M. Planck

Fig. 1 Letter of Planck sent on 17 October 1927 to the organizers of the 1927 Solvay Council with his last publications. Courtesy of *Service des Archives de l'Université Libre de Bruxelles* (S.a.b.ULB), custodian of the archives of the International Solvay Institutes (doc. 2558).

Remarks

i) Three "moderate" German physicists (including Planck) (fig. 1) were to be be invited for the first time after the war[5]. The rule at the Solvay Councils was that the country of affiliation of a member –not his nationality– should be taken into account (this is why Debije, a Dutch physicist working in Zurich, was listed as a Swiss member[6]).

ii) Bohr was invited but was not asked to present a report. The emphasis was clearly on radiation (only one report on the quantum behavior of matter).

iii) The fact that Schrödinger was listed as a possible substitute to Heisenberg shows that the importance of his recent results had been taken into account.

iv) W. Elsasser, a pioneer in the interpretation of Davisson and Kunsman's experimental results as proof of the

[3] This physicist refused to take part in the meeting; he was replaced by J.-E. Verschaffelt.

[4] Letter of Verschaffelt to Lefébure of 8 April 1926, FIS, S.a.b.ULB, doc. 2573.

[5] Only Einstein had been invited to attend the Solvay Councils of 1921 and 1924.

[6] Schrödinger, who in 1924 had been invited as a Swiss member, was now listed as an Austrian physicist (presumably in order to list a representative of this former enemy country).

existence of de Broglie's *matter waves*[7] was not invited (a point reminiscent of the absence of Ehrenfest at the first Solvay Council on physics).

v) More surprisingly, Sommerfeld's name did not appear on the list of invitees (in sharp contrast with that of Bohr which was top of the list); this point will soon be discussed.

Royal approval of the Committee's decisions

In Belgium, anti-German feelings were still strong at the time. Following the announcement in March 1926 of the forthcoming meeting of the Scientific Committee, the King had expressed the wish to meet Lorentz. The royal audience took place on 2 April. Lorentz reported the next day to Lefébure: "*His Majesty expressed the opinion that seven years after the war, the feelings that it created should slowly soften, that a better understanding among nations is strongly needed for the future, and that science should help to bring it about … The King also remarked that, in view of what the Germans had done in physics, it would be hard to work without them*".

However, E. van Aubel, the Belgian member of the SC, refused to take part in the Council on the grounds that it would be attended by German physicists. Members of the administrative commission feared that the Council could be spoiled by anti-German demonstrations. As a result, Lorentz was asked to come to Brussels to discuss the matter with Lefébure (this happened on 17 April 1927): it was decided that the list of invitees would not be communicated to the press.

2 Evolution in the list of invitees and reports

In August 1927, one of the members of the scientific committee (W. H. Bragg) announced his wish to resign. Lorentz asked him to reconsider his decision, but Bragg replied that he would not be present at the Solvay meeting. At the same time the French astronomer H.-A. Deslandres, made it clear that his duties might prevent him from attending the Council. Lorentz took advantage of these circumstances and proposed to invite W. Pauli and P. A. M. Dirac (breaking the balance between French, German and British invitees "*for the benefit of science*"). On 27 August 1927 he told Lefébure: "*Since last year, quantum mechanics, which will be our topic, has developed at an unexpected pace, and some physicists who stood formerly in second line have made extremely notable contributions. For this reason I would be vey pleased to be allowed to invite Mr. Dirac from Cambridge and Mr. Pauli from Copenhagen … Their collaboration would be very fruitful… I do not need to consult the scientific committee for Mr. Dirac and Mr. Pauli were both on the list that was drawn up last year…*".

Result: Dirac and Pauli were invited in September 1927.

A last minute addition to the list of invitees was that of Irving Langmuir, an American chemist attached to the General Electric Company (Schenectady). This addition is extraordinary, for we know that Lorentz refused to admit auditors to the Councils[8], so as to preserve their confidential character. We shall discuss Langmuir's invitation in the next chapter.

Regarding the Solvay reports, some changes intervened during the summer of 1927 (often under the influence of Ehrenfest). Thus, Einstein told Lorentz that he would rather not present a report; but he suggested a report from Schrödinger. Following Davisson and Germer's results on *matter waves,* Lorentz asked Louis de Broglie to report on his new dynamics. He also asked Born and Heisenberg to include Dirac's work in their report on *matrix mechanics*.

Hence, the final list of reports:

1) *The intensity of reflection of X rays*, by W. L. Bragg.
2) *Discordance between experience and the electromagnetic theory of radiation*, by A.-H. Compton.
3) *The new dynamics of quanta*, by L. de Broglie.
4) *The mechanics of quanta*, by M. Born and W. Heisenberg.
5) *Wave mechanics*, by E. Schrödinger.

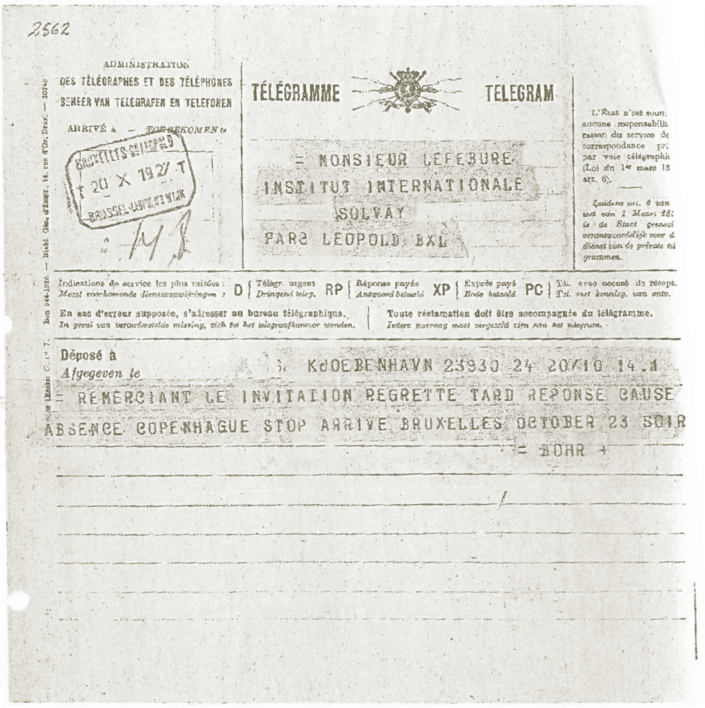
The list of participants looked now as follows:

Chair: H. A. Lorentz.
Members: Marie Curie, N. Bohr, M. Born, W. L. Bragg, L. Brillouin, A.-H. Compton, L. de Broglie, P. Debije, P. A. M. Dirac, P. Ehrenfest, A. Einstein, R. H. Fowler, Ch.-E. Guye, W. Heisenberg, M. Knudsen, H. A. Kramers, P. Langevin, W. Pauli, M. Planck, O.-W. Richardson, E. Schrödinger and C. T. R. Wilson.
Secretary of the meeting: J.-E. Verschaffelt.

Lorentz also wished to reduce the delay between the Council and the publication of its proceedings (the volume for the 1924 Council had only recently appeared). He decided to prepare the report of the Council's discussions (with Verschaffelt's help), to have it printed in Holland and to send it to the various contributors, with a deadline for correction.

[7] Elsasser's results, published in *Naturwissenschaften* in May 1925, had been reported by Born in 1926.

[8] Charles Manneback, a Belgian physicist and professor at the University of Louvain, had met Lorentz in September 1927 at the Como conference. He had asked permission to attend the Council as an auditor, but his demand was turned down. Yet Lorentz accepted the presence of professors of the Université Libre de Bruxelles, knowing that they would meet their foreign colleagues at the University's reception and at the banquet.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ADMINISTRATION DES TÉLÉGRAPHES ET DES TÉLÉPHONES
BEHEER VAN TELEGRAFEN EN TELEFONEN

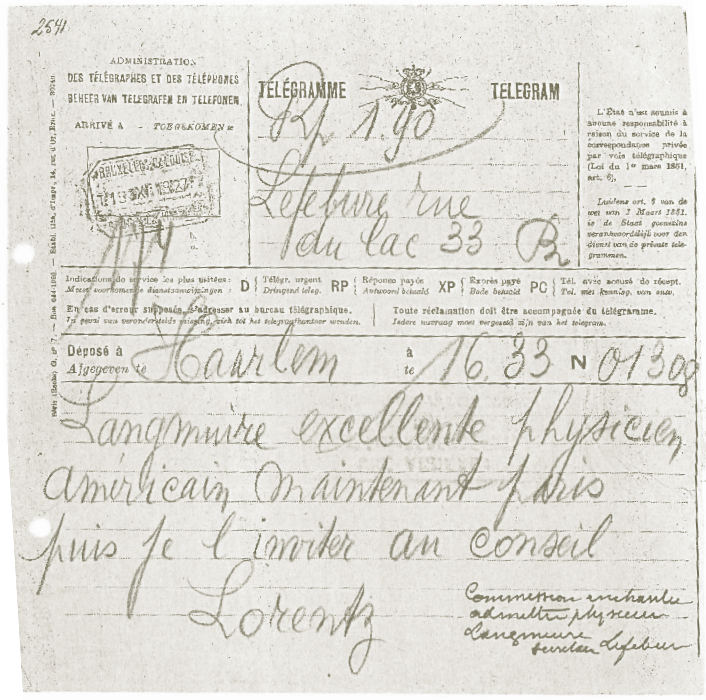
TÉLÉGRAMME TELEGRAM

ARRIVÉ A — TOEGEKOMEN te

= MONSIEUR LEFEBURE
INSTITUT INTERNATIONALE
SOLVAY
PARC LEOPOLD BXL

Déposé à / Afgegeven te KJOEBENHAVN 23930 24 20/10 14.1
= REMERCIANT LE INVITATION REGRETTE TARD REPONSE CAUSE ABSENCE COPENHAGUE STOP ARRIVE BRUXELLES OCTOBER 23 SOIR
= BOHR +

Fig. 2 Telegram of Bohr to Lefébure of 20 October 1927, announcing his late arrival in Brussels (doc. 2562). Courtesy of S.a.b.ULB, custodian of the archives of the International Solvay Institutes.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ADMINISTRATION DES TÉLÉGRAPHES ET DES TÉLÉPHONES
BEHEER VAN TELEGRAFEN EN TELEFONEN

TÉLÉGRAMME TELEGRAM

Lefebure rue du lac 33 B

Déposé à / Afgegeven te Haarlem à 16.33 N 0130

Langmuire excellente physicien americain maintenant Paris puis je l'inviter au Conseil
Lorentz

Fig. 3 Telegram of Lorentz to Lefébure of 19 October 1927, asking permission to invite Langmuir to the Solvay Council. Courtesy of S.a.b.ULB, custodian of the archives of the International Solvay Institutes.

More about Sommerfeld and Langmuir

We saw that Bohr (fig. 2) was invited and that Sommerfeld was not (in spite of his important recent works). The point is that the Munich professor lectured in occupied Belgium during the first months of 1918, addressing various matters and allowing German soldiers to benefit from his expertise on ballistics [4]. He also voiced publicly his support to German plans for transforming the University of Ghent into a Flemish speaking institution, a project intolerable to the Brussels bourgeoisie. Hence, Sommerfeld was no longer welcome in Belgium, and we may assume that Lorentz was aware of it.

In contrast, the last minute invitation of Langmuir came as a total surprise to the members of the administrative commission … and to Langmuir himself. On 19 October 1927, Lorentz sent this telegram (fig. 3) to Lefébure: "*Langmuir, excellent American physicist, now in Paris; may I invite him to the Council?*".

The reason of this unexpected move has been revealed by Patrick Coffey in 2008. These are his words [5]: "*Out of the blue, a week before the conference, Langmuir received an invitation. He was surprised –he was the only chemist to be invited– and wrote to his mother: «This year the subject is the quantum theory, a field in which I have contributed nothing, so I can't see why I have been invited». Langmuir was in Europe for vacation and was hobbling around on crutches after breaking his foot on the voyage from America. He was recuperating with his wife in Italy when a telegram arrived from Lorentz. Léon Brillouin, the French physicist and invitee to the conference had been in contact with Langmuir's boss Willis Whitney, trying to negotiate a consult-contract for himself with General Electric, and Whitney had asked Brillouin to make contact with Langmuir during his European trip. Brillouin was unable to meet Langmuir at an earlier conference in Como, so he apparently fudged things to get Langmuir an invitation to the Solvay conference. He led Lorentz to believe that Langmuir was going to be in Brussels anyway that week and asked him to extend Langmuir an invitation. Langmuir jumped at the chance and after sent Whitney a report on the conference: «I had planned to leave Cortina on October 23rd and to go to Eindhoven, but on the 19th I got a telegram from Lorentz inviting me to attend the Solvay congress, which was to meet to discuss the quantum theory. Brillouin had written to Lorentz suggesting that I be invited. I had heard about the Solvay congress in Como in September and had inquired about it even then from Lorentz, but was told that only those invited specially could attend and the membership limited to 23 to the most active workers in the quantum theory –so I was surprised to receive the invitation. Strenuous meetings –all day in lecture room and all evening (often till 1 a.m.) in hotel where*

all stayed– discussing quantum theory. The wave mechanics is a universal mode of expression today. For the first time the quantum theory is formulated in apparently complete form so that the discrepancy between the classical wave theory and the quantum phenomena (i.e. the photon theory) seems to be clearing up".

But why did Lorentz accept Brillouin's demand, in spite of his refusal to admit auditors to the Council?

Motives may be sought in Lorentz's recent visit to the United States and in the contacts he may have had with American colleagues. Langmuir also appears as a scientist capable of providing an expert report on the state of affairs regarding quantum theory (a point which may explain the fact that Lorentz described him as a physicist). Another clue may be found in Coffey's remark that the Langmuirs pursued their roundtrip after the Council, that they visited Lorentz in Haarlem[9], and that they stayed in Copenhagen at Bohr's home.

Whatever Lorentz's motives, we can say that his decision was a brilliant one, for Langmuir possessed a camera and realized a short film[10] showing the founding fathers of the quantum theory walking and discussing in Brussels!

3 Particulars of the Council

In the Brussels newspaper *Le Soir* of 23 October 1927, Lorentz presented his view on what was at stake at the Solvay meeting:

"*The subject of the present Council is closely related to the one that was discussed sixteen years ago. M. Planck had introduced the idea of discontinuities and of sudden transitions in the motion of atoms and electrons, and the problem in 1911 was twofold: to understand the role played by these discontinuities in physical phenomena, and to examine the fundamental laws by which they were governed. This first exploration of a new and wide domain, the richness of which would be revealed during the following years, provided already a glimpse of the fact that a basic reform of mechanics would be needed so that the existence of the above discontinuities, whose magnitudes are now called «quanta», would no longer be regarded as an additional factor, but as an essential and fundamental element. During this year's meeting, the discussions will focus on the attempts that have recently been made to develop a formalism that one may call «quantum mechanics» and to which Mr. de Broglie, Heisenberg, Born, Schrödinger, Dirac and others*[11]*, have taken part. The proposals of these physicists still constitute an ill-assorted set, for they exhibit some striking divergencies, despite their underlying unity. Hence, one may expect that «clashes of opinions» will not be lacking, and that they will lead to a closer approach of the truth. It is precisely under such circumstances that the «Solvay-method» is applicable, and that it should accelerate progress through a clarification of ideas…*".

The 1927 Solvay meeting would be marked by a contrast: reconciliation of physicists divided by the Great War, on the one hand; clash between the representatives of a new generation (Pauli, Heisenberg, Dirac, Brillouin…) and some older experts (Lorentz, Einstein, Schrödinger), on the other hand. It would also be remembered as the Council of *complementarity*, a concept put forward by Bohr as a generalization of Heisenberg's uncertainty principle and as a means of resolving the wave-particle paradox that had haunted physics during two decades.

After hearing Bragg's report in support of classical optics, the Council members heard Compton's arguments in favor of the *photon*. It was during the discussion of this second report that Lorentz defended for the last time his idea of an ether, arguing that the concept did not contradict the theory of relativity, nor the existence of *photons*.

The Council took notice of 3 proposals for a theory of quanta: de Broglie's "pilot-wave" theory, Schrödinger's wave mechanics and the "matrix mechanics" of Born-Heisenberg (reformulated by Dirac).

An unexpected event: the centenary of Augustin Fresnel

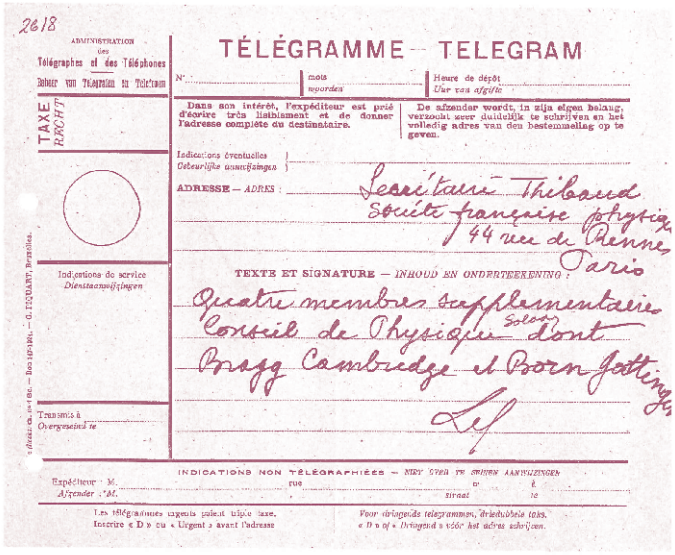
Lorentz had learned on 12 September 1927 that a celebration of the centenary of the death of Augustin Fresnel would be organized at the Sorbonne by the French Physical Society on thursday 27 October, and that the participants to the Solvay Council were invited to attend the ceremony. The timing was most unfortunate, for it was clear that some members would wish to go to Paris (Lorentz was expected to deliver a speech, and two conferences had been programmed: one by Zeeman on the same day, the other by de Broglie on the next day).

Yet, Lorentz found a way to solve the problem: he proposed to cancel the afternoon session of 27 October and the morning session of 28 October, to resume the Council's debates in the afternoon of 28 October, and to prolong them on Saturday 29 October. A list of members wishing to attend the Paris ceremony was sent to the French Physical Society (fig. 4). It comprised the following names: Einstein,

[9] Letter of Ehrenfest to Lorentz of 7 November 1927, Haarlem, Noord-Hollands Archief, 364, inv. nr. 20. The author is grateful to Frits Berends for providing this information.

[10] See Solvay Physics Conference 1927 - You Tube..

[11] It seems that Lorentz was referring to the contributions of Pascual Jordan.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TÉLÉGRAMME – TELEGRAM

TAXE / RECHT

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De afzender wordt, in zijn eigen belang, verzocht zeer duidelijk te schrijven en het volledig adres van den bestemmeling op te geven.

Indications de service / Dienstaanwijzingen

ADRESSE – ADRES :

Secrétaire Thibaud
Société française physique
44 rue de Rennes
Paris

TEXTE ET SIGNATURE – INHOUD EN ONDERTEEKENING :

Quatre membres supplémentaires Conseil de Physique Solvay dont Bragg Cambridge et Born Gottingen

Lef

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INDICATIONS NON TÉLÉGRAPHIÉES – NIET OVER TE SEINEN AANGEVINGEN

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Fig. 4 Telegram of Lefébure to J. Thibaud, secretary of the Société Française de Physique, announcing the participation of W. L. Bragg and M. Born to the celebration of the centenary of Augustin Fresnel on 27 October 1927. Courtesy of S.a.b.ULB, custodian of the archives of the International Solvay Institutes.

Langevin, Richardson, Guye, Bohr, Born, Kramers, Compton, Fowler, Wilson, Pauli, Heisenberg, de Broglie, Debije, Brillouin, Bragg, De Donder, Verschaffelt. A total of 25 train tickets (and restaurant reservations) for the Brussels-Paris journey were purchased by ISIP's administrative commission.

4 Einstein at "Solvay V"

In contrast to the Como conference, the Council was attended by Einstein. Everyone was eager to hear his reaction to Heisenberg's mechanics…but the father of the photon remained extremely discrete. The published proceedings mention only one intervention by Einstein: an analysis that he developed during the general discussion and from which he concluded that in its actual form quantum mechanics should not be regarded as a *complete* theory.

The Einstein-Bohr debate

In spite of Einstein's relative silence during the Council, there is a fact which is often mentioned: the famous Bohr-Einstein debate about the status of quantum theory. There is no doubt that animated discussions between Bohr and Einstein took place at the Grand Hotel Britannique, where all members stayed, during breakfast or in the evening, and that Einstein felt uneasy about a theory which implied the relinquishing of any causal description of processes in space-time.

In his memories [2] of the fifth Solvay Council, Bohr says that his debate with Einstein focused on one question: "*Should one consider that the description offered by quantum mechanics exhausts all possibilities of accounting of observable phenomena, or should one, as advocated by Einstein, push the analysis further in order to obtain a more complete description of these phenomena*?".

Bohr also says that his discussions with Einstein took a more "*dramatic turn*" at the next Solvay Council of 1930, recalling that after a sleepless night he managed to find a flaw in Einstein's subtle scenario which aimed at disproving Heisenberg's principle of indeterminacy.

Einstein's special encounters

It was on the occasion of the fifth Solvay Council that Einstein made the acquaintance of Georges Lemaître, father of the "Big Bang theory". This is how Lemaître describes his encounter with Einstein [6]:

"*Einstein had come to Brussels to attend the Solvay meeting of 1927. As we walked through the Parc Léopold, he told me about a paper, almost unnoticed, that I had written the previous year on the expansion of the universe, and that a friend had asked him to read. After a few technical and favorable remarks, he said that the paper sounded abominable from the physical point of view!*

As I tried to prolong the conversation, I was asked by Auguste Piccard, who accompanied Einstein, to take a taxi cab with them, and to visit Piccard's laboratory at the Université Libre de Bruxelles. In the taxi I spoke of the velocities of nebulae, and got the impression that Einstein knew not much about astronomical facts… At the University all conversations were in German, and I was surprised to be called "Herr Lemaître". I admired the interferometer which had recently travelled in a balloon, and signed, after Einstein, the golden book of the University… ".

Another memorable encounter took place on 29 October 1927, when Einstein attended, with 8 other Council members, a lunch at the royal palace with King Albert and Queen Elisabeth (who like Einstein was born in south Germany). Having been given a seat at the right hand side of the Queen (presumably at her majesty's own request[12]), the lunch became the starting point of a lasting friendship, witnessed by a lifelong correspondence (the letters of Einstein to the Queen are kept at the royal archives).

[12] Einstein had become famous overnight in 1919 after the success of his predictions regarding the deflection of light by the Sun (result of Eddington's solar eclipse expedition). However, there are additional elements which explain the Queen's eagerness to meet Einstein: her passion for music (they both played violin) and her special interest in judaism.

Einstein's invitation to the royal lunch was to be followed by a closing session of the Council (until 5 p.m.) and by a visit to his *Lieblingsonkel* Caesar Koch (brother of his mother Pauline), a Swiss citizen who lived since many years in Belgium[13]. The previous day he had sent him a letter to announce his visit. He would take a train to Liège, where Koch was living with his daughter Suzanne. However, he had no idea of the time at which he would be able to leave Brussels, and asked his uncle not to come to the railway station[14].

Einstein's encounter with the Queen would be followed by less official ones. Back in Brussels in 1929 to attend a meeting of ISIP's scientific committee, Einstein was invited once more at the royal palace. However, due to an unforeseen event, the lunch had to be cancelled at the last minute. This unfortunate development deprived the Queen of a renewed encounter with Einstein. Yet, she did not give up: she sent a message to Einstein, inviting him to come and play the violin at the royal castle of Laeken. This musical afternoon would be the first of a series of informal meetings between Einstein and his royal host, the mother of the last Queen of Italy.

Acknowledgements

The author wishes to express special thanks to his friend and colleague Frits Berends for his constant assistance in retracing the history of the early Solvay Councils on physics. He is also grateful to Didier Devriese, director of the Archives at ULB, and to Carole Masson for their help and the access they provided to the Solvay documents.

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[1] G. Bacciagaluppi, A. Valentini, "*Quantum Theory at the Crossroads*" (Cambridge University Press) 2013, xvii. The authors do not name authors of the misleading literature; however among all bibliographical sources reported, there is only one work which seems to be directly related to their claim: J. Mehra, "*The Solvay Conferences on Physics: Aspects in the Development of Physics since 1911*" (Reidel, Dordrecht) 1975.

[2] N. Bohr, "*Albert Einstein: Philosopher - Scientist*", *The Library of Living Philosophers, Inc.* (Tudor Publishing Company) 1949.

[3] W. Heisenberg, *"Die Entwicklung der Quantentheorie 1918-1928", Naturwiss.*, 14 (1929) 495.

[4] M. Eckert, "*Arnold Sommerfeld: Science, Life and Turbulent Times, 1868-1951*" (Springer) 2013, p. 292. The author thanks Michael Eckert for providing this valuable information.

[5] See P. Coffey, "*Cathedrals of Science. The Personalities and Rivalries that Made Modern Chemistry*" (Oxford University Press) 2008.

[6] G. Lemaître, "*Rencontres avec A. Einstein*", *Revue des Questions Scientifiques*, 20 janvier 1958.

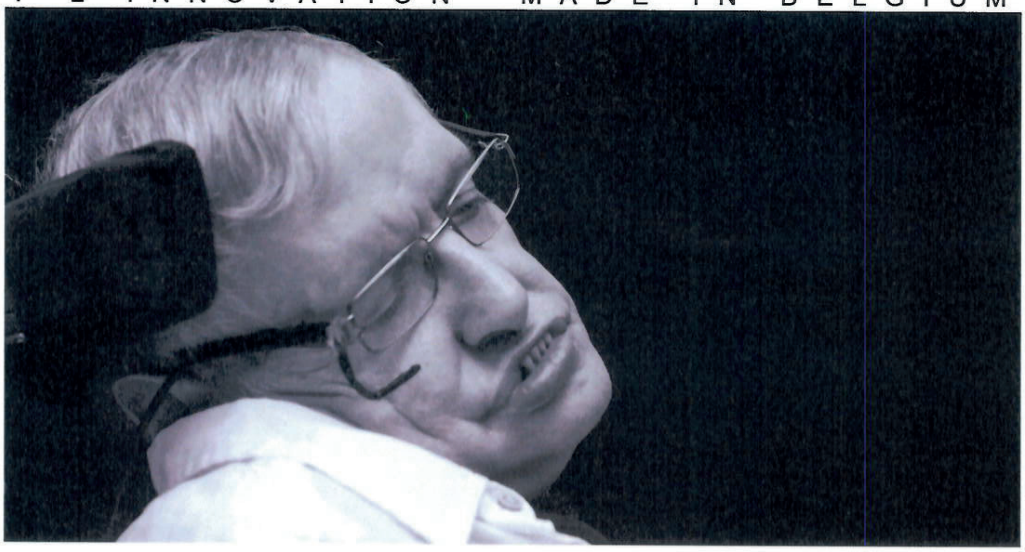
Franklin Lambert

As a professor at Brussels University (VUB), Franklin Lambert lectured on a variety of subjects in the field of mathematical and theoretical physics, as well as on the history of modern physics. He joined the board of the International Solvay Institutes in 1995 at the request of Ilya Prigogine (their former director), where he served as an administrator and as a deputy-director. Today he is in charge of the Institutes' archives, which are scattered over various centres in Europe and in the United States. Franklin Lambert's latest research focused on nonlinear dynamics (more specifically on solitons and on the theory of integrable systems).

[13] There are elements indicating that Caesar Koch was the man who supported Einstein at a critical time (when Einstein decided to end his studies in Munich and to renounce his German citizenship), encouraging him to apply to the ETH in Zurich, and enabling him to acquire the precious Swiss passport after completion of his studies at the ETH. Letters of Einstein to his Belgian family seem to suggest that this was the case, a point confirmed by a grand-daughter of Caesar Koch, Mrs. Lucienne Tréfois (thanks to the help of Mrs. Nathalie Ferrard). Note also that Einstein's grand-son was given the name Bernhard Caesar.

[14] The author is grateful to Mrs. Nathalie Ferrard, a grand-daughter of Einstein's cousin Suzanne Koch-Gottschalk, for offering him a copy of this letter (which is due to appear in the next volume of the "*Collected Papers of Albert Einstein*").

DAILY SCIENCE
DÉCOUVREZ LA SCIENCE, LA RECHERCHE ET L'INNOVATION "MADE IN BELGIUM"



STEPHEN HAWKING NE VIENDRA PLUS À BRUXELLES

Publié le 14 mars 2018

par Christian Du Brulle

Le physicien britannique Stephen Hawking est décédé dans la nuit de mardi à mercredi à l'âge de 76 ans. Souffrant d'une maladie neurodégénérative (une sclérose latérale amyotrophique) diagnostiquée à l'âge de 21 ans, alors qu'il était encore étudiant en physique à l'Université de Cambridge (dans les années '60), l'auteur du best-seller « Une brève histoire du temps », aura finalement connu une longue vie. À l'époque pourtant, les médecins ne lui laissaient pas deux années d'espérance de vie… Au cours de son existence, le physicien est venu à diverses reprises à Bruxelles, à l'invitation notamment des Instituts internationaux Solvay (ULB-VUB).

Une rencontre à Bruxelles

Les travaux théoriques de Stephen Hawking ont porté sur le temps, la vie de l'Univers et ses particularités, pour ne pas dire ses « singularités ». Quand nous l'avions rencontré en 2007, à Bruxelles, il nous avait parlé de certains volets de ses travaux. Principalement en ce qui concernait les trous noirs.

Il nous avait aussi expliqué pourquoi, alors qu'il était déjà largement immobilisé par la maladie, il venait de participer à un vol parabolique aux États-Unis. Il s'agit de ces vols où les avions suivent des trajectoires paraboliques, au sommet desquelles quelques secondes de microgravité sont générées dans la cabine. Cela avait permis à Stephen Hawking de ressentir ce qu'expérimentent les astronautes dans l'espace.

Pourquoi cet intérêt pour un vol parabolique? « La survie de l'espèce humaine dépendra de son aptitude à se trouver de nouveaux gîtes, ailleurs dans l'Univers parce que le risque de destruction de la Terre ne cesse de croître », disait-il. « Je veux donc attirer l'attention du public le plus large sur les vols spatiaux ».

Conseil de physique Solvay de 2011

« D'un point de vue scientifique, Stephen Hawking a été à l'origine de contributions remarquables sur les trous noirs », explique le Pr Marc Henneaux, directeur des Instituts Internationaux Solvay (ULB et VUB). Le Pr Henneaux a eu le plaisir d'accueillir à diverses reprises le Pr Hawking en Belgique, notamment dans le cadre du Conseil de physique Solvay de 2011, qui marquait le 100e anniversaire de ces fameux Conseils.

Conseil de physique Solvay, 2011, Bruxelles. © Instituts Solvay

« Dans un premier temps, la Communauté scientifique n'a pas pris ses solutions sur les trous noirs très au sérieux. Elles portaient sur un effondrement gravitationnel de la matière sur elle-même que rien ne pouvait arrêter. Certains physiciens ont jugé dans un premier temps ses solutions absurdes, arguant que dans la nature un tel phénomène ne pouvait pas se réaliser », détaille le Pr Henneaux, depuis Princeton, où il mène actuellement et pour quatre semaines des recherches scientifiques.

Prédiction mathématique de l'existence des trous noirs

« Les travaux d'Hawking étaient purement mathématiques, rappelons-le. Ses travaux mathématiques étaient réalisés sur base des équations qui décrivent la gravitation (les équations d'Einstein) », continue-t-il. « Elles avaient en effet un côté qui était très perturbant. Mais au final, il est apparu qu'il avait raison. Les astrophysiciens ont fini par détecter, de manière indirecte, l'existence de très nombreux trous noirs dans l'Univers ».

Les trous noirs et les problèmes qui s'y rapportent ont longuement occupé ses travaux. Il a ainsi notamment découvert ce qu'on appelle désormais le rayonnement de Hawking. « Il a montré que si on tenait compte de la mécanique quantique, les trous noirs n'étaient pas aussi noirs que ce que l'on pensait », reprend Marc Henneaux. « Il a montré mathématiquement qu'ils pouvaient aussi rayonner. Cela n'a toutefois pas été mis en évidence par des « observations » (une façon de parler). Parce que le rayonnement des trous noirs de taille astrophysique est extrêmement faible et donc trop petit pour pouvoir être détecté directement ».

« Il a aussi contribué aux développements de nos connaissances en cosmologie. Il a montré l'origine quantique des fluctuations initiales dans le rayonnement de corps noirs de l'Univers. Des petites fluctuations qui ont ensuite été amplifiées par la gravitation et ont donné naissance aux galaxies ». Il a donc pu démontrer l'origine quantique de la structure dans l'Univers ».

Du sommet de l'Atomium à la « Mort Subite »

« Sa volonté et sa passion pour la physique l'ont porté tout au long de sa vie », estime Marc Henneaux. « Cela l'a certainement aidé à surmonter sa maladie.

Il avait également une économie de pensée extraordinaire », se souvient le scientifique belge. « Sa maladie l'y a obligé. Il allait droit au but. Il disait en quelques mots, en quelques phrases les points essentiels d'un raisonnement, d'un mécanisme ou d'une pensée. C'était remarquable ».

Stephen Hawking avait été invité à trois Conseils Solvay. Il avait accepté ces invitations, mais n'avait finalement pu se rendre qu'à celui de 2011, pour des raisons de santé.

Stephen Hawking à Bruxelles, en 2007, avec le Pr Marc Henneaux (à gauche), directeur des Instituts de physique chimie Solvay. © ULB

Par contre, il participa à plusieurs ateliers scientifiques organisés en Belgique. Il fit même le déplacement en 2007, toujours à l'invitation des Instituts Solvay, pour donner une conférence grand public au Heysel.

Un événement qui a marqué Marc Henneaux. A cette occasion, le Pr Hawking avait demandé à déjeuner au restaurant situé au sommet de l'Atomium… « Ce fut toute une expédition pour l'y amener », se souvient le physicien théoricien belge. « L'ascenseur n'arrivait pas jusqu'au niveau du restaurant. Les derniers escaliers étaient les plus difficiles à franchir, tellement le fauteuil du Pr Hawking, doté d'imposantes batteries, était lourd. Mais nous avons réussi. »

« Une autre fois, c'est à la Mort Subite (un célèbre café à Bruxelles) que Stephen Hawking avait voulu se rendre », indique encore Marc Henneaux. « Curieux de tout, il désirait goûter une gueuze… ».

Les séjours de Stephen Hawking étaient aussi rythmés par des diners chez Madame Solvay, à La Hulpe, qui le recevait systématiquement. Une autre facette des relations particulières qu'il entretenait avec la Belgique.

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
2017 The Physics of Living Matter: Space, Time and Information in Biology

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
2017 The Physics of Living Matter: Space, Time and Information in Biology

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

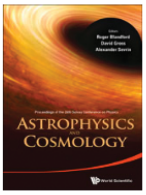
1911 - 1928 Hendrik Lorentz, 1902 Nobel Laureate, Haarlem (The Netherlands)
1928 - 1946 Paul Langevin, Paris (France)
1946 - 1962 Sir Lawrence Bragg, 1915 Nobel Laureate, Cambridge (UK)
1962 - 1967 Robert Oppenheimer, Princeton (USA)
1967 - 1968 Christian Møller, Copenhagen (Denmark)
1969 - 1980 Edoardo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

The Solvay Conferences on Chemistry

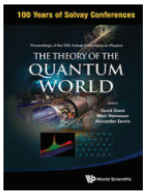
1922 Five topical questions in chemistry
1925 Chemical structure and activity
1928 Topical questions in chemistry
1931 Constitution and configuration of organic molecules
1934 Oxygen : chemical and biological reactions
1937 Vitamins and Hormons
1947 Isotops
1950 Oxidation mechanism
1953 Proteins
1956 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
2016 Catalysis in Chemistry and Biology

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

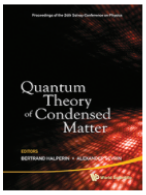
1922 - 1939 Sir William Pope, Cambridge (UK)
1945 - 1958 Paul Karrer, 1937 Nobel Laureate, Zurich (Switzerland)
1958 - 1988 Alfred Ubbelohde, London (UK)
1989 - 2011 Stuart Rice, Chicago (USA)
2011 - present Kurt Wüthrich, 2002 Nobel Laureate, Zurich (Switzerland) and La Jolla (USA)



Astrophysics and Cosmology
Proceedings of the 26th Solvay Conference on Physics
Edited by: Roger Blandford, David Gross & Alexander Sevrin

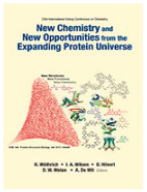


The Theory of the Quantum World
Edited by: David Gross, Marc Henneaux & Alexander Sevrin



Quantum Theory of Condensed Matter
Edited by: Bertrand I Halperin & Alexander Sevrin

The Quantum Structure of Space and Time
Edited by: David Gross, Marc Henneaux & Alexander Sevrin



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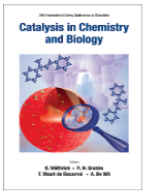

Catalysis in Chemistry and Biology
Proceedings of the 24th International Solvay Conference on Chemistry
Edited by: Kurt Wüthrich, Robert H Grubbs, Thierry Visart de Bocarmé & Anne De Wit

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, Santa Barbara, USA

2009 Valery Rubakov, Moscow, Russia

2010 Serge Haroche, 2012 Nobel Laureate, 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

2015 Peter Zoller, Innsbruck, Austria

2016 Dam Thanh Son, Chicago, USA

2017 Uri Alon, Rehovot, Israel

2018 Bernard Derrida, Collège de France, France

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, Zurich, Switzerland

2013 Egbert Meijer, Eindhoven, The Netherlands

2014 Richard Schrock, MIT, USA

2015 Andreas Manz, KIST Europe, Saarbrücken, Germany

2016 Raymond Kapral, Toronto, Canada

2017 Richard Henderson, 2017 Nobel Laureate, Cambridge, UK

2018 Ben Feringa, 2016 Nobel Laureate, University of Groningen, The Netherlands

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

18 October 2015 – One hundred years of Einstein's general relativity

"Massive Black Holes and the Evolution of Galaxies"

by Reinhard Genzel (Max Planck Institute Munich, Germany)

"From Nothing to the Universe"

by Viatcheslav Mukhanov (LMU Munich, Germany)

23 October 2016 – Chemistry for the World of Tomorrow

"Translation of Academic Science into the Commercial"

by Robert Grubbs (California Institute of Technology, USA)

2005 Nobel Laureate in Chemistry

"The Art of Building Small"

by Ben Feringa (University of Groningen, The Netherlands)

2016 Nobel Laureate in Chemistry

22 October 2017– Frontiers of Science from Physics to Biology

"From Genes to Cell Shape: The Mechanics of Embryonic Development"

by Professor Eric Wieschaus (Princeton U., USA)

1995 Nobel Laureate in Physiology or Medecine

"The Many Frontiers of Physics"

by Professor David Gross (Kavli Institute, USA)

2004 Nobel Laureate in Physics

21 October 2018

" De novo protein design: bringing biology out of the Stone Age"

by David Baker (University of Seattle)

"Random Walk to Graphene"

by Andre Geim (University of Manchester, UK)

2010 Nobel Laureate in Physics University of Manchester

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