2024 ANNUAL REPORT

Institut 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

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SOLVAY

There are no limits to what science can explore

Ernest Solvay

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

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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, physicists and biologist 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 for 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 Lectures) directly benefit from the support of the National Lottery.

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A word of the President

This is a historical moment for the Institutes, after over one 100 years, in 2024, we decided to embark on a new scientific journey, namely biology. Until now, we were mostly known in the fundamental physics and the fundamental chemistry scientific communities, for the Solvay conferences. We were dedicated to organizing these scientific conferences each every 3 years and found delight in assembling bright minds in these disciplines and their confines, bringing greater understanding to complex natural phenomena. It is true to say that since the beginning of the 20th century this understanding has greatly impacted our world and lifted billions of people out of poverty.

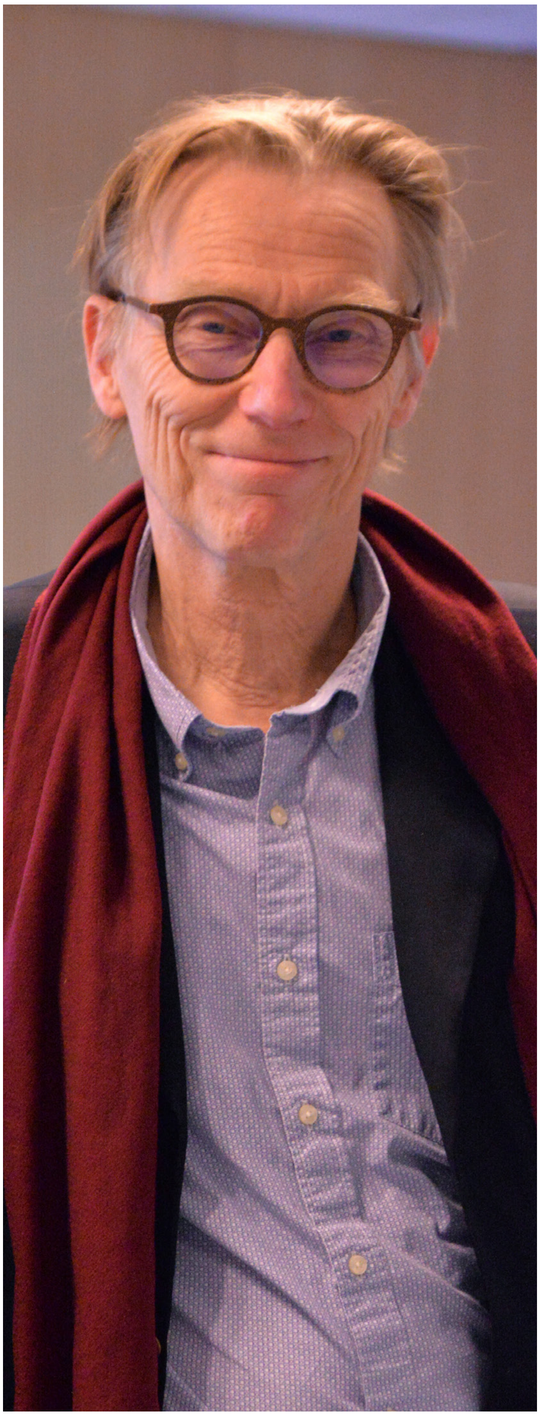
Our friend Lars Brink, former president of our advisory committee had told us that we would have to enlarge one day the scope of our domain of study to cover life science. And indeed, in 2017 we organized a biophysics conference which assembled two communities, namely biology and theoretical physics. We were surprised to see how well these two communities enjoyed the interaction and we were encouraged to follow-up on that initiative.

What makes us think that we may be relevant in this field, considering the many scientific conferences happening in this day and age?

We are on the eve of fundamental discovery in biology.

Our conferences have a convening power. The format of a Solvay Conferences is the same since the beginning in 1911: we bring together a diverse community, seekers on the frontiers of their intersecting fields to focus their attention on compelling questions. We ask that all participants come to Brussels in presence and stay here for the whole conference, thereby extracting themselves from the daily distractions. The interactions are all in presence. The time spent at the margins of the conference such as meals, chatting, walking in the city, enjoying a moment, gathering for coffee, is as important as the time spent in debate during the sessions. It is well known that the Solvay conferences exist only for the exchanges, for the dynamic discussions between the participants. That is the reason participants keep coming back.

As we embark on this new journey, we are excited to bring new scientific communities together in search for new knowledge in the realm of living matter. As we add another Institute in 2025, we will launch a fundraising campaign to fund the additional expenses that will be incurred by the new structure and the associated costs to make it sustainable.



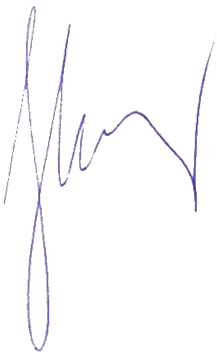
A word of thanks: None of this would have been possible without our Sponsors, the ULB and the VUB Universities, the Syensqo Company, the UCB Company, the Belgium national Lottery, BNP-Paribas-Fortis, the FWO, the FNRS, the Brussels Region, the Fédération Wallonie-Bruxelles, the Solvac Company.

Equally essential has been the daily commitment of the director, Marc Henneaux, his team, Dominique Bogaerts and Isabelle Van Geet. As you will see, they make all this happen as if it was easy.

I want to extend my special thanks to Dominique for the twenty years she has given the Solvay Institutes to make them what they are today: a statement of excellence.

Finally, please let us welcome to the team Inès Tirvengadum.

Jean-Marie Solvay | President



A word of the Director

The year 2024 will most likely be regarded by historians of science as a landmark in the life of the International Solvay Institutes. Indeed, our long-matured initiative of launching activities in biology has seen the light of day in April with the successful organization of the first Solvay Conference on biology entitled "Biological information and information processing". If it is often stated that the 21st century will be the century of biology... well, the year 2024 has definitely been our year of biology!

This first conference was chaired by Professor Thomas Lecuit (Centre Turing, Marseille & Collège de France, Paris), and co-chaired by Professors James Briscoe (Crick Institute, London), Frank Jülicher (Max-Planck-Institute, Dresden), Edwin Munro (University of Chicago), Manu Prakash (Stanford University) and Aleksandra Walczak (Ecole Normale Supérieure, Paris). The International Solvay Institutes are most grateful to all of them for the splendid "première" that they have been able to organize so successfully.

The conference on biology was followed by our annual public event, which was naturally devoted to subjects related to the main theme of the conference, namely, information and information processing in biological systems. As usual, the event was followed by an enthusiastic attendance, filling the studio 4 of Flagey.

The biology initiative would not have been possible without the enthusiastic support of our President, of the entire Solvay family and the company UCB. It is the will of the Institutes to perpetuate the activities in biology through an increase of the endowment. To that effect, an ambitious fund raising campaign will start in 2025.

The present report describes at length the activities organized or supported by the International Solvay Institutes during the year 2024. These activities covered a wide spectrum of developments at the frontiers of science. In addition to the first biology conference and the 2024 public event, we had:

- the 2024 "Jacques Solvay chair in physics" held by Professor Samaya Nissanke from Nikhef (Amsterdam);

- the 2024 "Syensqo Chair in Chemistry by the International Solvay Institutes" held by Professor Markus Antonietti from the Max-Planck-Institute in Potsdam;

- the 2024 New Horizons Lectures in chemistry given by Professor Alexis Komor from the University of San Diego;

- the 2024 New Horizons Lectures in physics given by Professor Netta Engelhardt from MIT;

- as well as more than ten workshops and colloquia, the annual Amsterdam-Brussels-Paris doctoral school etc.

All the detailed information can be found in the core of the report.

Besides the activities of the Institutes, the report describes the research carried in the groups of the Director and of the deputy-Directors. The research highlights of other researchers connected with the Institutes are outlined too.

I would like to express the gratitude of the Institutes to the individuals and institutions who subsidize us and stimulate our mission, which are the Université Libre de Bruxelles, the Vrije Universiteit Brussel, the Syensqo company, the UCB company, the Belgian National Lottery, BNP-Paribas-Fortis, the FWO, the FRS-FNRS, the Brussels Region, the Fédération

A word of the Director

Wallonie-Bruxelles, the Solvac company, and last but not least, the Solvay family who continues with the same conviction a more than a century-old tradition of support to fundamental research.

The Solvay family also supports directly the research of the group of the Director. I heartily thank them for this most precious help and trust.

Finally, I want to thankfully praise the commitment and the exceptional sense of responsibility of Dominique Bogaerts and Isabelle Van Geet, who have as usual managed with remarkable efficiency and dedication the logistics of our activities.

The year 2024 also marks a big change in the management of the Institutes since Dominique is leaving us after 20 years of faithful and distinguished service. This well-deserved retirement gives us the opportunity to warmly thank her again for her competent dedication to the Institutes and to wish her great success in her many new projects. I would also like to welcome on this occasion Inès Tirvengadum who is joining the staff of the Institutes in January of 2025.

Marc Henneaux | Director

01

GENERAL INFORMATION

Board of Directors

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VUB representative

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de Maret Pierre

Mondron Edouard

Querton Alain

Querton Cédric

Rolin Olivia

Rolin Patrick

Sanglier Michèle

Schaus Annemie

de Selliers de Moranville Jacques

Solvay Anne-Christine

Solvay Carole

Solvay Denis

Solvay Mimi

Van Camp Benjamin

Van Houtte Patricia

Van Ypersele Nathalie

Wielemans Patrick

Willems Hans

Willems Hans Assistant

Willox Ralph

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).

Executive Committee

Director

Professor Marc Henneaux

Physics

Professor Alexander Sevrin / VUB
Deputy Director for Physics

Professor Glenn Barnich / ULB

Professor Ben Craps / VUB

Chemistry

Professor Gert Desmet / VUB
Deputy Director for Chemistry

Professor Ann De Wit / ULB

Professor Yves Geerts / ULB

Administrative Staff

The Director is assisted in his management tasks by the administrative staff.

Ms Dominique Bogaerts
Office Manager

Ms Isabelle Van Geet
Project Coordinator

Mr Tahar Hmida
Accounting Officer

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 their own respective International Scientific Committees), make suggestions if appropriate, report to the Board of Directors and provide advice for future developments.

In 2024, the Board of Directors of the International Solvay Institutes appointed Professor Robbert Dijkgraaf as Chair of the International Advisory Committee of the Institutes.

Professor Dijkgraaf has been the director of the Institute for Advanced Study at Princeton, the president of the Royal Dutch Academy for Sciences, and more recently, Minister of Education, Culture and Science in the Netherlands. Until his inauguration as a minister, he served on the Solvay International Scientific Committee for Physics. He also holds an honorary degree from the VUB.

We are most grateful that Professor Dijkgraaf accepted this important task that provides us invaluable guidance.

Chair

Professor Robbert Dijkgraaf
University of Amsterdam,
The Netherlands

Members

Professor Costas Bachas
École Normale supérieure (ENS),
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Professor Leticia Cugliandolo
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Professor Gunnar von Heijne
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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.

Chair

Professor David Gross
2004 Nobel Laureate
Kavli Institute for Theoretical Physics,
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Germany

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1997 Nobel Laureate
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Professor Fabiola Gianotti
CERN, Switzerland

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Harvard University, USA

Professor Wolfgang Ketterle
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Technology, USA

Professor Juan Maldacena
IAS Princeton, USA

Professor Giorgio Parisi
2021 Nobel Laureate
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University of Innsbruck, Austria

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The Netherlands

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Professor Thomas Ebbesen
Strasbourg University, France

Professor Stefan Hell
2014 Nobel Laureate
Max-Planck-Institute,
Göttingen, Germany

Professor David MacMillan
2021 Nobel Laureate
Princeton University, USA

Professor Bert Weckhuysen
University of Utrecht,
The Netherlands

Professor Helma Wennemers
ETH Zurich, Switzerland

Professor Omar Yaghi
Berkeley University, USA

Local Scientific Committee for Physics

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

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ULB, Brussels

Observer

Professor Ann De Witt
ULB, Brussels

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Professor Nicolas Boulanger
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UAntwerp

Professor Petr Tinyakov
ULB, Brussels

Professor Sophie Van Eck
ULB, Brussels

Professor Frank Verstraete
UGent

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VUB, Brussels

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ULB, Brussels

Professor Marc Henneaux
ULB, Brussels

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UAntwerp

Professor Benoît Champagne
FUNDP, Namur

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ULB, Brussels

Professor Frank De Proft
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Professor Anne De Wit
ULB, Brussels

Professor Yves Geerts
ULB, Brussels

Professor Jeremy Harvey
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Professor Sophie Hermans
UCL, Louvain

Professor Roberto Lazzaroni
UMONS

Professor Luc Moens
UGent

Professor Jean-Christophe Monbaliu
ULiège

Professor Han Remaut
VUB, Brussels

Professor Marlies Van Bael
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Professeur Lode Wyns
VUB, Brussels

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1989 Nobel Laureate
Boulder, Colorado, USA

Professor Claude Cohen-Tannoudji
1997 Nobel Laureate
École Normale Supérieure, Paris,
France

Professor Robbert Dijkgraaf
President-Elect of the International
Science Council

Professor François Englert
2013 Nobel Laureate
ULB, Belgium

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

Professor Graham Fleming
University of Berkeley, USA

Professor Gerard 't Hooft
1999 Nobel Laureate
Spinoza Instituut, Utrecht,
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Christian Jourquin
Former CEO Solvay Group,
Belgium

Professor Roger Kornberg
2006 Nobel Laureate
Stanford University, USA

Professor Jean-Marie Lehn
1987 Nobel Laureate
Collège de France, Paris,
France

Professor Henk N.W. Lekkerkerker
Utrecht Universiteit
The Netherlands

Professor Hermann Nicolai
Max-Planck-Institut für
Gravitationsphysik, Golm, Germany

Professor Kyriacos Costa Nicolaou
University of California, San Diego,
USA

Professor Jacques Prost
Institut Curie, Paris, France

Professor Pierre Ramond
University of Florida, Gainesville,
USA

Professor Victor A. Sadovnichy
Moscow State University, Russia

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Professor Roald Sagdeev
University of Maryland
College Park, USA

Madame Solvay de la Hulpe
Belgium

Professor JoAnne Stubbe
Massachusetts Institute of Technology, USA

Professor Irina Veretennicoff
Emeritus Professor VUB, Belgium

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

Professor George M. Whitesides
Harvard University, USA

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

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

In memoriam

The International Solvay Institutes mourn the passing away of two scientific personalities close to the Institutes, Professors Stuart Rice (22 December 2024) and Jan Zaanen (18 January 2024).

Professor Stuart Rice was a distinguished American Chemist from the University of Chicago. He was a Fellow of both the National Academy of Sciences and the American Academy of Arts and Sciences. He received the prestigious Wolf Prize in 2011. He served as chair of the International Solvay Committee for Chemistry for the 1995, 2007 and 2010 Solvay Conferences on Chemistry.

Professor Jan Zaanen was a renowned Dutch Physicist from the Lorentz Institute and the University of Leiden. He was a Fellow of the Royal Netherlands Academy of Arts and Sciences. He received in 2006 the Spinoza Prize, the highest scientific award in the Netherlands. He held the Jacques Solvay Chair in Physics in 2012.

The Institutes will deeply miss them.

02

1ST SOLVAY CONFERENCE ON BIOLOGY

“The organization and dynamics of biological computation”

16–20 April 2024

Organizing Committee

Chair

Thomas Lecuit
IBDM Marseille
and Collège de France,
Paris

Co-Chair

James Briscoe
Crick Institute, London,
United Kingdom

Frank Jülicher
MPI PKS, Dresden, Germany

Edwin Munro
University of Chicago, USA

Manu Prakash
Stanford University, USA

Aleksandra Walczak
ENS, Paris, France

The 20th century has witnessed revolutionary developments in physics and chemistry.

Through the celebrated Solvay Conferences, the International Solvay Institutes have played a leading role in these scientific breakthroughs. Not only did they contribute to the development of quantum mechanics in the first half of the 20th century, but since then, they have been and still are at the forefront of all the significant advances taking place in physics and chemistry.

It is often said that the 21st century will be the century of biology. It was therefore high time for the Solvay Institutes to become actors of the forthcoming revolution in our understanding of the living world.

Actually, Ernest Solvay, the founder of the Institutes, was already extremely interested in biology. He emphasized three directions of research, which, in his eyes, were of crucial importance: "First, a problem of general physics: the constitution of matter in space and time; second, a problem of physiology: the mechanism of life, from its most humble manifestation up to the phenomena of human thought; and third, a problem complementary to the first two: the evolution of the individual and of social groups."

It is instructive that he considered these three problems as complementary and in fact forming only one.

The International Solvay Institutes decided therefore to launch in 2024 a similar cycle of conferences in fundamental biology. It is our ambition and hope that the first Solvay Conference, which took place in Brussels (hotel "Le Châtelain") in April, will start a series that will play the same precursor role as its physics and chemistry cousins.

What makes the success of the Solvay conferences is their distinctive format, which gives crucial importance to intense discussions between world leaders in the field. The number of participants is deliberately limited to be small in order to ensure exchanges as active and fruitful as possible. This method is particularly efficient for clarifying ideas and accelerating progress.

The same successful Solvay format was adopted for the biology conference, with an additional variant that further increased the interactions: scientists split in small groups in the afternoon to focus on a specific question, which was then addressed by the whole community of participants in a subsequent plenary session.

The International Solvay Institutes are grateful to the chairs and co-chairs of the conference, Professors Thomas Lecuit, James Briscoe, Frank Jülicher, Edwin Munro, Manu Prakash and Aleksandra Walczak, who invested a lot of their time in order to carefully prepare a remarkable program.

As it is the tradition, conference proceedings containing the vivid and informative discussions will be published. Great thanks go to the Belgian editorial team, Professors Sophie de Buyl, Geneviève Dupont and Lendert Gelens, who will co-produce the volume with the chair and co-chairs.

Scientific Background

Living matter is organized across scales, from subcellular molecular assemblies to cells, tissues, organisms and ecosystems. Such organization is intrinsically dynamical, with components of any system turning over on time scales of seconds to hours and days. The organization and dynamics of living systems unfold in characteristic ways during processes like embryonic development. They persist over time as coherent states, and they respond dynamically to inputs from a changing environment to perform key physiological functions, such as homeostasis, perception and navigation, or to evolve new ones. Thus, fundamental to living systems at all scales is the dual ability: (a) to encode information as internal organization and dynamics, and (b) to extract, store, process, respond to, and evolve in response to information from the environment.

From this perspective, biological systems are uniquely powerful computational systems, and it is natural to ask: What are the principles of such computation across different systems and different spatial and temporal scales? How is information stored within the dynamic architecture of genomes, cells, and tissues, whole organisms and ecosystems? How is information processed dynamically to yield reliable outputs in the face of internal and external noise? What is the origin of biological robustness?

Information pervades every corner of life science, but there is a need to better understand the unique nature of Biological information, its encoding in living matter, and its modes of transmission, processing and control.

The first Solvay conference on Biology addressed these problems with the goal of identifying new ways to reveal and understand general principles of biological computation. Three central themes constituted the backbone of the scientific discussions: “Dynamics and Information flow”, “Robustness, tunability and evolvability”, “What is biological computation?”. Scientists with different backgrounds in experimental and theoretical sciences, working on a variety of disciplines (from biology to physics, mathematics and computer sciences), were brought together during the entire length of the meeting.

The Conference opened with a lecture by Professor Thomas Lecuit who gave a broad view of the current status and challenges of the field and set the stage for the meeting. This opening lecture was attended by members of the Solvay family as well as auditors from the UCB company, who stayed for the whole meeting.

Program

18 April 2024

Welcome speech by Marc Henneaux and Thomas Lecuit

Session 1: "Dynamics and Information flow"

Chairs: **James Briscoe & Ed Munro**

Rapporteurs: Jordi Garcia-Ojalvo, Amy Gladfelter, Thomas Gregor and Mukund Thattai

Reports and discussions

19 April 2024

Session 2: "Robustness, tunability and evolvability"

Chairs: **Frank Jülicher and Aleksandra Walczak**

Rapporteurs: Buzz Baum, Arvind Muruga, Orit Peleg and Berta Verd

Reports and discussions

20 April 2024

Session 3: "What is biological computation?"

Chairs: **Thomas Lecuit and Manu Prakash**

Rapporteurs: Jeremy Gunawardena, Wallace Marshall, Jeremy Gunawardena and Wallace Marshall

Reports and discussions

Participants

Karen Alim
Technical University of Munich, Germany

Nathalie Balaban
The Racah Institute of Physics, Israel

Buzz Baum
Cambridge University, UK

Cédric Blanpain
ULB, Belgium

James Briscoe
The Francis Crick Institute, UK

Sophie de Buyl
VUB, Belgium

Geneviève Dupont
ULB, Belgium

Adrienne Fairhall
University of Washington, USA

Jordi Garcia Ojalvo
University Pompeu Fabra, Spain

Zev Gartner
UCSF, USA

Lendert Gelens
KULeuven, Belgium

Amy Gladfelter
University of North Carolina, USA

Thomas Gregor
Institut Pasteur, France

Jeremy Gunawardena
Harvard University, USA

Anthony Hyman
Max Planck Institute, Germany

Frank Jülicher
Max Planck Institute, Germany

Thomas Lecuit
Aix-Marseille University, France

Lisa Manning
Syracuse University, USA

Wallace Marshall
UC San Francisco, USA

Michel Milinkovitch
University of Geneva, Switzerland

Ed Munro
University of Chicago, USA

Arvind Murugan
University of Chicago, USA

Stephanie Palmer
University of Chicago, USA

Orit Peleg
University of Colorado Boulder, USA

Manu Prakash
Stanford University, USA

Madan Rao
NCBS, India

Boris Shraiman
UC Santa Barbara, USA

Mukund Thattai
NCBS, India

Shashi Thutupalli
NCBS, India

Berta Verd
University of Oxford, UK

Aleksandra Walczak
ENS, France

Sara Walker
ASU, USA

Eric Wieschaus
Princeton University, USA

Erik Winfree
Caltech, USA

Claire Wyart
ICM, France

03

OUTREACH ACTIVITIES

Solvay Public Lectures

21 April 2024

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 Syensqo Company, 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 list of all our public events is given at the end of this report.

On the day following the 1st Solvay Conference on Biology, the International Solvay Institutes organized their traditional annual public event, devoted to the theme of the conference, namely, information and information processing in biological systems.

Two splendid popular lectures were delivered by Professor Stephanie Palmer and Professor Anthony Hyman, who are leading world experts in the field. The first lecture, “Seeing what’s coming”, explained how the brain processes signals received by the eyes and anticipates “what’s coming”. The second lecture “The social life of a cell”, described the sophisticated social organization of the various components of a cell. Both lectures captivated the audience which filled, as usual, the Studio 4 of Flagey.

The lectures were followed by a panel debate addressing questions raised by the audience. The event closed with a drink offered to all the participants, during which the public could interact more with the speakers and the panel members.

The International Solvay Institutes are most grateful to the lecturers and the panellists for their active involvement in the success of the event.

Program

Moderator	**Alexandre Sevrin** VUB & International Solvay Institutes
Opening by	**Marc Henneaux** ULB & International Solvay Institutes
Lecture	*"Seeing what's coming"* **Stephanie Palmer** University of Chicago, USA *"The social life of a cell"* **Anthony Hyman** Max Planck Institute, Germany
Panel Discussion	**Cédric Blanpain** ULB, Brussels **Thomas Lecuit** Chair, Collège de France **Adrienne Fairhall** University of Washington **Aleksandra Walczak** ENS, France **Eric Wieschaus** 1995 Nobel laureate for Medicine, University of Princeton, USA
Closing	**Marc Henneaux** ULB & International Solvay Institutes
Drink	

Lecturers

Anthony Hyman

Max Planck Institute, Germany

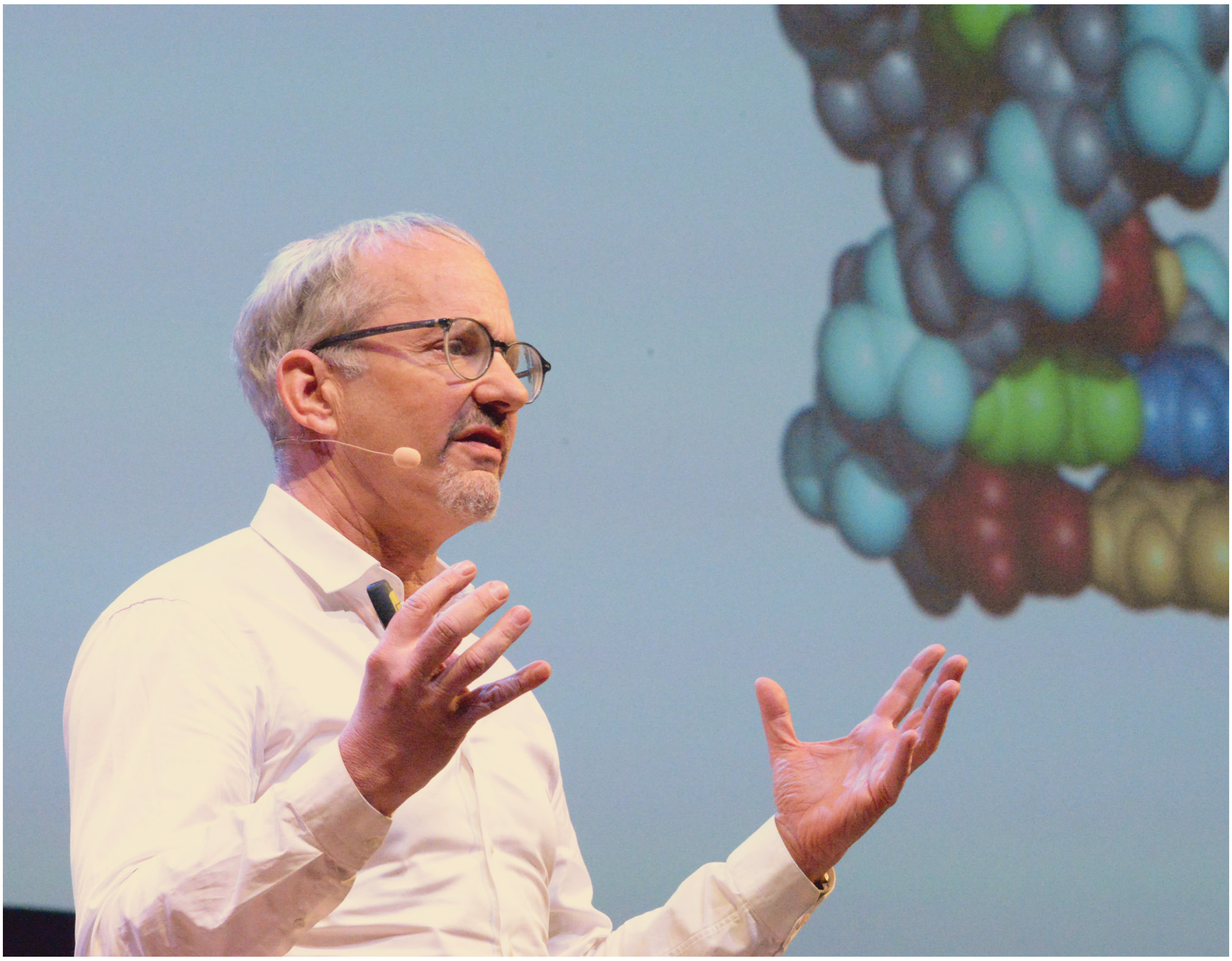
Anthony Hyman is Director and Research Group Leader at the Max Planck Institute of Molecular Cell Biology and Genetics in Dresden (Germany). He has a PhD degree from Cambridge University where he was working in the group of Nobel Laureate Sydney Brenner. He moved then as a postdoctoral researcher at the University of California in San Francisco, was subsequently group head at the European Molecular Biology Laboratory EMBL in Heidelberg before becoming one of the founding directors of the Max Planck Institute in Dresden. Anthony Hyman is a world leader in molecular cell biology and genetics. His work has been recognized by many awards and prizes, among which the Gottfried Wilhelm Leibniz Prize - Germany's most prestigious research award – in 2011 "for his work on microtubules and cell division", the Körber European Science Prize – one of the world's highest endowed prizes – in 2022 "for the groundbreaking discovery of a completely new state of biological matter: condensates" and the Breakthrough Prize in Life Sciences in 2023 "for discovering a fundamental mechanism of cellular organization mediated by phase separation of proteins and RNA into membraneless liquid droplets".

"The social life of a cell"

Abstract

Ever since Hooke looked down a microscope and saw structure that reminded him of monk's cells in a monastery, biologists have been fascinated by how cells organise their lives. We now know that a cell is full of billions of individual components that have to work together in a robust and efficient manner to for instance produce energy, or to make decisions based on the outside world. But, much like our society, these components do not function as individuals, but as collectives. And like us, they have a social life. But what does the social life of a cell look like?

In this lecture we will explore how physics has helped illuminate these long standing questions and show how diseases emerge when the social life begins to fail.



Lecturers

Stephanie Palmer

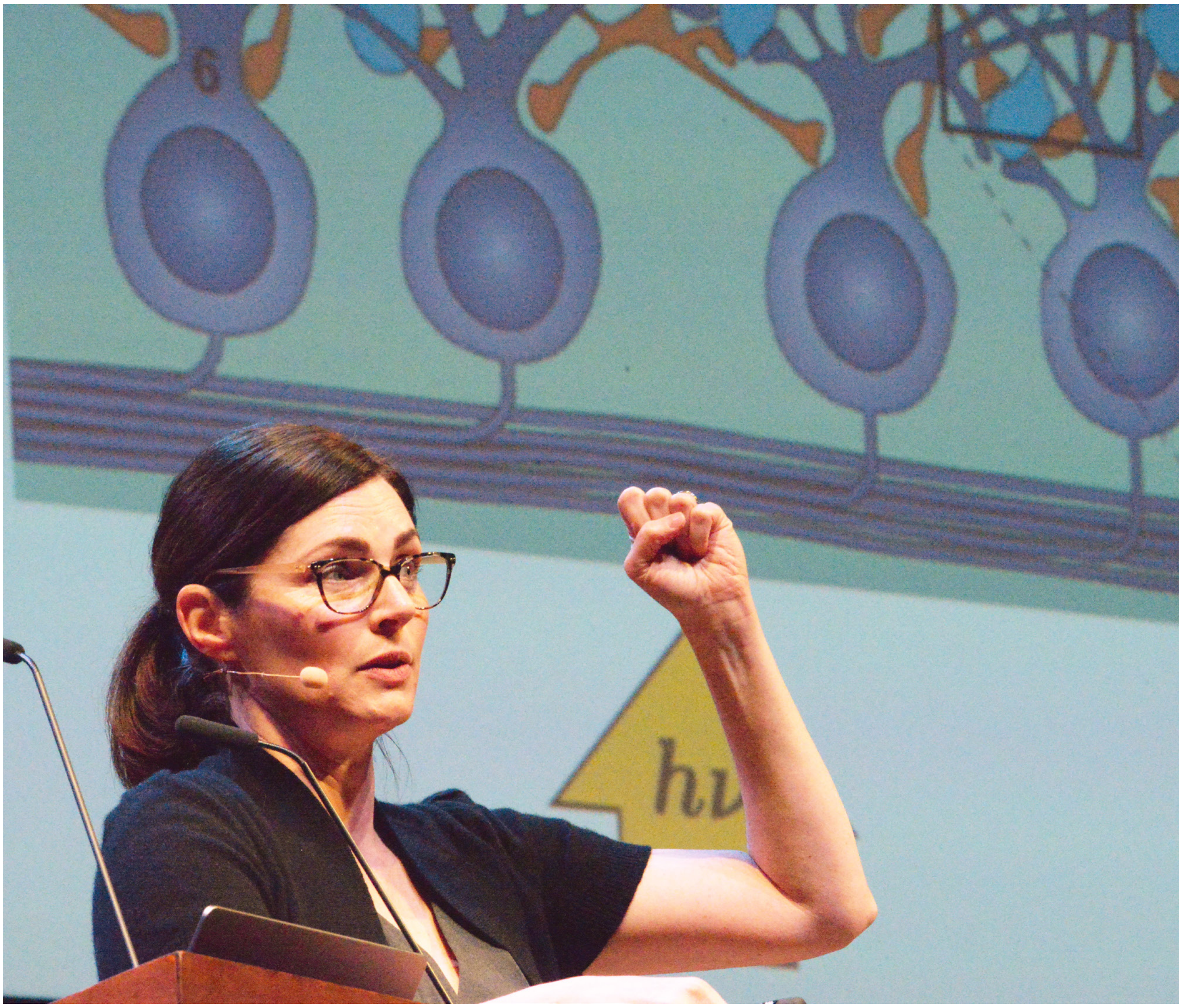
University of Chicago, USA

Stephanie Palmer is an Associate Professor in the Department of Organismal Biology and Anatomy and in the Department of Physics at the University of Chicago. She has a PhD in theoretical physics from Oxford University where she was a Rhodes Scholar, and works on questions at the interface of neuroscience and statistical physics. Her recent work explores the question of how the visual system processes incoming information to make fast and accurate predictions about the future positions of moving objects in the environment. She was named an Alfred P. Sloan Foundation Fellow and was granted a CAREER award from the NSF. Beginning in her undergraduate years at Michigan State University, Stephanie has been teaching chemistry, physics, math, and biology to a wide range of students. At the University of Chicago, she founded the Brains! Program, which brings local middle school students and science teachers from the South Side of Chicago to her lab to learn hands-on neuroscience. Stephanie is part of the leadership teams for two new major efforts in Chicago at the interface of biology, physics, and mathematics: The NSF Centre for Living Systems at the University of Chicago and the NSF-Simons Institute for Theory and Mathematics in Biology.

"Seeing what's coming"

Abstract

Prediction is essential for interacting fluidly and accurately with our environment because of the delays inherent to all brain circuits. In order to interact appropriately within a changing environment, the brain must respond not only to the current state of its sensory inputs but must also make rapid predictions of the future. In this lecture, we'll explore how our visual system makes these predictions, starting as early as the retinal cells in the eye. We'll borrow techniques from statistical physics and information processing to assess how we get terrific, predictive vision from these imperfect component parts.



Panel Members

Thomas Lecuit

Chair
Collège de France

Thomas Lecuit is a biologist whose research focuses on morphogenesis, i.e. the origin of forms in living organisms, such as a neuron or an embryo. During embryogenesis, millions of cells divide, move, change shape and collectively give rise to a complex organism. What are the mechanical forces at play, and what information flows guide these complex processes to their conclusion?

To answer these questions, Thomas Lecuit heads the Marseille-based Turing Centre for Living Systems, an interdisciplinary centre that studies the complexity and self-organization in biology, through the contribution of physics, computer science, mathematics and biology. His research team uses Drosophila as a model organism, experimentally observing, characterizing and perturbing the physical and biological properties of development, and collaborating with physicists on theoretical and modelling approaches.

Thomas Lecuit is also Professor at the College de France in Paris.

Cédric Blanpain

ULB, Brussels

Cédric Blanpain is a Belgian researcher in the field of stem cells (embryology, tissue homeostasis and cancer). He is a tenured professor of developmental biology and genetics at Université libre de Bruxelles and director of the stem cell and cancer lab at its Faculty of Medicine.

He was one of the first researchers in the world to use cell lineage tracing in cancer research and he showed for the first time the existence of cancer stem cells in solid tumours in vivo.

He was selected by Nature as one of 10 People who mattered most in 2012 and he received the outstanding young investigator award of the International Society for Stem Cell Research.

Adrienne Fairhall

University of Washington

Adrienne Fairhall holds a first class honours degree in theoretical physics, working with Bob Dewar in plasma physics, from ANU in Canberra, Australia and completed her PhD in physics at the Weizmann Institute, with Itamar Procaccia working on turbulence, in 1998. She moved into neuroscience research as a postdoc with Bill Bialek at NEC Research Institute in Princeton, then with Michael Berry at Princeton University. She joined the faculty of UW's Department of Physiology and Biophysics in 2004 and became a co-director of the WRF Institute for Neuroengineering in 2014. With Eric Shea-Brown, she co-directs the Computational Neuroscience Centre's research and educational program at UW. In 2022, Adrienne was a Tocqueville-Fulbright scholar at Ecole Normale Supérieure in Paris.

Aleksandra Walczak

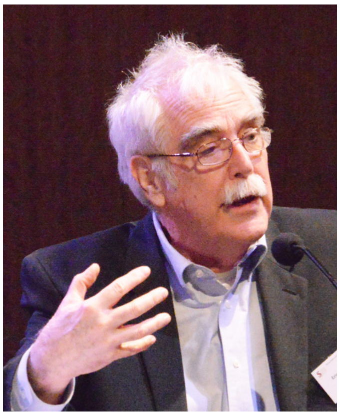
ENS, France

Aleksandra Walczak received her PhD in physics at the University of California (US), working on models of stochastic gene expression. After a graduate fellowship at the Kavli Institute for Theoretical Physics (California), she worked on applying information theory to signal processing in small gene regulatory networks at the Princeton Centre for Theoretical Science (US). Currently based at the École Normale Supérieure as a CNRS researcher, she studies the effects of selection on population genealogies, collective behaviour of bird flocks and statistical descriptions of the immune system. Dr Walczak was awarded the "Grand Prix Jacques Herbrand de l'Académie des sciences" in 2014 and the bronze medal of CNRS in 2016. Her ERC project "RECOGNIZE" focuses on the self-organization of the immune repertoire at the molecular and evolutionary level, by using a combination of data analysis and statistical mechanics modelling. Dr Walczak aims to shed light on the diversity and complexity of immune receptors on the surfaces of B and T cells, which interact with pathogens, recognize them and initiate an immune response.

Panel Members

Eric Wieschaus

1995 Nobel laureate for Medicine
University of Princeton, USA



Eric Wieschaus is an American developmental biologist. He holds a B.S. degree in biology from the University of Notre Dame (Indiana) and a Ph.D. degree in Biology from Yale University. He is Emeritus Squibb Professor in Molecular Biology at Princeton University and Emeritus Professor of Molecular Biology at the Lewis-Sigler Institute for Integrative Genomics (Princeton).

Professor Wieschaus is a HHMI investigator, a member of the National Academy of Sciences (USA) and a foreign member of the Max Planck Society. Most of his research focuses on the embryonic development of the fruit fly Drosophila melanogaster and its genetic control. It concentrates specifically on the patterning which occurs in the early Drosophila embryo.

For his research, Professor Wieschaus received many prestigious awards and distinctions. In 1995, he shared the Nobel Prize in Physiology or Medicine with Edward B. Lewis and Christiane Nüsslein-Volhard “for their discoveries concerning the genetic control of early embryonic development”.

Science Day

In collaboration with the VUB the Solvay Institutes participated in the Science Days of the Flemish Community more precisely in the Science Festival, organized on Sunday November 14, 2024, at Muntpunt in the center of Brussels.

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

On the other hand a workshop was organized by Paul Geerlings (Emeritus Professor Chemistry at VUB and Vice-President of the Solvay Institutes) 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 19 th 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 "odor" experiment where they could smell themselves that substances composed out of mirror –molecules do not always have the same odor. 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. Finally, even the presence of chirality in architecture was addressed as witnessed in the spirality of skyscrapers.

The Solvay/VUB exhibition stand received all day long many visitors enthusiastically interacting with Eline Desmedt, Jochen Eeckhoudt and Thibault Cauwenbergh (predoctoral researchers at the Chemistry Department of 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".


Ernest Solvay
The Solvay Public Events
The Solvay Conferences

04

SCIENTIFIC ACTIVITIES

International Solvay Chairs

The International Solvay Chair program 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 program 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. This key support was taken over in 2024 by the Syensqo Company. To express the gratitude of the Institutes, the Chemistry Chair was renamed "Syensqo Chair in Chemistry by the International Solvay Institutes".

2024 Syensqo Chair in Chemistry by the International Solvay Institutes

Markus Antonietti

Max-Planck Institute of Colloids and Interfaces,
Potsdam, Germany

The seventeenth International Chair in Chemistry was held by Professor Markus Antonietti from the Max Planck Institute in Potsdam (Germany).

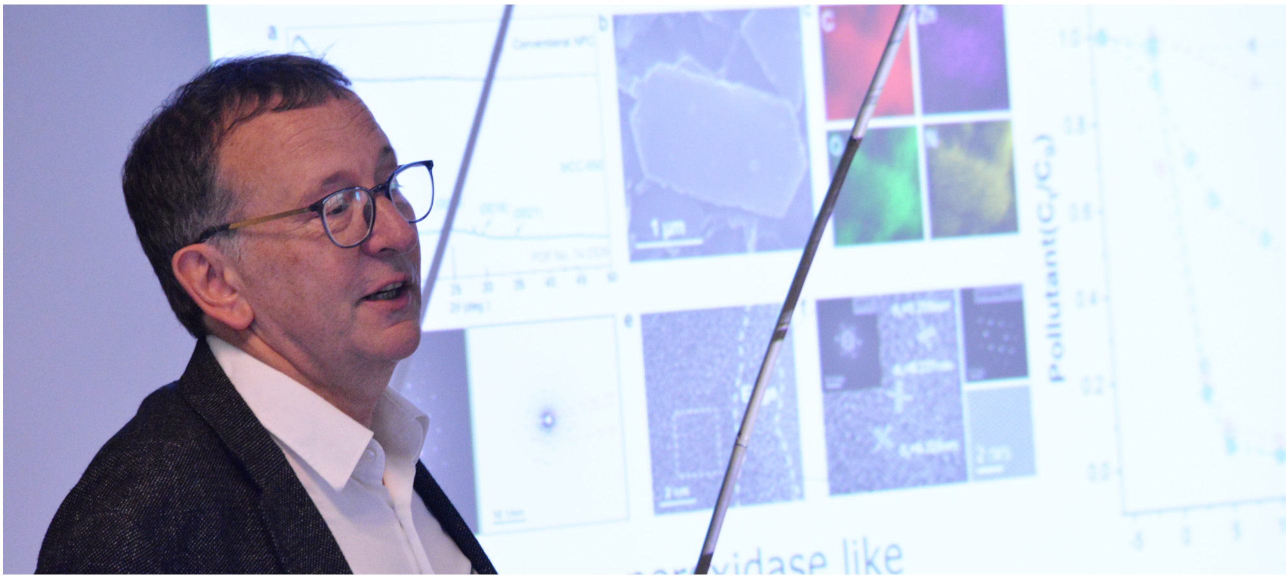
Professor Antonietti is a world-leading expert on colloids and interfaces. He is the founding Director and Scientific Member at the Max Planck Institute for Colloids and Interfaces in Potsdam (since 1993). His group contributed breakthrough developments in the synthesis of various colloidal structures having new characteristics through the "teamwork" of their different functional groups.

The International Solvay Institutes are most grateful to Professor Antonietti for his exceptional availability.

Professor Markus Antonietti received his basic education in Mainz and studied at the Gutenberg University where he also completed a PhD in chemistry. After that, he became Professor in Marburg, and in 1993, he switched to his current position as a Director of the Max Planck Institute of Colloids and Interfaces. He received a number of awards for his science, among them: in 1997 an Honorary degree (Dr. sci. h. c.) of Clarkson University Potsdam/New York, in 2003 the Goldschmidt-Elhuyar-Award of the Real Sociedad Espanola de Quimica and in 2009 the Macro Gold Medal of the Royal Society of Chemistry (UK).

He is a Member of the Berlin-Brandenburg Academy of Sciences, and listed in ISI as a World Top 50 cited Material Scientist. He has contributed with about 1000 papers to the field of material/polymer chemistry, in the last 20 years. His work was appreciated with a number of honors, and his current work is cited about 14000 times/year, with an H-index of 213. He is simply one of the best and most productive chemists in the world.

Beside Polymer Science and the Chemistry of materials, he is a first hour person of nano sciences. In recent years, he is active in the field of sustainability, raw material change and green material science.



2024 Syensqo Chair in Chemistry by the International Solvay Institutes

Program

Professor Antonietti split his visit in two 2-week stays, one in the Spring and the other in the Fall of 2024. He was hosted by Professor Yves Geerts (ULB), who has played a central role in the scientific organization of the chair, and to whom the Institutes are very grateful.

Professor Antonietti's inaugural lecture, delivered on May 14, dealt with the magic potential of functional carbocatalysts, which could replace noble metals thereby vastly expanding the options of chemistry with positive environmental impact.

The inaugural lecture was followed by three other more specialized lectures given in May. The topics encompassed soil materials for carbon neutral agriculture, materials for disruptive electro catalysis and energy storage, and carbon-nitride for artificial photosynthesis. He visited Syensqo research division on November 15. Professor Antonietti also participated in the Solvay workshop on "Chirality, Spin and Reactivity" (12-14 November 2024).

Inaugural lecture

14 May 2024

“Simply Black Magic: Functional carbocatalyst to replace noble metals and expanding the options of chemistry as such“

In times of sustainability, Carbon materials with their high surface area and abundant functionality, best made from simple starting products, are a convincing choice. Here, the notation “carbon” is rather broad and includes a diversity of covalent organic compounds with different composition, architecture, textures and the related properties. A common denominator is however that all these systems are made by cross-linking processes to become insoluble, rather inert solids at elevated temperatures. I will summarize in my talk some of our recent approaches to generate new as such carbons, e.g.“oxocarbons” or P-doped carbons, focusing on simplicity (the real sophistication).

I will show that many of the resulting 2d- and 3d structures are chemo-, photo- and electrocatalytically active and show even enzyme-like activity for some –in synthetic chemistry- very unusual reactions, such as binding and conversion from nanomolar concentrations for environmental cleaning or polymer degradation of otherwise stable polymers.

2024 Syensqo Chair in Chemistry by the International Solvay Institutes

Lectures at ULB

16 May 2024

"New modifications of Carbon nitrides and their use in artificial photosynthesis and single atom support"

Some recent observations made polymeric graphitic Carbon Nitride a valuable extension to current semiconducting organic materials. This is due to the ease of synthesis, but also due to its extreme chemical stability. Made from urea under early-Earth conditions, as reported already by Justus Liebig in 1832, it just recently turned out to be a novel catalyst which -among other reactions- can even chemically activate CO_2 or photochemically turn water into hydrogen, oxygen, or more valuable compounds. This opens the door to a new chemistry on the base of a sustainable and most abundant polymer base. Current apparent quantum yields partly exceed 0.85, i.e. the transduction from light energy to chemical energy is good enough for a real world.

I will report in this presentation on new ionic members of the Carbon Nitride family which are most stable organic semiconductors, highly crystalline and have HOMO potential down to +2.7 Volt. This accesses not only a cocatalyst-free full artificial photosynthesis, but also a new deep oxidation chemistry realizing a number of organic chemistry dream reactions that could previously be not performed.

Single atom functionalization is a biomimetic tool that even extends reactivity space, and even ions as Mg^{2+} or Ca^{2+} change electronic properties and substrate binding and promote new chemical reactivity.

If time allows, I will also talk about photochemical pumping with Carbon Nitride nanostructures and how that adds an engineering component to photoenergy conversions.

Lectures at ULB

21 May 2024

"New porous organic materials for disruptive Electrocatalysis and Energy storage"

A key feature of the current transition from a fossil based energy system to a carbon neutral, fully sustainable mode of operation is energy conversion and storage. EU countries are leaders in the field of Sustainable Energy Generation, but its intermittent Nature without novel storage will restrict its relative contribution to about 50 %, taking Germany as a typical case. This is why energy-to-chemicals schemes ("electrocatalysis") or fundamentally new, denser and more affordable electron storage devices are eagerly needed.

I will report in this presentation first on new, noble Carbons and COF-like, ionic Carbon Nitrides with extreme stability. These systems directly enable cocatalyst-free new electrocatalysis and new electrode constructions. Due to the positive work-function the new versions are remarkably suitable for single atom deposition and thereby represent a key step to extend the electronegativity and reactivity range of known metals ("making Ni to act as Pd"). Here I report on direct H2O2 synthesis and methane mono-oxidation enabled as such.

In electric energy storage, I will present the use of these systems for new, save metal anodes, for solid-state sulfur cathodes. If time allows, I will also report on a new, record breaking "Nitrogen-battery", where we ideally can store 8 electrons per nitrogen atom.

2024 Syensqo Chair in Chemistry by the International Solvay Institutes

Lectures at ULB

23 May 2024

"Can Soil Materials Make us Carbon Neutral?"

"Polymer chemistry" can create some of the beauties of civilization, but also can tackle the serious downsides of non-closed global element cycles. In a fictive world of circularity and sustainability, it will become difficult for the current "fossil" business schemes, and biomass as a source of monomers and polymers is an obvious alternative, especially for dense carbon products. However, biomass usually comes with water and chemical functionality, making our current catalytic toolbox rather poor.

Hydrothermal reforming (HTR) and hydrothermal carbonization (HTC) are chemical processes to turn carbohydrates (including crude forestry side products, but waste biomass in general) into diverse products. All these processes occur also naturally, but processes can be highly accelerated with minor chemical engineering.

I will introduce the scientific key problems along these now classical processes, but focus on "hydrothermal humification", where the polymer product turned out to be extremely useful for agriculture and soil remediation. Two billion hectares of arable land are actually affected by moderate to severe soil degradation and actually need two billion tons of humic substances, which in return then probably sequester up to 350 billion tons of CO_2 through "living matter system engineering" of soil microbiology. That is no less than the equivalent to the amount emitted by humanity in the last ten years.

If time allows, I will dare a discourse on creativity and scholastic restrictions. The question is why it is so difficult to see the sometimes most nearby solutions and how education also outside the core disciplines is expanding our mind capabilities.

Visit of Syensqo research division

15 November 2024

2024 Jacques Solvay International Chair in Physics

Samaya Nissanke
University of Amsterdam,
The Netherlands

The 2024 International Jacques Solvay Chair in Physics was held by Professor Samaya Nissanke from the University of Amsterdam (The Netherlands).

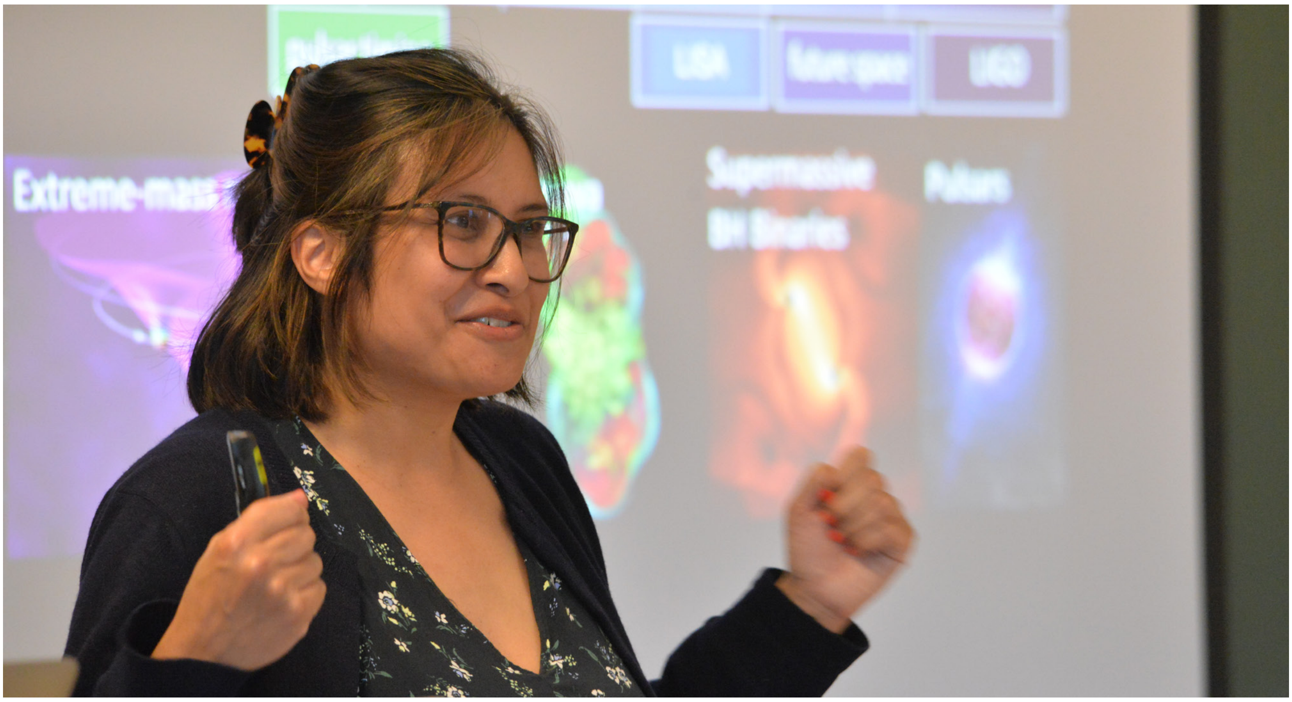
Samaya Nissanke is a leading figure in the booming field of gravitational wave astronomy, where she made major contributions recognized by many prestigious prizes. Her chair has led to the development of new collaborations with the Belgian community working in gravitation.

Many thanks go to Professor Nissanke who accepted the 2024 Jacques Solvay Chair. The International Solvay Institutes are also grateful to the colleagues who organized Professor Nissanke's visit: Giacomo Bruno (UCL), Nicolas Chamel (ULB), Sébastien Clesse (ULB), Geoffrey Compère (ULB), Archisman Ghosh (Universiteit Gent), Nick Van Remortel (Universiteit Antwerpen), Alberto Mariotti (VUB) and Alex Sevrin (VUB).

Samaya Nissanke is an associate professor at GRAPPA, the research center for gravity and astroparticle physics at the University of Amsterdam. Since 2018, she has been working in a joint appointment both for the Anton Pannekoek Institute and for the Institute of Physics – and through the latter is also affiliated to the National Institute for Subatomic Physics (Nikhef) in Amsterdam.

Nissanke's research on gravitational waves is at the intersection of astronomy and fundamental physics. She is internationally regarded as one of the pioneers in the field of multimessenger astronomy, where information from gravitational waves, particle physics and astronomical observations come together and provide new insights.

In 2020, she was awarded the New Horizon Prize in Physics for her work on the new techniques she helped develop. In 2021, she won a Suffrage Science Award from the London Medical Council for her efforts on behalf of women in the natural sciences.



2024 Jacques Solvay International Chair in Physics

Program

Professeur Nissanke inaugural lecture, given on October 1, 2024, was entitled "New perspectives onto the universe in the era of multi-messenger astrophysics" and gave a remarkably broad and up-to-date perspective on the field.

The program of her chair also involved teaching at the master level as well as specialized lectures at the frontiers of her research. Professor Nissanke came back in February of 2025 for the organization of a workshop on "Gravitational Wave Cosmology".

Inaugural lecture

1 October 2024

"New perspectives onto the universe in the era of multi-messenger astrophysics"

Since the revolutionary discovery of gravitational wave (GW) emission from a binary black hole merger in 2015, the remarkable GW detectors LIGO, Virgo and KAGRA have detected at least ninety compact object mergers. These events are transforming modern astronomy. In particular, the first binary neutron star merger, dubbed GW170817, was observed in both gravitational and electromagnetic radiation, thus opening up a new era in multi-messenger astrophysics. The multi-messenger characterization of such an event has enabled major advances into diverse fields of modern physics from gravity, high-energy astrophysics, nuclear physics, to cosmology. In this talk, I will present a review of gravitational wave observations to date, as well as my work in strong-field gravity astrophysics and how combining observations, theory and experiment have been key in making progress in this field. I will present the challenges and the opportunities that have emerged in multi-messenger astrophysics, and what the future holds in this new era.

Master classes on gravitational waves at ULB

14 and 16 May 2024

Colloquium at ULC

3 October 2024

"New perspectives onto the universe in the era of multi-messenger astronomy: the opportunities and challenges"

Lecture at ULB

4 October 2024

"New frontiers in cosmology and nuclear physics in the era of multi-messenger astronomy"

2024 Jacques Solvay International Chair in Physics

Workshop on "Gravitational Wave Cosmology"

19-21 February 2025

This workshop was organized on the occasion of Professor Nissanke's chair.

The aim of this workshop is to bring together experts working in diverse fields of observational cosmology to address pressing questions that the new observations are currently bringing such as:

- How can we distinguish cosmological sources from the detected Pulsar Timing Array signal?
- What is the nature of the Hubble tension: systematic errors or a sign for new physics?
- How will gravitational waves standard sirens contribute in the near future?
- How to distinguish the primordial gravitational wave background from the astrophysical background?
- Which notable multi-messenger signatures should be searched for?

More information in the 2025 report.

Feedback from Professor Nissanke

"A massive thank you for the wonderful organisation and welcome during the last couple of days. It was such an honour to give my inaugural lecture (and also great fun!) and thank you for organising such a memorable and special dinner, also with Alexandre and colleagues and Marina and Jean-Marie Solvay present.

I spent a great and very full day yesterday at UCL with Giacomo, and colleagues there. It was very special and we are already planning that I visit again in the next months for a few days to interact more and start collaborations there.

I have also been invited to visit KU Leuven by Hans Van Winckel and meet with colleagues from the physics and astronomy departments there. In addition, I hope to visit Antwerp, Liege and Ghent in the coming months. It has been such a wonderful opportunity to be the Jacques Solvay Chair this year to interact with so many great groups and colleagues.

Please extend my thanks and gratitude to everyone involved."

New Horizon Lectures

The “New Horizons Solvay Lectures” are given by brilliant young scientists with already high visibility and well established stature. They deliver one broad lecture at the Solvay Institutes on their current research and the challenges they see for their discipline. A second, complementary lecture is given in another Belgian university. More lectures are encouraged whenever possible.

There are each year “New Horizons Solvay Lectures in Chemistry” and “New Horizons Solvay Lectures in Physics”.

This program receives the generous support of the Syensqo company.

Past New Horizon lectures

Chemistry

2018 **Alexandre Tkatchenko**, University of Luxemburg
2019 **Rafal Klajn**, Weizmann Institute, Israel
2020 **Hans Jakob Wörner**, ETH Zürich, Switzerland
2021 **Ying Diao**, University of Illinois, USA (postponed in 2023)
2022 **Cornelia Meinert**, CNRS, Université Côte d’Azur, France
2023 **Danna Freedman**, MIT, USA
2024 **Alexis Komor**, San Diego University, USA

Physics

2018 **Zohar Komargodski**, Weizmann Institute, Israel & Simons Canter University of NY, Stony Brook, USA
2019 **Aleksandra Walczak**, LPT ENS, Paris, France
2020 **Douglas Stanford**, Stanford University, California, USA
2021 **Maria Bergemann**, Max Planck Institute, Heidelberg, Germany
2022 **Nir Navon**, Yale University, USA (postponed in 2023)
2023 **Alexander Zhiboedov**, CERN, Genève, Switzerland
2024 **Netta Engelhardt**, MIT, USA

New Horizon Lectures in Chemistry

Alexis Komor

San Diego University, USA

Alexis Komor received her B. S. degree in chemistry from the University of California, Berkeley in December of 2008. She then joined the lab of Jacqueline K. Barton at the California Institute of Technology for her doctoral studies. While at Caltech, she worked as an NSF Graduate Research Fellow on the design, synthesis, and study of DNA mismatch-binding metal complexes and received her Ph.D. in 2014. She pursued postdoctoral work as a Ruth L. Kirschstein NIH Postdoctoral Fellow in the laboratory of David R. Liu, where she developed base editing, a new approach to genome editing that enables the direct, irreversible chemical conversion of one target DNA base into another in a programmable manner, without requiring double-stranded DNA backbone cleavage. Alexis joined the Department of Chemistry and Biochemistry at the University of California at San Diego in 2017, where her lab develops and applies new precision genome editing techniques to the functional genomics field. Alexis's contributions in teaching, mentoring, and research have been recognized through many awards, including the Cottrell Scholar Award, the "Talented 12" recognition by C&EN News, an NSF Faculty Early Career Development (CAREER) award, an NIH early stage investigator Maximizing Investigators' Research Award (MIRA), and a "40 under 40" recognition in healthcare by Fortune Magazine.

Program

Lecture at ULB

5 November 2024

"Development and Characterization of Precision Genome Editing Tools"

Prior to the development of base editing in 2016, genome editing technologies functioned by introducing double stranded DNA breaks (DSBs) at a target genomic locus as the first step of genome editing. This is typically accomplished using Cas9 (a programmable endonuclease) and a piece of RNA called a guide RNA (gRNA) that encodes for the genomic location at which Cas9 will bind and cleave using simple Watson-Crick-Franklin base pairing rules. The cellular processing of DSBs results in a mixture of genome editing products, including both precision editing outcomes and insertion and deletion (indel) byproducts. The high frequency of indels versus precision products has been a long-standing challenge in the genome editing field since its inception in the 1990s. Here I will describe my lab's efforts to develop new genome editing methodologies with improved efficiency and precision. These include the development of new base editor (BE) tools, as well as new methods to improve the precision of DSB-reliant methods.

New Horizon Lectures in Chemistry

Colloquium at UGent

6 November 2024

"Engineering and Evolving Nucleic Acid Modifying Enzymes"

Base editors (BEs) are comprised of a catalytically inactivated Cas9 (dCas9 or Cas9n) tethered to a single-stranded DNA (ssDNA) modifying enzyme, which directly chemically modifies target nucleobases within a "base editing window". Two classes of base editors exist, which use cytosine and adenine deamination chemistries to catalyse the conversion of C•G base pairs to T•A (CBEs), and A•T base pairs to G•C (ABEs), respectively. These transition mutations (purine-purine or pyrimidine-pyrimidine) are mediated by uracil (cytosine deamination) or inosine (adenine deamination) intermediates, and occur with high efficiencies (up to 90% conversion) with little to no competing indel formation. Expansion of the BE toolbox to include transversion editors will require engineering of new nucleic acid editing enzymes. As ABEs were developed by engineering and evolving a tRNA adenosine deaminase enzyme, TadA, into a ssDNA adenosine deaminase enzyme, TadA7.10, the development of future BEs may be accomplished by converting additional tRNA modifying enzymes into ssDNA editing enzymes. In this talk I will describe my lab's efforts to mechanistically understand how current BE enzymes function. The enhanced understanding of how known DNA editing enzymes function, and in particular how wtTadA was converted into TadA7.10, can inform the development of future DNA editing enzymes.

Colloquium at de Duve Institute UCLouvain

7 November 2024

"Understanding Human Genetic Variation with Precision Genome Editing Tools"

New Horizons Solvay Lectures in Chemistry Technological advances are making the routine sequencing of human genomes increasingly ubiquitous, including in clinical settings. However, our inability to interpret the disease-relevance of genetic variants discovered by sequencing remains a critical obstacle to the progress of precision medicine: there are currently over 685 million human single nucleotide variants (SNVs) identified from sequencing data, and less than 0.5% have a defined clinical characterization. New laboratory-based methods capable of interpreting SNVs and predicting the clinical relevance of previously unobserved mutations would not only enhance the efficacy of current therapies by better informing patient selection strategies, but also accelerate the development of new approaches to combat diseases with a genetic component. Here I will describe my lab's work to develop new methods and strategies to characterize the impact of SNVs in cellular contexts.

New Horizon Lectures in Physics

Netta Engelhardt

MIT, USA

Netta Engelhardt grew up in Jerusalem, Israel and Boston, MA. She received her BSc in physics and mathematics from Brandeis University and her PhD in physics from the University of California, Santa Barbara. She was a postdoctoral fellow at Princeton University and a member of the Princeton Gravity Initiative prior to joining the physics faculty at MIT in July 2019. Professor Engelhardt works on quantum gravity, primarily within the framework of the AdS/CFT correspondence. Her research focuses on understanding the dynamics of black holes in quantum gravity, leveraging insights from the interplay between gravity and quantum information via holography. Her current primary interests revolve around the black hole information paradox, the thermodynamic behaviour of black holes, and the cosmic censorship hypothesis (which conjectures that singularities are always hidden behind event horizons).

Program

Lecture at ULB

11 June 2024

"The Black Hole Information Paradox: a resolution on the horizon?"

Can information escape from a black hole? General Relativity, which describes the behaviour of black holes, and quantum mechanics, which describes the behaviour of information, do not agree on the answer. This disagreement is the essence of the famous nearly 50-year-old Black Hole Information Paradox. Understanding the resolution of this problem is a central pillar in the quest for quantum gravity, a theory that describes the universe at the smallest scales by unifying General Relativity and quantum mechanics. Recently there has been an unprecedented amount of progress towards a resolution. I will describe the origin of the paradox and the current status in light of the new developments.

Colloquium at UGent

12 June 2024

New Horizon Lectures in Physics

Science & Cocktails

13 June 2024 at Atelier 210 in Brussels

Besides regular events featuring science lectures by world renowned scientists, Science & Cocktails aims at reaching out to an ever growing and diverse audience of all ages via novel forms of communication.

In the context of the New Horizon Lectures program, Professor Engelhardt gave a fascinating lecture on one of the post pressing issue in physics.

"Does Anything Ever Come Out of a Black Hole?"

Stephen Hawking made a number of memorable contributions to physics, but perhaps his greatest was a puzzle: what happens to information that falls into a black hole? The question sits squarely at the overlap of quantum mechanics and gravitation, an area in which direct experimental input is hard to come by, so a great number of leading theoretical physicists have been thinking about it for decades. Now there is a possibility that physicists might have made some progress, by showing how subtle effects relate the radiation leaving a black hole to what's going on inside. Netta Engelhardt is one of the contributors to these recent advances, and together we go through the black hole information puzzle: what it is, what we have learned about it, and what it all might teach us about quantum gravity.

Colloquia

"How reticular chemistry will solve the climate and water problems, fast!"

Professor Omar Yaghi

James and Neeltje Tretter Chair Professor of Chemistry
University of California, Berkeley, USA
2024 Laureate of the Ernest Solvay Prize

20 March 2024

The clean air, clean energy, and clean water challenges facing our planet today impact our health, wealth, happiness, and future. These three stresses present difficult science and engineering problems as they require, among many aspects, the selective capture of small molecules (e.g. hydrogen, methane, carbon dioxide, and water). Our ability to capture, store, manipulate, and harness the power of these molecules in an efficient and economical manner is paramount to our success in building a sustainable future. The emerging field of reticular chemistry and materials has yielded extensive classes of nanoporous metal-organic frameworks and covalent organic frameworks. The flexibility with which these materials can be made, modified, and scaled bodes well for their integration into devices and providing robust solutions to these challenges. In this presentation, I will highlight how thirty years of establishing the basic science of reticular materials has led us to carbon capture from air and flue gas, and harvesting water from air to produce drinking water in various parts of the world regardless of temperature and humidity levels. Our efforts in taking this technology from the laboratory to the field including the design and engineering of prototypes will be discussed and the results presented. Time permitting, I will also highlight our results of how discovery of materials and their deployment can be accelerated by ChatGPT.

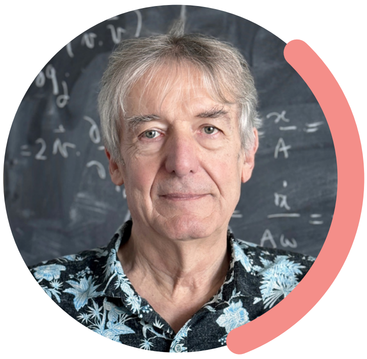
Colloquia

Building spacetime from chaos

Professor Julian Sonner
Université de Genève, Switzerland

26 March 2024

I will describe recent developments in formulating theories of quantum gravity as arising from the tell-tale correlations of quantum chaos. This gives an interesting application of the statistical physics to the realm of gravity; I will begin my colloquium by motivating in general terms the gravitational questions of interest and introducing the necessary background in statistical physics to describe our more recent work to address these. Our approach represents a bridge between the statistical mechanics of chaotic systems and the theory of gravity, giving a new perspective on the mechanism of the emergence of spacetime. More specifically, we generate random triangulations of spacetime from generalised Wigner-type ensembles of quantum chaotic correlations, generalising old ideas on random matrix theory. In concrete examples, the relevant matrix/tensor models can be derived by formalising the notion of the "statistics of the crossing equation", or in other words the "statistical conformal bootstrap". I will discuss the relationship of these random matrix/tensor models to the physics of chaotic conformal field theories (CFT) underlying them.



Axion Dark Matter

Professor Pierre Sikivie
University of Florida, USA

2 April 2024

Axions have a double motivation: they solve the "strong CP problem" of the Standard Model of elementary particles and they are a candidate for the dark matter of the Universe. Dark matter axions can be detected on Earth by converting them to photons in an electromagnetic cavity permeated by a strong magnetic field. A signal in such a detector, called an axion haloscope, would immediately reveal the velocity spectrum of dark matter axions on Earth in great detail. This prospect motivated the study of the special properties that axions have in large scale structure formation. It is shown that cold dark matter axions thermalize through their gravitational self-interactions, and form a Bose-Einstein condensate. As a result, axion dark matter behaves differently from the other proposed forms of dark matter. The differences are observable.

Colloquia

Theory of liquids, fundamental bounds in condensed matter physics and fundamental physical constants

Professor Kostya Trachenko
Queen Mary University of London, United Kingdom

30 April 2024

Theories of gases and solids are well developed and date back 100-150 years ago. In contrast, understanding most basic thermodynamic properties (e.g. energy and heat capacity) of the third state of matter - the liquid state - turned out to be a long-standing problem in physics. Landau & Lifshitz textbook states that no general formulas can be derived for liquid thermodynamic functions because the interactions are both strong and system-specific. Phrased aptly by Pitaevskii, liquids have no small parameter.

Recent theoretical results open a new way to understand liquid thermodynamics on the basis of collective excitations (phonons) as is done in the solid state theory. Differently from solids, the number of phonons is variable in liquids and decreases with temperature. This effect is quantified in a phonon theory of liquid thermodynamics and explains the universal decrease of liquid constant-volume specific heat with temperature. One implication of this theory is that liquids can now be consistently understood on par with solids and are no longer “Cinderella of Physics” as believed until recently. I will also explain how this picture extends above the critical point where the Frenkel line separates two physically distinct states on the supercritical phase diagram.

I will subsequently describe how this picture leads to the theory of minimal quantum viscosity in terms of fundamental physical constants including the Planck constant. This answers the long-standing question discussed by Purcell and Weisskopf of why viscosity never drops below a certain value. This also means that water and life and well attuned to the degree of quantumness of the physical world. This, in turn, implies, that we can better understand fundamental physical constants from biological and life processes.

Materials-Electrolyte-sensing Innovations Towards improved and Sustainable Battery Chemistries

Professor Jean-Marie Tarascon
Collège de France, Paris, France

15 October 2024

As one of the most versatile energy storage technologies, batteries play a central role in the current transition from fossil fuels to renewable energy. Therefore, improving the performance, reliability, longevity and durability of batteries becomes a crucial challenge for the coming years, as it will reduce their environmental footprint and contribute to climate neutrality. To meet this challenge, new material concepts, new chemistries, advanced electrolyte designs and innovative sensing strategies are required. This presentation will address these different aspects with specific examples.

First, in terms of new concepts, we will show how the discovery of anionic redox activity has led to the design of high-capacity, lithium-rich layered oxide or sulfide electrode materials, some of which can be used in solid-state batteries. Concerning new chemistry, we will present our new findings with the Na-ion chemistry that have led to the practical development of the Na-ion technology. Finally, we will present the benefits of adding sensing function to a battery, focusing on optical sensing to improve its lifetime.

Colloquia

Beyond Nanostructures: Will Chiral and Magnetic Fields Transform Clean Energy Technologies?

Professor Magalí Lingenfelder
Helvetia Institute for Science and Innovation & EPFL, Switzerland

12 November 2024

The transition to a sustainable energy landscape requires a shift from fossil fuels to renewable energy sources. Central to this shift is the development of efficient, earth-abundant catalysts capable of either converting chemical energy into electricity or using electrons to drive chemical reactions at catalytic interfaces. Recent in-situ and operando studies at electrified interfaces have provided critical insights, allowing us to characterize and control catalytic processes down to the atomic scale. These advances are essential for improving key reactions towards CO2 valorization, green hydrogen production, and oxygen oxidation and reduction. While optimizing nanostructures has been the focus of many researchers over the past years, the role of the electron spin in influencing catalytic activity and selectivity remains largely unexplored.

This colloquium will begin by examining the atomic-scale processes occurring at catalytic interfaces, followed by an exploration of two innovative approaches that dramatically enhance the efficiency and selectivity of 2D catalysts. The first approach involves incorporating chiral molecules to produce spin-polarized currents that direct reaction pathways at the interface. The second approach uses magnetic fields to control both the catalytic interface and the movement of electrolyte species around the active surface. By exploring and comparing the fundamental phenomena in both approaches, we will offer a versatile framework for implementing spin-selective solutions across diverse catalytic systems, supporting the broader goal of reducing dependency on critical materials for sustainable energy applications.

Workshops organized by the Solvay Institutes

Symmetries, Anomalies and Dynamics of Quantum Field Theory

2-5 April 2024

Organizing and Scientific Committee

Jeremias Aguilera Damia
(ULB, Belgium)

Riccardo Argurio
(ULB, Belgium)

Nikolay Bobev
(KU Leuven, Belgium)

Andres Collinucci
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Marc Henneaux
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Christoph Uhlemann
(VUB, Belgium)

Key Participants

Fabio Apruzzi
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Francesco Benini
(SISSA, Italy)

Matthew Buican
(Queen Mary U. of London, UK)

Michele Del Zotto
(Uppsala U., Sweden)

Po-Shen Hsin
(UCLA, USA)

Pavel Putrov
(ICTP, Italy)

Ingo Runkel
(Hamburg U., Germany)

Sakura Schafer-Nameki
(U. of Oxford, UK)

Yifan Wang
(NYU, USA)

Workshops organized by the Solvay Institutes

Program

2 April 2024

Welcome speech

Matthew Buican
New Explorations of an Old Symmetry

Pavel Putrov
On p-form symmetries in functorial quantum field theory

3 April 2024

Sakura Schafer-Nameki
Categorical Symmetries and Phases

Yifan Wang
Topological Interfaces and Generalized Gauging

Fabio Apruzzi
Title TBA

Andrea Antinucci
Anomalies of categorical symmetries

Ethan Torres
Topological Sectors of Frozen Singularities

Stathis Vitouladitis
A state-operator correspondence for nonlocal operators

4 April 2024

Michele Del Zotto
Exploring the Higher Structure of Symmetries

Francesco Benini
Anomalies and Gauging of U(1) Symmetries

Federico Bonetti
SymTFTs for Continuous non-Abelian Symmetries

Christian Copetti
Crossing, Anomalies & non-invertible Symmetry

Brandon Rayhaun
Thoughts on the interplay between generalized symmetries and the classification of 2d RCFTs

5 April 2024

Ingo Runkel
Non-invertible symmetries and their gauging in low-dimensional field theory

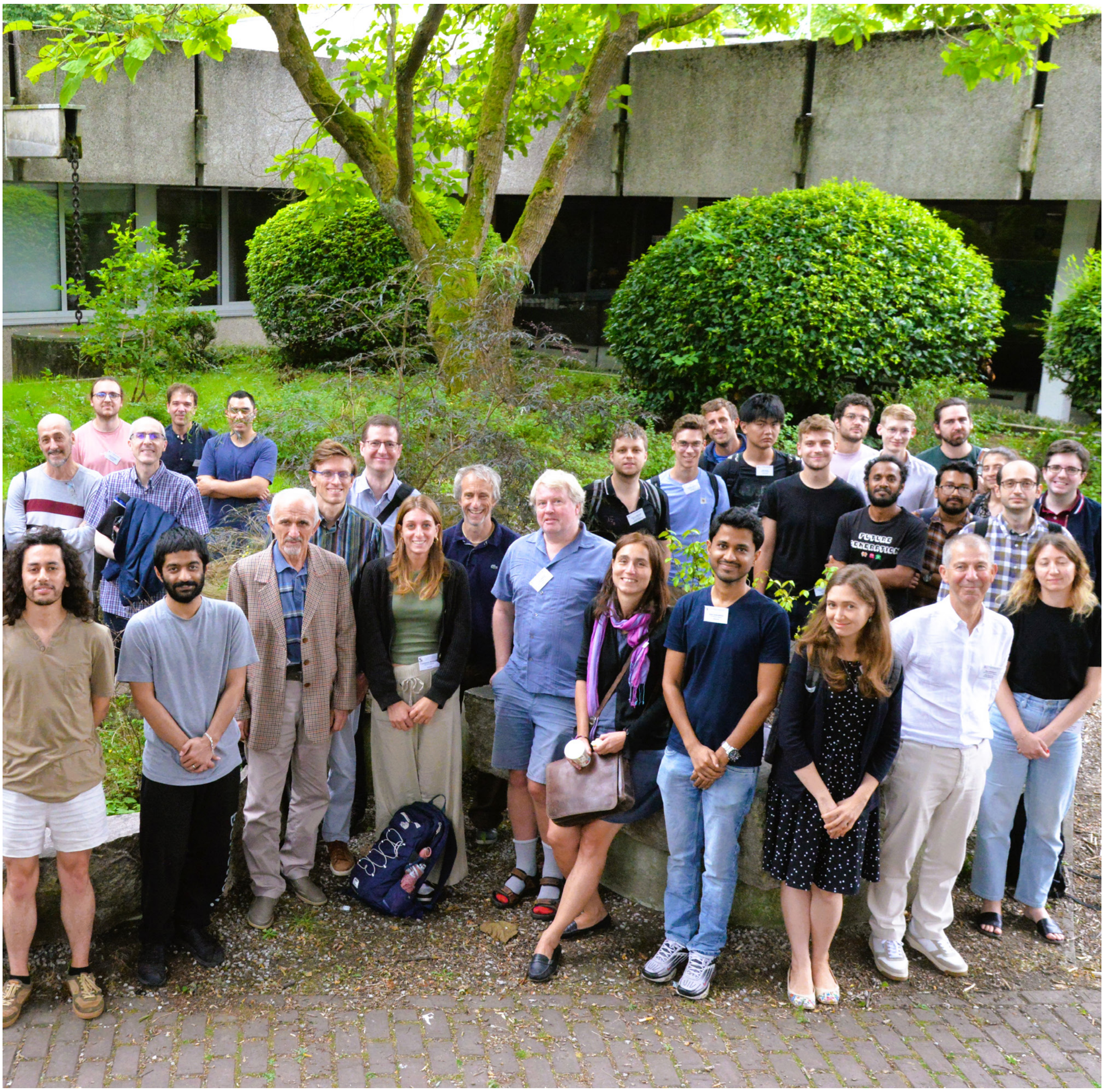
Giovanni Galati
On the symTFT of Chern-Simons theory

Rajath Radhakrishnan
Non-anomalous line operators and SymTFTs

Workshops organized by the Solvay Institutes

Near-Extremal Black Holes

2-4 September 2024



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Marc Henneaux
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Thomas Mertens
(Ghent U., Belgium)

Alejandro Vilar Lopez
(ULB, Brussels, Belgium)

Invited Speakers

Ankit Aggarwal
(TU Vienna, Austria)

Dionysios Anninos
(King's College London, UK)

Geoffrey Compère
(ULB, Brussels, Belgium)

Roberto Emparan
(Barcelona U., Spain)

Monica Guica
(Institut de Physique Théorique, Saclay)

Luca Iliesiu
(UC Berkeley, USA)

Finn Larsen
(U. of Michigan, USA)

Francesca Mariani
(Ghent U., Belgium)

Swapnamay Mondal
(Banaras Hindu U.)

Jacopo Papalini
(Ghent U., Belgium)

Achilleas Porfyriadis
(U. of Crete, Greece)

Mukund Rangamani
(UC Davis, USA)

Grant Remmen
(New York U., USA)

Joan Simon
(Edinburgh U. UK)

Chiara Toldo
(U. of Milan, Italy)

Workshops organized by the Solvay Institutes

Program

2 September 2024

Welcome speech by Marc Henneaux

Luca Iliesiu
Review: Title TBA

Grant Remmen
Effective Field Theory Breakdown Near Cool Black Holes

Swapnamay Mondal
An extremal black hole with a unique ground state

Mukund Rangamani
Looking at extremal black holes from very far away

Francesca Mariani
Contributed talk: Near-extremal charged and rotating black holes in de Sitter space

3 September 2024

Geoffrey Compère
Review: Features of near-extremal black holes

Finn Larsen
Instability of extremal black holes in AdS-supergravity

Chiara Toldo
Thermodynamics of spinning black holes near extremality

Monica Guica
Kerr/"CFT": a case study in non-AdS holography

Ankit Aggarwal
Near-extremal quantum field theories

4 September 2024

Roberto Emparan
Lifting the index

Achilleas Porfyriadis
Anabasis and Accidental Symmetry

Joan Simon
Aspects of near-extremal BHs

Dionysios Anninos
Flow Geometries

Jacopo Papalini
Contributed talk: Gravity hologram of double-scaled SYK

Workshops organized by the Solvay Institutes

Chirality, Spin & Reactivity

12-14 November 2024

The workshop explored the link between molecular chirality and electron spin. Chemists, physicists, experimentalists, and theorists shared and discussed their ideas. Topics included understanding and applying the chiral-induced spin selectivity (CISS) effect, as well as the CISS and electrical magneto-chiral anisotropy (eMChA) effects.

Organizing and Scientific Committee

Narcis Avarvari
(CNRS & U. of Angers, France)

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Sandra Van Aert
(U. of Antwerpen, Belgium)

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Imane Arbouch
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Bart van Wees
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(Northwestern U., Evanston, USA)

Angela Wittmann
(U. of Mainz, Germany)

Hiroshi Yamamoto
(Institute of Molecular Science, Okazaki, Japan)

Helmut Zacharias
(U. of Münster, Germany)

Workshops organized by the Solvay Institutes

Program

12 November 2024

Welcome speech by Ben Feringa and Yves Geerts

Ron Naaman
The CISS effect- Opportunities and Challenges

Helmut Zacharias
The spin of photoelectrons transmitted through molecules adsorbed on metal surfaces

Daniel Bürgler
Spin-Selective Electron Transport and Enantioselective Adsorption of Heptahelicene on Co Surfaces

David Waldeck
Chiral Induced Spin Selectivity and Its Application for Spin Control in Redox Chemistry

Yossi Paltiel
Chiral phonons and the CISS effect

Matteo Mannini
Spin-Selective Electron Transport through monolayers of magnetic molecules

Narcis Avarvari
CISS and eMChA with helicenes and tetrathiafulvalene

Magalí Lingenfelder
Beyond Nanostructures: Will Chiral and Magnetic Fields Transform Clean Energy Technologies?

Poster session

13 November 2024

Assaf Ben Moshe
Enantioselectivity in preparation of nanocrystals: lattice, shape, defects and electronic structure

Sara Bals
3D characterization of chiral metal nanoparticles by advanced electron tomography

Furkan Ozturk
A New Spin on the Origin of Biological Homochirality

Yves Geerts
On the difficulties to control chiral symmetry breaking by external fields

Hiroshi Yamamoto
Chiral molecules and helical electrons

Yoshihiko Togawa
Generation and Transfer of Spin and Phonon Angular Momenta with chiral Inorganic materials

Michael Wasielewski
Chirality-Induced Spin Selectivity in Electron Donor-Acceptor Systems

Angela Wittmann
Chiral-induced unidirectional spin-to-charge conversion

Jonas Fransson
Chirality facilitates two-electron pairing and processes

Bert Meijer
The role of supramolecular chemistry in spin-controlled chemistry

Workshops organized by the Solvay Institutes

Program

14 November 2024

Roland Resel
Polymorph Selection by Thin Film Preparation: the Appearance of Chiral Phases

Christoph Tegenkamp
Electron transport along chiral polypeptides: the role of coupling, order and electric fields

Steven De Feyter
Chirality and CISS of self-assembled molecular networks formed at the liquid-solid interface

Bart van Wees
Mechanism for electrostatically generated magnetoresistance in chiral systems without spin dependent transport

Pierre Seneor
Molecular spintronics: new opportunities for spintronics

Robert Bittl
Many-Body Effects in Chirality-Induced Spin Selectivity

Carmen Herrmann
First-principles approaches for chiral induced spin selectivity


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Workshops organized by the Solvay Institutes

Mixing: at the crossroads of foundations and practices

4-6 December 2024

This workshop is intended to bring together specialists in the field of Mixing in the broad sense. This event will be the opportunity to appreciate recent advances, both experimental and conceptual on the topic, and discuss the future of the discipline.

Organizing and Scientific Committee

Anne De Wit
(ULB, Brussels, Belgium)

Tanguy Le Borgne
(U. Rennes, France)

Emmanuel Villermaux
(Aix-Marseille U. & IUF, France)

Invited Speakers

Eric Clément
(ESPCI, Paris, France)

Colm-Cille Caulfield
(Cambridge U., UK)

Marco Dentz
(IDAEA, Barcelona, Spain)

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(U. Rennes, France)

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Jörg Schumacher
(TU Ilmenau, Germany)

Eleonora Secchi
(ETH Zurich, Switzerland)

Tom Solomon
(Bucknell U., USA)

Emmanuel Villermaux
(Aix-Marseille U. & IUF, France)

Workshops organized by the Solvay Institutes

Program

4 December 2024

Welcome speech

Patrice Meunier
The diffuselet method for scalar mixing

Marco Dentz
Dispersion and mixing in heterogeneous media across scales

Emmanuel Villermaux
The quantum architecture of mixtures

Kevin Roger
Nanoprecipitation: when (mixture) thermodynamics meet (mixing) hydrodynamics

Joachim Mathiesen
Dispersion in two-phase porous flow

Poster session

5 December 2024

Colm-Cille Caulfield
Something old, something new: (Some of the ways) history matters for stratified mixing

Jörg Schumacher
Numerical studies of mixing in clouds

Detlef Lohse
Melting and mixing

Eric Clément
Active bacterial mixing from individual to collective

Eleonora Secchi
Stress hardening, transport dynamics, and adaptive strategies in the environment

Marc Hesse
Mixing and transport across ice shells in ocean worlds

6 December 2024

Chris MacMinn
Deformation-driven mixing in a soft porous medium

Elisabeth Guazzelli
Break-up of falling clouds of particles in vortical flows

Henri Lhuissier
Mixing with viscosity contrast

Tom Solomon
Active mixing in laminar flows: swimming microbes and propagating reaction fronts

Anne De Wit
Reactive fluids: from mixing to self-organization

Tanguy Le Borgne
Mixing-induced reactions in porous media

Workshops organized by the Solvay Institutes

Workshop in the honour of Prof. Pierre Gaspard

9-11 December 2024

The Workshop is organized in the honour of Pierre Gaspard, covering various aspects of statistical mechanics, thermodynamics and nonlinear physics.

Scientific Committee

David Andrieux
(McKinsey & Company, Belgium)

Massimiliano Esposito
(U. of Luxembourg, Luxembourg)

David Lacoste
(ESPCI Paris, France)

Raymond Kapral
(U. of Toronto, Canada)

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Nathan Goldman
(ULB, Brussels, Belgium)

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Sergio Ciliberto
(ENS Lyon, France)

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Astero Provata
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Felix Ritort
(U. de Barcelona, Spain)

Udo Seifert
(U. of Stuttgart, Germany)

Thomas Speck
(U. of Stuttgart, Germany)

Shoichi Toyabe
(Tohoku U., Japan)

Workshops organized by the Solvay Institutes

Program

9 December 2024

Welcome speech

Session 1: Experiments

Shoichi Toyabe
Information and energy flow in biological molecular motor

Sergio Ciliberto
First passage time distribution as a fuel in an information engine

Felix Ritort
Variance sum rule for negentropy

Session 2: Complex Systems and the living world

Alain Destexhe
Linking molecular mechanisms to the emergence of large-scale activity in the brain

Astero Provata
Bump states and chimera states in integrate-and-fire networks: the role of synaptic plasticity

David Lacoste
Emergence of life in compartmentalized molecular systems

Luca Peliti
Information flow in a model of immune-pathogen coevolution

10 December 2024

Session 3: Complex quantum systems

Tomaž Prosen
On Ruelle-Pollicot resonances of Quantum Many-Body dynamics

Felipe Barra
Thermodynamic-like properties of an open quantum system evolving by scattering events

Jorge Kurchan
The "full" Eigenstate Thermalization Hypothesis and Free Probability

Daniel Alonso
Exploring Work Distributions from Single Energy Measurements in Simple Systems

Session 4: Complex Thermodynamics

Massimiliano Esposito
Complex systems: A thermodynamic perspective

Thomas Speck
Stochastic and effective thermodynamics of active Brownian particles

Christian Maes
Birds can fly!

Udo Seifert
Model-free inference of entropy production: The thermodynamic uncertainty relation and beyond

David Andrieux
Beyond the Fluctuation Theorem

Workshops organized by the Solvay Institutes

Program

11 December 2024

Session 5: Chemistry

Norbert Kruse
Rate and selectivity oscillations in heterogeneous catalysis: from nanosized model catalysts to ensemble averaged systems

Raymond Kapral
Micromotors: how they self-organize in complex chemical media, and can acquire a hint of intelligence

Jean-Sabin McEwen
Atomistic Modelling of Catalytic Processes for Energy Applications

Workshops sponsored by the Solvay Institutes

Meandering "edge states" and the tunable nature of quantized charge transport

14 March 2024, ULB

Organized by: The Belgian Quantum Physics Initiative (BQPi)

Program

Main Lecture

by **Prof. Dmitry Kovrizhin**
(LPTM Universite de Cergy-Pontoise, France)

"Meandering "edge states" and the tunable nature of quantized charge transport"

The discovery of the quantum Hall effect founded the field of topological condensed matter physics. The amazingly accurate quantisation of the Hall conductivity, now enshrined in quantum metrology, was ascribed to its "topological protection": essentially, it is stable against any reasonable perturbation. Conversely, topological protection thus implies a form of censorship, as it completely hides any local information from the observer. The spatial distribution of the current in the sample is such a piece of information, which has become accessible thanks to spectacular experimental advances. It is an old question whether an original, and intuitively compelling, picture of the current flowing in a narrow channel along the sample edge is the physically correct one. Motivated by recent experiments locally imaging the quantised current flow in a Chern insulating (Bi, Sb)$_2$Te$_3$ heterostructure, we theoretically demonstrate the possibility of a broad "edge state" meandering away from the sample boundary deep into the sample bulk. Further, we show that varying experimental parameters permits continuously tuning between narrow edge states and meandering channels all the way to incompressible bulk transport. This accounts for various features observed in, and differing between, experiments. Overall, this underscores the robustness of topological condensed matter physics, but it also unveils a phenomenological richness hidden by topology – much of which we believe remains to be discovered.

Lecture 2

Yanliang Guo
(Universität Innsbruck, Austria)

"Strongly-interacting bosons at dimensional crossover"

Lecture 3

Eduardo Serrano - Ensástiga
(ULiège, Belgium)

"Absolute separability of symmetric multiqubit systems under unitary transformations"

Workshops sponsored by the Solvay Institutes

Colloquium organized by the Belgian National Committee of Pure and Applied Physics

20 April 2024, Brussels

"The Nature of Time in Physics"

Scientific Committee

Thierry Bastin
(ULiège)

Vincent Boucher
(B12 Consulting)

Yves Caudano
(UNamur)

Ben Craps
(VUB)

Pascale Defraigne
(Royal Observatory of Belgium)

Nathan Goldman
(ULB)

Clément Lauzin
(UCL)

Alexander Sevrin
(VUB)

Jacques Tempere
(UAntwerpen)

Xavier Urbain
(UCL)

Christian Maes
(KUL)

Speakers

Jacques Tempere
(UAntwerpen, Belgium)

Stefan Vandoren
(Universiteit Utrecht, The Netherlands)

Francesca Calegari
(DESY and Universität Hamburg, Germany)

Jun YE
(University of Colorado, Boulder, USA)

Patrizia Tavella
(Bureau International des Poids et Mesures, France)

Christophe Salomon
(Ecole Normale Supérieure, Paris, France)

Pascale Defraigne
(Royal Observatory of Belgium)

Program

Introduction by Jacques Tempere

Stefan Vandoren
The Nature of Time in Physic

Francesca Calegari
Ultrashort Time Pulses

Jun YE
The quantum frontier for atomic clocks and fundamental physics

Patrizia Tavella
The Redefinition of the Second and the BIPM roadmap

Christophe Salomon
Testing Fundamental Physics with Atomic Clocks

Conclusion by Pascale Defraigne

Workshops sponsored by the Solvay Institutes

General scientific Meeting 2024 of the Belgian Physical Society

29 May 2024, VUB

The General Scientific Meeting of the BPS (Belgian Physical Society) was held at the University of Namur on May 29, 2024. The supervisor of the local organizing committee is Prof. Alberto Mariotti, VUB in close collaboration with Prof. Michael Tytgat, also VUB and Prof. Gilles De Lentdecker, ULB.

The General Scientific Meeting of the Belgian Physical Society covers all main fields of physics research in Belgium. The research can be carried out at any Belgian university or Research Institute. Research concerning physics education (at secondary school and high school/university level) and physics research in the industry is also included. Parallel sessions and poster sessions are organized about:

- Astrophysics, Geophysics, and Plasma Physics
- Biophysics, Medical, Mathematical and Statistical physics
- Condensed Matter and Nanostructure physics
- Fundamental interactions, Particle and Nuclear Physics
- Mathematical and statistical physics, theoretical astronomy
- Physics and Education
- Atoms, Molecules, Optics and Photonics

Organizing committee

Alberto Mariotti
(VUB)

Michael Tytgat
(VUB)

Gilles De Lentdecker
(ULB)

Program

Planetary Lecture 1

Prof. Marc Van Montagu
(VIB)

"Bringing some energy to biological Macromolecules"
The Physics of the living World

Planetary Lecture 2

Prof. Niek Van Remortel
(UAntwerpen)

"Einstein Telescope"

Workshops sponsored by the Solvay Institutes

Chaos, Order and Beyond

19 October 2024, Brussels

Second edition of the cycle ***"Beyond Boundaries: Arts, Science & Society"***

Organized by The Académie royale des Sciences, des Lettres et des Beaux-Arts de Belgique

Program

Welcome Speach by the Perpetual Secretary

Introduction by **Mireille Al Houayek**,
Director of the Collegium

Artistic performance by **Claude Cattelain**
Empirical online column

Leticia Cugliandolo
On phase transitions in nature, computing and beyond

Vincent Wens
Neuronal disorder and brain oscillations

Virginie Van Ingelgom
On the legitimacy of the social order

Fabrizio Cassol
Polyrythmie and the world of Aka Moon: an interactive introduction

Aka Moon's Show

Doctoral Schools

XX Modave

25-31 August 2024, VUB

The Modave Summer School in Mathematical Physics is a summer school organised by and aimed at Ph.D. students. The school provides blackboard lectures given by young researchers. The lectures cover core subjects that contribute to the backbone knowledge of the participants working in the field of theoretical and mathematical physics, which includes topics in General Relativity, Quantum Field Theory and String Theory.

This year marks the 20th edition of the school! As for the previous years, the ULB, VUB, KUL, UGENT and UMONS joined their forces to propose a unique scientific and human experience in the heart of the Belgian countryside.

Organizing committee

Dongming He
(VUB)

Ludovico Machet
(KUL)

Francesca Mariani
(UGent)

Léa Mele
(UMons)

Louan Mol
(ULB)

Noémie Parrini
(UMons)

Program

Andreas Blommaert

"Introduction to double scaled SYK"

I will talk about the exact solution of the double scaled limit of the SYK model involving chord diagrams and an associated auxiliary quantum mechanics system. Furthermore I will discuss certain gravitational features of this model, and introduce a precise holographic dual.

Marine De Clerck

"Introduction to BKL theory"

This set of lectures will introduce the chaotic behaviour that arises in solutions of Einstein's equation of General Relativity near a space-like singularity. Well-known near-singularity geometries, such as the interior of a Schwarzschild black hole, are quite fine-tuned in this regard. Seminal work by Belinski, Khalatnikov, Lifshitz (BKL) and others from the 60s and 70s, which we will review in detail, showed that the dynamics of generic solutions are in fact much more complex. These developments have led to the fascinating realization that the chaos governing the near-singularity dynamics is of a quite special nature. After a brief overview of common characterizations of (quantum) chaos, we will delve into the peculiar symmetries appearing in this problem and find out about their effect on the chaotic aspects of the near-singularity evolution of the metric.

XX Modave

Program

Caroline Jonas

"Quantum Cosmology: wavefunction of the universe, no-boundary proposal and gravitational path integral"

These lectures aim to provide a first introduction to quantum cosmology, the study of the very early universe including quantum effects. We will start by reviewing the early attempt to canonically quantize gravity. We will see how this led to the concept of a wavefunction of the universe together with the Wheeler-de Witt equation governing it. Then we will turn to the no-boundary and tunnelling proposals and review the many successive endeavours to make these proposals concrete in simplified models. We will study in detail the Euclidean and Lorentzian gravitational path integrals, including some specific mathematical tools used in this context such as the Picard-Lefshetz theory of complex analysis. Finally and depending on time, we will consider the approach of so called top-down quantum cosmology as well as the more recent developments related to the complex metrics criterion of Kontsevich and Segal.

Chrysoula Markou

"An introduction to string states and their interactions"

The spectrum of string theory comprises infinitely many physical states, which can collectively be visualized along Regge trajectories of increasing mass and spin. In these lectures, we will review traditional methodologies of constructing physical states in bosonic string theory and the rudiments of computing string scattering amplitudes. We will illustrate the framework with the example of a massless spin-2 state, which finds itself in closed-string spectra and whose low-energy self-interactions match those of the graviton of GR. Time permitting, we will discuss elements of a novel and efficient technology of excavating entire physical trajectories along with their interactions.

Josh O'Connor and Ismael Ahlouche Lahlali

"Coset symmetries and particle dynamics"

In these lectures we will encounter two different approaches to constructing particle Lagrangians from coset spaces of symmetry groups: (1) non-linear realisations, and (2) coadjoint orbits. The first method is more algebraic and has been used to understand theories of gravity in more detail, and the second involves more geometric definitions and has recently been used to shed light on BMS dynamics. At the level of particle Lagrangians these methods are equivalent, and we will demonstrate this by working out several examples. If time permits, we will discuss non-linear realisations leading to field theories, and a sketch of the Kirillov orbit method.

XX Modave

Participants

Richard van Dongen
Arsenii Sukhanov
Augustin Basilavecchia
Arnaud Delfante
Dima Fontaine
Dongming He
Eduardo Velasco-Aja
Emilie Despontin
Francesca Mariani
Gonzalo Barriga
Guillaume Lhost
Javier Carballo
José Figueroa
Lea Mele
Loïc Honet
Louan Mol
Mathieu Beauvillain
Mattia Serrani
Maxim Pavlov
Mikhail Markov
Nicolas Maindiaux
Noémie Parrini
Robin Guarini
Seppe Geukens
Shailesh Dhasmana
Sylvain Thomée
Thomas Tappeiner
Tim Blankenstein
Josh O'Connor
Adrien Arbalestrier
Maria Knysh
Aguilar Gutierrez Sergio Ernesto
Thomas Smoes
William Delplanque
Ming Yang

Doctoral Schools

Doctoral School on "Quantum Field Theory, Strings and Gravity"

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

Participating Institutions

Institute for theoretical physics
University of Amsterdam

Laboratoire de physique théorique
Ecole Normale Supérieure (Paris)

Physique théorique et mathématique
ULB

Theoretical particle physics
VUB

SwissMap
(ETH, U. Bern, U. Geneva, CERN)

Organizing Committee Brussels

Riccardo Argurio
(ULB)

Ben Craps
(VUB)

Frank Ferrari
(ULB)

Isabelle Van Geet
(Solvay Institutes)

Doctoral Schools on “Quantum Field Theory, Strings and Gravity”

Program

Brussels
7-25 October 2024

Adel Bilal
Advanced Quantum Field Theory

Marco Billó
Introduction to String Theory

Geoffrey Compère
Advanced General Relativity

Alberto Lerda
Introduction to String Theory

Geneva
4-22 November 2024

Mariana Grana
Superstrings and D-branes

Elias Kiritsis
Dualities in string theory

Silvia Penati
Introduction to supersymmetry

Antoine van Proeyen
Supergravity

Amsterdam
2-20 December 2024

Kyriakos Papadodimas
AdS/CFT

Lorenz Eberhardt
2d CFT and 2d gravity

Guilherme Pimentel
Primordial cosmology

Erik Verlinde
Topics in quantum gravity

Participants

Arundine Mattia

Baccianti Marco Maria

Barriga Delgadillo Francisco Gabriel

Borsboom Silvester

Cheng Gongrui

Delplanque William

Despontin Emilie

Djukić Vladan

Dulac Raphael

Ferragatta Maddalena

Kadhe Ameya

Kaluç Osman Erkan

Kamath Niranjan

Krawczyk Kuba

Lamouret Quentin

Lochet Angèle

Maindiaux Nicolas

Marto Pedro

Mera Álvarez Guillermo

Meurrens Nathan

Molines Adrien

Morros Miguel

Moura Soysüren Sina

Perugini Diego

Proust Aymeric

Raymond Thibaud

Robert Sébastien

Trezzi Stefano

van den Heuvel Pim

van der Steen Tom

Vincenti Antoine

Doctoral Schools on “Quantum Field Theory, Strings and Gravity”

Student’s opinion

Emilie Despontin (ULB)

The Solvay Doctoral School was one of the best experiences of my life, and it reassured me that I want to be a researcher. It helped me grow up to become a better physicist.

First, through the physics content it offered. Starting a PhD after years of structured studies can be challenging: you have to delve into difficult topics, without maybe knowing many people in your field, while also managing your own schedule… The school happens to be the bridge that makes this transition smoother. This journey through string theory, AdS/CFT, and quantum gravity, with stops along the way to supergravity, supersymmetry, superstrings and D-branes… and other super-topics was the best gift a first-year PhD student could receive. Renowned and amazing professors from prestigious universities gave us the opportunity to learn about these advanced topics and thus equipping us with some valuable tools for the next few years of research to come.

But it did not stop there! The different frameworks were just as enriching. This year, we began the first set of lectures in Brussels, at the university that hosts one of the pioneers of AdS/CFT correspondence. We could enjoy its nice weather while walking through “Parc Léopold” in order to reproduce the famous 1927 Solvay Conference picture. Then, after a well-deserved week-off - I mean, a week to catch up with our current research work - we arrived in Geneva, at CERN. Imagine this bunch of young physicists allowed to live there for three weeks! This month was intense, as we were all staying in the same place, spending mostly the whole day and evening together, playing ping-pong, working at the CERN cafeteria, running around the CERN campus, and even hiking to reach “Le Reculet”. Our trip ended in Amsterdam and its beautiful university. We could enjoy visiting the Van Gogh Museum, eating the delicious cinnamon rolls from the UvA cafeteria, and enjoyed many other things.

Of course, it was not all smooth sailing, as every day of these three times three weeks of lectures were dense and lasted about six hours. But the people I shared it with made that brighter! Indeed, we were quite the group. We quickly built some nice friendships, talking about physics, but also much more. In my opinion, this Doctoral School stands out not only for the quality of its courses but also for the opportunity to connect with brilliant first-year PhDs from around the world, all driven by the same passion for physics but also sharing other common interests beyond that. This will help establishing a human and research community that will last after the School.

It is difficult to summarise such an incredible experience in so few words, but I am truly grateful to have been part of it. I obviously would recommend attending this school to anyone starting a PhD in mathematical and theoretical physics!

Doctoral Schools on “Quantum Field Theory, Strings and Gravity”

Student’s opinion

Vladan Đukić (University of Belgrade)

The Solvay Doctoral School 2024 provided an exceptional platform to explore the intricacies of modern theoretical physics while fostering international connections with peers and experts. The program’s thoughtfully designed curriculum struck a perfect balance between foundational knowledge and exposure to cutting-edge research topics. We began with introductory courses in quantum field theory, general relativity, and bosonic string theory, progressing to more advanced subjects such as superstrings, AdS/CFT, 2D quantum gravity, and the black hole information paradox.

This structured progression enabled us to explore a wide range of high-energy physics topics in a pedagogically sound manner, delivered by experts at the forefront of their fields. The knowledge gained throughout these courses has already proven invaluable in shaping my doctoral research. The diverse subjects we covered provided me with new tools, insights, and perspectives that I am actively applying to my ongoing academic work.

One of the most enriching aspects of the program was the opportunity to experience its international dimension. Over the course of several weeks, we spent three weeks in Brussels, followed by three weeks at CERN in Geneva, and concluded with three weeks in Amsterdam. This international setting not only allowed us to explore different research environments but also provided an immersive cultural experience. The chance to interact with physicists from diverse backgrounds and research approaches was immensely valuable, enriching both my academic and personal growth.

The program also created ample opportunities for social networking. Our journey began in Brussels, where we visited the historic Solvay conference building in Park Leopold. There, we had the privilege of recreating the iconic 1927 photograph with Nobel laureates, an unforgettable moment that connected us to the history of physics. In Geneva, bouldering—an activity popular among physicists—became a fun way to relax and bond with others during our downtime at CERN. Table tennis, another favourite pastime, became a staple of our leisure time at the CERN cafeteria. Finally, in Amsterdam, we explored the Rijksmuseum and enjoyed ice skating at Museumplein under the open sky.

These and many other moments of camaraderie—whether through intellectual exchange, recreational activities, or shared experiences—fostered lasting friendships among fellow researchers. The connections made during this program have created a strong and supportive network that will undoubtedly continue to enrich my academic journey.

In conclusion, the Solvay Doctoral School 2024 was an unforgettable experience that seamlessly blended high-level academic learning with cultural exploration and professional networking. The diverse perspectives I gained throughout the program have already influenced my approach to research, and the friendships forged will continue to shape my academic and personal growth. The knowledge and experiences gained during this program will undoubtedly guide my future endeavours in theoretical physics.

05

RESEARCH AND RESEARCHERS

Research and researchers

These sections describe successively:

- The research carried in the groups of Professors Marc Henneaux, Director, and Alexander Sevrin, Deputy-Director for Physics and Scientific Secretary of the International Scientific Committee for Physics, in the Gravitation, stringtheory and cosmology Groups
- The research carried in the group of Sophie Van Eck, at the Institute of astronomy and astrophysics
- The research carried in the group of Frank De Proft and professor Emeritus Paul Geerlings, Vice-President
- The research carried in the group of Yves Geerts, Director of Chemistry since 2025, and Guillaume Schweicher, at the Laboratory of Polymer Chemistry
- The research carried in the group of Professor Gert Desmet, Deputy-Director for Chemistry, in the Chemical Engineering research group

Gravitation, string theory and cosmology Group

Group of Marc Henneaux and Alexandre Sevrin (ULB and VUB)

Researchers

Faculty members

Riccardo Argurio
(ULB)

Vijay Balasubramanian
(VUB)

Glenn Barnich
(ULB)

Vladimir Belinski
(ICRAN, Italy)

Andrès Collinucci
(ULB)

Geoffrey Compère
(ULB)

Ben Craps
(VUB)

Nathalie Deruelle
(ULB & CNRS)

Stéphane Detournay
(ULB)

François Englert
(ULB, Honorary Member of the Institutes)

Oleg Evnin
(VUB)

Frank Ferrari
(ULB)

Marc Henneaux
(ULB)

Laura Lopez Honorez
(VUB)

Axel Kleinschmidt
(Max-Planck-Institute, Potsdam, Germany)

Alberto Mariotti
(VUB)

Mairi Sakellariadou
(VUB)

Alexandre Sevrin
(VUB)

Daniel Thompson
(VUB)

Christoph Uhlemann
(VUB)

Postdoctoral members

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(ULB)

Soumyadeep Chaudhuri
(ULB)

Mario De Marco
(ULB)

Sudipta Dutta
(ULB)

Oscar Fuentealba
(ULB)

Giovanni Galati
(ULB)

Marius Gerbershagen
(VUB)

Juan Hernandez
(VUB)

Sk Jahanur Hoque
(ULB)

Salvatore Mancani
(ULB)

Kévin Nguyen
(ULB)

Gabriel Andres Piovano
(ULB)

Andrew Rolph
(VUB)

Shang-Ming Ruan
(VUB)

Jakob Salzer
(ULB)

Luigi Tizzano
(ULB)

Miguel Vanvlasselaer
(VUB)

Alejandro Vilar López
(ULB)

Stathis Vitouladitis
(ULB)

Gravitation, string theory and cosmology Group

Graduate students

Adrien Arbalestrier
(ULB)

Gonzalo Barriga
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Augustin Basilavecchia
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Emilie Despontin
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Hannah Duval
(VUB)

José Figueroa Silva
(ULB)

Dima Fontaine
(ULB)

Seppe Geukens
(VUB)

Dongming He
(VUB)

Loïc Honet
(ULB)

Niranjan Kamath
(VUB)

Maria Knysh
(VUB)

Ludovico Machet
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Louan Mol
(ULB)

Xander Nagels
(VUB)

Gabriele Pascuzzi
(VUB)

Maxim Pavlov
(VUB)

Elise Paznokas
(ULB)

Aäron Rase
(VUB)

Sébastien Robert
(ULB)

Thomas Smoes
(ULB)

Antoine Somerhausen
(ULB)

Wen-di Tan
(ULB)

Romain Vandepopeliere
(ULB)

Elise Van Den Bossche
(VUB)

Quentin Vandermiers
(ULB)

Research Summary

Of all the fundamental forces (electromagnetism, gravitation, weak and strong nuclear forces), gravity remains the most mysterious. In spite of its remarkable successes, Einstein's general theory of relativity, which has led to an unprecedented geometrization of physics, is an unfinished revolution. 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). Two lines of investigation have been in particular vigorously pursued recently: developing flat space holography and understanding the role of quantum information and complexity in quantum gravity.

The direct detection of gravitational waves has opened in the last years a spectacular new window on the universe. The group has also invested major efforts towards developing new analytical and numerical tools for analysing gravitational radiation and is involved as well in the development of new detectors.

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.

We have continued our research along the general directions outlined above. This has led to 138 published papers and preprints submitted for publication. These are listed from pages 180 to 193. Specific achievements by some researchers from the group are described in the subsequent pages.

Gravitation, string theory and cosmology Group

2024 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.

Previous Marina Solvay Fellowship

2012–2014
Waldemar Schulgin

2015
David Tempo

2016
Jelle Hartong

2017
Adolfo Guarino

2018
Charlotte Sleight

2019
Sucheta Majumdar

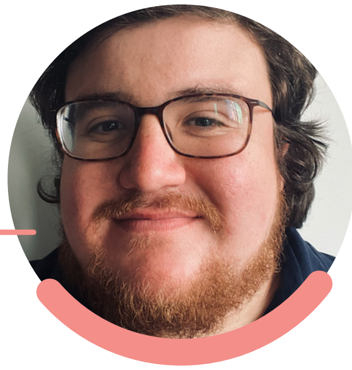
2020
Oscar Fuentealba

2021
Luca Ciambelli

2022
Jakob Salzer

2023 - 2024
Oscar Fuentealba

Oscar Fuentealba



Oscar Fuentealba got his PhD degree at the University of Concepción (Chile) in 2015. After a postdoctoral stay at CECs (Valdivia), he joined the group of the Director at ULB. His research deals with the Einstein theory of gravity: black hole solutions, black hole thermodynamics, supersymmetric models. More recently, he worked on the asymptotic symmetries of gravity in the asymptotically flat space context, where infinite dimensional groups appear at infinity. He already held twice the Marina Solvay fellowship (2020 and 2023) and got it for a third time in 2024. He was recently appointed professor at the Universidad Arturo Prat in Iquique, as well as permanent research member at the Instituto de Ciencias Exactas y Naturales ICEN (also in Iquique). His research in the group of Theoretical and Mathematical Physics at ULB has been mostly focused on various key properties of Einstein theory of gravity and its various generalizations in four and other dimensions. This work has allowed them making a major progress in the context of the so-called Bondi-Metzner-Sachs (BMS) symmetries, where they provided an independent, original solution the longstanding problem of “angular momentum ambiguities” in asymptotically flat spacetimes.

Non-minimal couplings to U(1)-gauge fields and asymptotic symmetries

During the last year, in collaboration with Marc Henneaux and Jules Mas, we have analysed the asymptotic symmetries of electromagnetism non-minimally coupled to scalar fields, with non-minimal coupling of the Fermi type that occurs in extended supergravity models [1]. This study showed that minimal and non-minimal couplings exhibit very different asymptotic properties: while the former generically cannot be neglected at infinity, the latter can. In this sense, electromagnetic non-minimal couplings are very similar to gravitational minimal couplings (which are also asymptotically subdominant). Thus, we explicitly proved that the non-minimally interacting model is asymptotic to the free one, by showing that its asymptotic symmetries are described by angle-dependent u(1) gauge transformations.

Gravitation, string theory and cosmology Group

Oscar Fuentealba

Logarithmic matching between past infinity and future infinity

In [2], we have addressed the problem of matching conditions relating the fields at future of past null infinity with the fields at the past of future null infinity (see Figure 1), which plays a central role in the analysis of asymptotic symmetries and conservation laws in asymptotically flat spacetimes. Specifically, we derived some mathematical identities called matching conditions for a massless scalar field in four spacetime dimensions with initial conditions leading to logarithms – in the radial coordinate – at null infinity. We also analysed the matching of the corresponding angle-dependent conserved charges, by proving that they are well-defined and finite at null infinity even in the presence of leading.

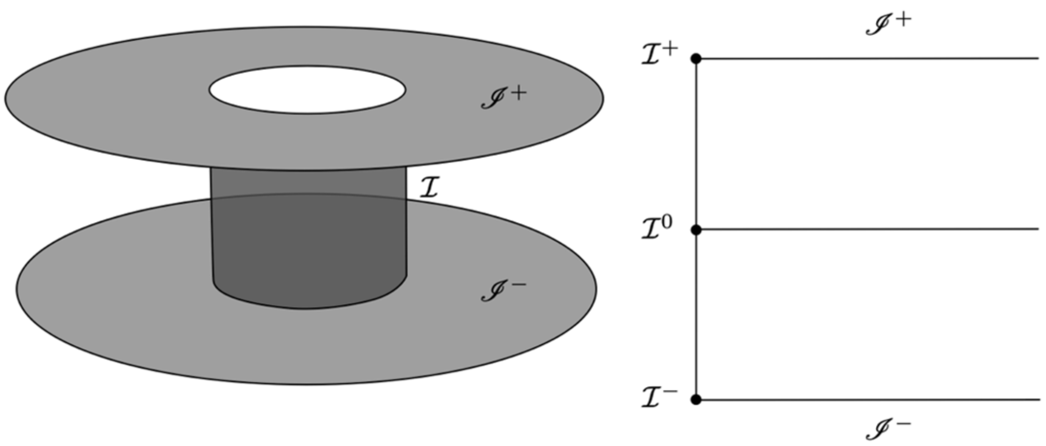


Figure 1: Representation of the cylinder at spatial infinity. In this diagram (past and future) null infinities, denoted by $J^{\pm}$, correspond to the regions that can only be reached by lightrays (electromagnetic or gravitational radiation). Spatial infinity is represented by the cylinder $\mathbf{I}$, whose boundaries are denoted by $\mathbf{I}^{+} = J_{-}^{+}$ (past of the future null infinity) and $\mathbf{I}^{-} = J_{+}^{-}$ (future of the past null infinity). The latter are also known as the critical surfaces. Matching conditions connect limiting values of the fields at the critical surfaces (Credit figure: [3]).

The novelty of our results relies on the fact that standard matching conditions considered in the literature are valid only in the case when the expansion near null infinity has no dominant logarithmic term. In this article, we have also considered the case of higher dimensions, where fractional powers of the radial coordinates (odd spacetime dimensions) or subdominant logarithmic terms (even spacetime dimensions) are present. Thus, the problem of the free massless scalar field has the virtue of presenting polylogarithmic features (of the asymptotic expansion) in a particularly clear setting that shows their inevitability, since there is no subtle gauge fixing issues or nonlinear intricacies involved in the problem. It is part of our forthcoming results to extend this analysis to the electromagnetic and gravitational fields.

Enhanced conformal BMS_3 symmetries

I have also been involved in different collaborations addressing the problem of finding a bona fide conformal extension of the aforementioned BMS algebra, which seemed to be generically a hard nut to crack. However, in three spacetime dimensions we proved that this work can be successfully achieved provided that an infinite number of "superdilations" and "superspecial conformal transformations" are incorporated within a nonlinear algebra. This was dubbed conformal BMS3 algebra in a previous collaboration [4]. This mathematical algebra has been shown to emerge in different interesting physical setups, as it is the case of the asymptotic symmetry algebra of conformal gravity in three dimensions, as well as from the free field realization of the BMS_3 Ising model in two dimensions. In [5], in collaboration with Iva Lovrekovic, David Tempo and Ricardo Troncoso, we wondered about the chance of enhancing the conformal BMS algebra in some appropriate way (which by the way looks already very undeformable). As a strategy to achieve this task, we proposed to explore the asymptotic structure of a suitable extension of conformal gravity in three dimensions. A nice and simple theory enjoying the sought features was proposed long ago by Pope and Townsend with the aim of further enlarging it in order to describe an infinite tower of conformal higher spin fields in 3D. Thus, we found an enhanced version of the conformal BMS_3 algebra, which span a precise nonlinear W algebra, whose central extensions and coefficients of the nonlinear terms are completely determined by the central charge of the Virasoro subalgebra. Remarkably, this new algebra can be also regarded as an infinite-dimensional nonlinear extension of the AdS_5 algebra with nontrivial central extensions. It is worth mentioning that the boundary conditions of this work might be considered as a starting point in order to consistently incorporate either a finite or an infinite number of conformal higher spin fields.

Gravitation, string theory and cosmology Group

Oscar Fuentealba

Permanent position in Chile: Instituto de Ciencias Exactas y Naturales (ICEN - Iquique)

My postdoctoral stays, first at Centro de Estudios Científicos - CECs - in Valdivia and then at ULB in Brussels, permit me to acquire not only long-term collaborations with world-top specialist, but also the experience to get a permanent professor position in the Instituto de Ciencias Exactas y Naturales – ICEN in Iquique (Figure 2). The generous support of Mrs. Marina Solvay was fundamental in order to get this position, as it covered most of my stay while in Belgium allowing me to pursue my career as a researcher in theoretical physics.

Figure 2: ICEN front (Iquique, Chile).

ICEN at Universidad Arturo Prat - located in Iquique (seaside city in northern Chile) - is a public institution developing research in the lines of theoretical physics and chemistry, geophysics and applied mathematics. Its main objective is to promote the development of these disciplines at international level through the generation of cutting-edge knowledge and the training of students and young scientists. The institute provides a vivid and rich academic environment between graduate students, postdoctoral researchers and faculties, pursuing to become a referent concerning scientific research, contributing to foster the decentralization of the scientific duties in our country and strengthening the link between science and society. In order to achieve these objectives, ICEN aims to focus its efforts to create collaboration networks with renowned and experienced institutions around the globe, as it is the case of the International Solvay Institutes. Indeed, in this respect it must be mentioned the recent incorporation of Per Sundell and David Tempo as new faculties at ICEN, being the latter a former Marina Solvay fellow at ULB as well. Thus, the Belgian-Chilean collaboration, initiated more than 45 years ago, in the context of gravitational physics is having a great impact in the development of Chilean theoretical physics.

References

[1] O. Fuentealba, M. Henneaux and J. Mas, "Non-minimal couplings to U(1)-gauge fields and asymptotic symmetries," JHEP 09 (2024), 180 [arXiv:2407.06376 [hep-th]].

[2] O. Fuentealba and M. Henneaux, "Logarithmic matching between past infinity and future infinity: The massless scalar field," to be published in JHEP [arXiv:2412.05088 [gr-qc]].

[3] M. M. A. Mohamed and J. A. V. Kroon, "Asymptotic charges for spin-1 and spin-2 fields at the critical sets of null infinity," J. Math. Phys. 63 (2022) no.5, 052502 [arXiv:2112.03890 [gr-qc]].

[4] O. Fuentealba, H. A. González, A. Pérez, D. Tempo and R. Troncoso, "Superconformal Bondi-Metzner-Sachs Algebra in Three Dimensions," Phys. Rev. Lett. 126 (2021) no.9, 091602 [arXiv:2011.08197 [hep-th]].

[5] O. Fuentealba, I. Lovrekovic, D. Tempo and R. Troncoso, "Enhanced Conformal BMS3 Symmetries," to be published in JHEP [arXiv:2501.00439 [hep-th]].

Gravitation, string theory and cosmology Group

Riccardo Argurio

Research Director | ULB

Quantum Field Theory and Symmetry: A Generalized Story

Symmetries are probably the most important building blocks of Quantum Field Theory. The latter is, more than a theory, the framework in which all physical theories are, or should be, formulated. It is sufficient to type "symmetries in quantum field theory" in your favorite search engine, and a slew of nice pictures will immediately show up illustrating the close link between the two concepts (admittedly, the results will be biased by your own search history...). In fact, the protagonism of symmetries in the theory of fundamental interactions starts well within Quantum Mechanics. A good example is the motivation for the 1963 Nobel Prize in Physics awarded to Wigner, "for his contributions to the theory of the atomic nucleus and the elementary particles, particularly through the discovery and application of fundamental symmetry principles." Quantum Field Theory itself, is born out of the desire to formulate Quantum Mechanics in a way that is consistent with a particular symmetry, namely the Poincaré symmetry of relativity, that mixes space and time into space-time.

Poincaré symmetry is actually a very special symmetry, since it concerns space-time, which is the backdrop on which all physical theories stage their play, at least when high energies are considered. Fittingly, it is called a space-time symmetry. By definition, this is a symmetry which is always present in a relativistic physical theory, that is a Quantum Field Theory (QFT) from now on. However QFTs can, and do have many more symmetries than that. They are called "internal" symmetries, perhaps because physicists like to think of space-time as external. A most celebrated example of an internal symmetry is the one of "flavor" in particle physics. Particles, and the fields associated to them in the Standard Model (which is the QFT that describes the observed fundamental particles and their interactions), come in various flavors, or families, that have otherwise identical properties. Internal symmetries are actually the core data that allows physicists to characterize, classify, and study QFTs both with the aim of describing physical systems, and as theoretical laboratories.

The particles of the Standard Model come in three families with symmetric properties (credit for the plushies: https://www.particlezoo.net/)

Since we want eventually to discuss the ongoing generalizations of the concept of symmetry in QFT, we need first to remind ourselves what are the usual kind of symmetries, and what is the mathematical formalism that describes them. Symmetries can be continuous, like a circle that can be rotated by any angle and still look the same, or discrete, like a square that can be rotated only by multiples of 90° otherwise it will look tilted. Mathematically, what is important is that symmetries can be composed one after the other. Like, in the previous examples, performing two rotations, possibly of different angle, one after the other. It will still be a rotation. They form a "group." Then for decades, QFTs have been described by the groups, both continuous and discrete, under which they are invariant. We will see that one of the recent breakthroughs is to go past the notion of group.

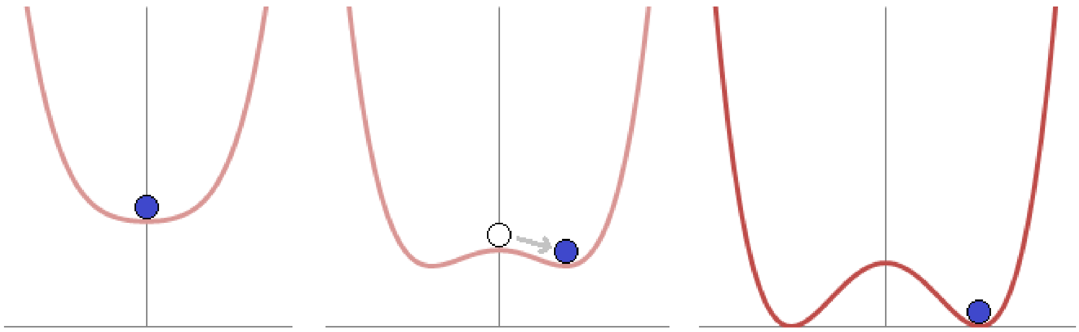
In the context of QFT, there is a very important distinction between local and global symmetries. Local symmetries are symmetries that act differently at different points of space-time. As a consequence, they are more like redundancies of the description. In other words, it is equivalent to performing a sort of "average" (in a QFT sense) over all such symmetry transformations. It follows that local symmetries are not really observable. In contrast, global symmetries are precisely those that constrain the observable features of the theory.

Gravitation, string theory and cosmology Group

Riccardo Argurio

An equally important distinction is whether symmetries are preserved or broken in a given QFT. In order for this distinction to be meaningful, and physically interesting, we should first recall that the usual picture of a QFT is that it is defined at sufficiently high energies/short distance (the "UV"), then one can ask what happens at lower energies/large distance (the "IR"). To answer this question is often difficult, because it involves dealing with QFT at strong coupling, namely when the textbook tools of QFT are of no use. How a QFT selects its vacuum, namely its lowest energy state, is then obviously one of such, potentially hard, IR questions. In any case, a logical possibility is that a symmetry that is present in the UV, is broken spontaneously in the vacuum. Here one can immediately think of the familiar picture of the "mexican hat" potential (or its section, for a discrete version): the potential is symmetric, but any single minimum is not. The symmetry is then said to be spontaneously broken.

Landau, in his infinite wisdom, had put forward long time ago his paradigm according to which the possible IR behavior of any QFT is indeed determined by the pattern of spontaneous symmetry breaking. As the parameters of a QFT are varied, the IR can go from one phase where the symmetry is preserved, to one where it is broken. In the latter case, there must be an "order parameter", whose value in the vacuum being non-zero is in one-to-one correspondence with the breaking of the symmetry. This is Landau's theory of phase transitions.



A phase transition: as the shape of the potential is varied, the minimum goes from being in a symmetric position to a position that breaks the reflection symmetry about the vertical axis.

How can one predict the IR properties of a given QFT, in particular how a symmetry is realized at low energies? A handle to address this problem in general is to see if symmetries are themselves under some constraint. It turns out that a strong constraint is given by anomalies, after the intuition of another genius, 't Hooft. One can ask whether a global symmetry can be made local, in the sense of performing a QFT average over it. Sometimes this cannot be done consistently, and moreover the obstruction in doing that is parameterized by a quantity, the anomaly, that has very interesting properties. First of all, it is intrinsically quantum mechanical by the way it appears. Then, it usually takes discrete values, which means that it cannot continuously vary. Such a parameter is called "topological", since it will depend only on global features of the theory, and not on local, or continuous ones. This anomaly then characterizes the symmetry of a given QFT, and its value in the UV must be matched by its value in the IR. This can impose strong constraints on the IR of a theory, for instance preventing a symmetry to be broken, or forcing the IR to have massless particles.

In fact, topology plays a crucial role when defining symmetries in QFT. It is familiar from basic electro-magnetism that in order to measure a localized distribution of electric charges, one has to perform an integral over a closed surface. An important property of this integral is that as long as the surface encloses all the charges, its shape is not important. The final value of the integral will depend only on the number of charges inside. If the surface is deformed so that a charge is now outside, the value of the integral will change by a discrete amount—again a topological quantity! It turns out, as formalized recently (in 2014) by a work of Gaiotto, Kapustin, Seiberg and Willett, that all symmetries in a QFT can be seen as topological operators acting on the various objects of the theory. Fusion of topological operators corresponds to the composition of symmetry transformations.

In a very interesting twist, it was soon realized that one can easily switch the terms of the identification, and state that all topological operators of a given QFT should be considered as symmetry operators. This is a bold statement, because it is not at all granted that fusing two arbitrary topological operators, the result will be a third simple one, as mandated by group theory. Indeed, it is not the case, but in fact, identifying symmetries to group elements is too restrictive. In mathematics, this generalization goes under the name of the theory of categories. In physics, one speaks more colloquially of "non-invertible" symmetries, because one of the properties of groups that is forgone is precisely that every element should have an inverse. Our new symmetries will have the property that after transforming the system, one cannot always transform it back to its original state.

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Riccardo Argurio

Non-invertible symmetries are particularly interesting when they are spontaneously broken. Usual symmetries imply, when broken, that there is a degeneracy of physically equivalent vacua. In the case of non-invertible symmetries, when broken in the IR, there is still a degeneracy of vacua, but the physical properties of each vacuum may differ. This degeneracy would be understood as accidental, and hence impossible to predict, were it not for the presence of these additional non-group-like symmetries. Generalized symmetries then allow us to extend the Landau paradigm to situations where it would not apply for group-like symmetries.

The team at ULB has made many contributions to this ongoing effort in studying generalized symmetries in QFTs. We have studied the occurrence of non-invertible symmetries, and more complicated structures called “higher groups” (or even “higher categories”) in model QFTs in many space-time dimensions: from two to five! With a particular attention to the four-dimensional case nevertheless. At present, the focus is really to study in which ways these kind of symmetries emerge in QFTs, hence the interest of studying many different models. It is to be noted that this research effort, formal as it is, has very interesting points of contact and cross-fertilization with neighboring domains in physics and also in mathematics. For instance the theory of categories is not as developed as the one for groups. In particular, the equivalent of continuous groups is not yet well-defined. We have made the case for their study, since they are needed to define non-invertible generalizations of continuous symmetries, that appear in as basic physical theories as Quantum Electro-Dynamics (QED). There is also a point of contact with condensed matter systems, where topological aspects of QFTs also play an important role. In fact, a considerable part of our focus has been on topological QFTs, which function as specific QFTs (the ones the mathematicians like to define rigorously!), and also as descriptions of the topological sector of a given QFT, i.e. its topological defects. We are now in a position where we can, with our collaborators, address deeper questions, such as what new physics can we learn using generalized symmetries, both by firmly establishing properties of known theories, and by building new, more appropriate QFTs.

Romain Vandepopeliere

Doctoral researcher | ULB

Quantum Field Theory (QFT) stands as one of the most profound frameworks for understanding the interactions of fundamental particles and the dynamics of fields. It is a language that not only unifies the description of particle physics but also extends its reach to explain diverse phenomena, e.g. in condensed matter systems. One of the central pillars of QFT is the concept of gauge symmetry. Gauge theories, which incorporate these symmetries, have been instrumental in describing the fundamental forces of nature, most notably within the Standard Model of particle physics. However, despite their tremendous success, gauge theories also present deep challenges, especially when it comes to understanding their non-perturbative aspects, such as confinement and the generation of a mass gap. Confinement, which is the phenomenon by which quarks are perpetually bound within hadrons, remains one of the most intriguing puzzles in theoretical physics.

In these theories, while the local dynamics is dictated by the Lie algebra underlying the gauge symmetry, a full understanding of physical phenomena like confinement necessitates an exploration of the global properties of the gauge group. These global aspects, which include features such as the center of the group and its fundamental group, are not captured by a local analysis of the Lagrangian alone. Instead, they become manifest through the behaviour of extended operators, such as Wilson and 't Hooft lines, which probe the topological and non-local features of the theory. This sensitivity to global properties becomes even more pronounced when the theory is compactified on non-trivial spaces, where non-contractible cycles allow topological features to exert a tangible influence on the dynamics. Consequently, modern approaches to gauge theories have increasingly focused on generalized global symmetries, and in particular on even more exotic structures: non-invertible symmetries. Together, they offer a refined language for describing duality transformations and phase transitions in strongly coupled systems.

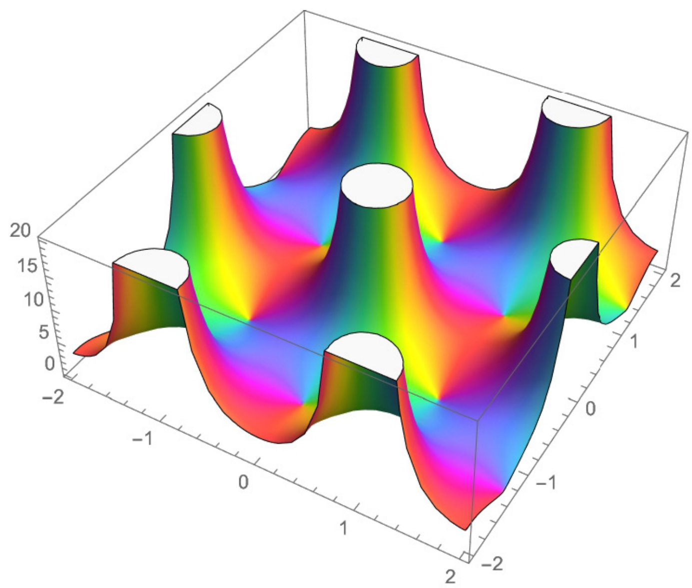
Gravitation, string theory and cosmology Group

Romain Vandepopeliere

In this context, the study of N=1* theories has emerged as a powerful avenue to probe non-perturbative phenomena. By considering a massive deformation of N=4 Super-Yang-Mills (SYM) theories, one leverages the enhanced control provided by supersymmetry, which facilitates a detailed analysis of the low-energy dynamics. Unlike pure N=1 theories, the N=1* models inherit a rich duality structure from their parent N=4 theory. This inheritance not only endows the theory with discrete vacua but also amplifies the interplay between local field dynamics and global topological effects. In some N=1* theories, the supersymmetric framework allows for an exact determination of the vacuum structure, which is inherently richer than in less supersymmetric settings. The discrete set of vacua, emerging from the spontaneous breaking of non-invertible duality defects, reveals subtleties in the behaviour of the theory that are intimately tied to the underlying global properties of the gauge group.

In collaboration with J. Aguilera Damia (Barcelona U.), R. Argurio (ULB), A. Bourget (iPhT) and V. Tatitscheff (Heidelberg U.), we investigated the intricate vacuum structure of N=1* theories by employing the framework of integrable systems. In general terms, an integrable system is a mathematical model characterized by the existence of a large number of conserved quantities, allowing for an exact solution or a very detailed qualitative analysis. Such systems often bridge abstract mathematical structures with concrete physical phenomena. In the context of N=1*theories, the twisted elliptic Calogero–Moser (CM) system plays a pivotal role. Its extrema have been shown to correspond precisely to the discrete vacua of the gauge theory when compactified on non-trivial space. This correspondence is not only conceptually elegant but also practically powerful, as it enables us to extract detailed insights into the vacuum structure through a well-controlled mathematical framework.

To this end, we proposed a notion of global form for the integrable system itself, specifically designed to match the rich structure of the N=1* gauge theory on a compactified space. By incorporating these global topological features into the structure of the CM system, our proposal mirrors the dependence of the vacuum structure on the gauge group's global form. The modular features of the proposed integrable system captures the interplay between global aspects of the gauge theory and duality transformations. In addition, we studied the low-energy effective theories that emerge in these vacua, which are typically topological in nature, thereby capturing the essential non-perturbative dynamics and residual degrees of freedom of the theory.



Gravitation, string theory and cosmology Group

Hannah Duval

Doctoral Researcher | VUB

Laser Interferometer Space Antenna (LISA), which will be launched in space, will expand detection capabilities into the millihertz frequency band, in contrast to the sensitivity of the LVK network within the hertz frequency band. The different configurations of this next-generation network are currently under study and discussion, promising a new era of GW astronomy.

The goal of all GW detectors is to capture the diverse range of signals, which can be classified into four categories based on their duration and how well their waveforms match theoretical predictions. A useful analogy is that of a musical performance, where each category contributes a distinct sound to the cosmic symphony. So far, the LVK network has detected GWs originating from energetic astrophysical phenomena, such as the mergers of black holes and neutron stars. These signals are loud and well-modelled, belonging to the first category: compact binary coalescences (CBCs). These CBCs produce short, high-amplitude bursts with well-defined waveforms—analogous to the sudden crash of cymbals in a symphonic concert. Yet these energetic and loud events represent only one part of the cosmic orchestra. In contrast, a second category consists of continuous GWs, expected from rapidly spinning neutron stars with surface irregularities. These signals persist over long periods, much like a lone violin sustaining a steady note throughout a performance. A third category includes burst GWs, which are brief, unpredictable, and arise from unknown or poorly understood astrophysical processes. These signals resemble the spontaneity of a jazz improvisation, emerging suddenly, without a clear pattern, and posing unique challenges for detection. Taking the analogy one step further, we can also hear a faint yet persistent cosmic hum. This hum, known as the gravitational-wave background (GWB), is formed by the superposition of countless unresolved sources. The GWB arises from events similar to those already detected by the LVK network, but because these signals are much weaker, they remain undetected. Instead, they overlap, forming a background of GWs. This cosmic background melody carries valuable information about fundamental astrophysical processes, including the rate of star formation, the frequency of supernova explosions, the mass distribution of newborn black holes, and the mechanisms driving black hole growth over time.

In addition to its astrophysical origins, there is also the possibility of a cosmological GWB, which would provide a unique glimpse into the earliest moments of the Universe. Detecting such a background would be groundbreaking for early-universe cosmology and high-energy physics, revealing phenomena inaccessible through traditional observational methods. However, the precise contributions of various theoretical sources to the GWB remain unknown. For now, the best approach is to refine predictions of the distinctive GW signatures associated with different potential sources. By doing so, future detections may allow us to trace these signals back to their origins, unlocking new insights into the Universe's deepest mysteries.

The GWB is defined by a dimensionless energy density spectrum, ΩGW, which fully characterizes it, assuming it is Gaussian, isotropic, and stationary. Detecting the GWB is a challenge because its amplitude is significantly smaller than that of GWs produced by binary black hole or binary neutron star mergers. Additionally, distinguishing the GWB from noise in the GW interferometers is difficult, as both are random in nature. To overcome this, we apply a technique called cross-correlation, which involves comparing data from multiple GW interferometers. The key assumption behind this method is that noise sources in different detectors are uncorrelated—an assumption that holds when the detectors are widely separated. By cross-correlating the data, any uncorrelated noise contributions are averaged out, while a true GWB signal, which would be present in all detectors, appears as a consistent, non-zero correlation. This approach has already been used in previous observing runs by the LVK network to set limits on ΩGW. In addition, indirect constraints on the GWB come from other cosmic observations, such as the abundances of light elements from Big Bang Nucleosynthesis and the Cosmic Microwave Background (CMB).

Gravitation, string theory and cosmology Group

Hannah Duval

Even though no detection of a GWB has been made thus far, valuable insights can still be gained from its absence by performing a Bayesian analysis, a statistical framework that updates the probability of a hypothesis as new data becomes available. This allows us to constrain key parameters of the models sourcing the GWB, providing meaningful constraints on the history and evolution of the Universe. The evolution of the Universe can be described by different epochs. This is done by treating the Universe as a cosmological fluid with two parameters: the density ρ and the pressure P. The equation of state parameter $w = P/\rho$ is a useful way to describe the Universe's behavior across these epochs. The earliest epoch, widely believed to be one of inflation, describes a period of rapid exponential expansion. Inflation was introduced to address several theoretical challenges in our understanding of the early Universe, such as why it appears so uniform on large scales. Additionally, it provides an explanation for the formation of large-scale structures in the Universe. This formation arises from primordial perturbations, which not only generate density fluctuations crucial for structure formation, but also produce GWs in the form of a GWB. The characteristics of this GWB are highly dependent on the specifics of the inflationary model. While multiple observations, such as temperature measurements of the CMB, support its validity, no GWB sourced by inflation has been detected thus far. This is because the most basic inflationary models predict a very weak GWB, one that is not detectable by current or future GW detectors.

The weak inflationary GWB provides a compelling reason to explore alternative cosmological models that could produce a detectable inflationary GWB. One promising approach is to investigate the evolution of the Universe beyond the standard model. In the standard cosmological history, inflation is followed by a radiation domination era ($w = 1/3$), then a matter domination era ($w = 0$), and finally the current era of dark energy domination ($w = -1$). However, this standard framework leaves room for alternative scenarios. Our research explores a non-standard cosmological history that introduces additional, unconventional epochs between the end of inflation and the well-established eras. In our model, after inflation the Universe undergoes an exotic sequence of eras: an exotic radiation dominated era, an exotic matter dominated era, and then a phase driven by stiff energy—where the equation of state parameter lies between 1/3 and 1. The most extreme version of this stiff-energy phase, known as kination, occurs when w is fixed at 1. This model is not only interesting because it enhances the inflationary GWB, but it is also motivated by particle physics models. To investigate this intriguing history, we analyze GW data from the LVK network collected during their first three observing runs, applying Bayesian inference techniques to constrain the GW spectrum predicted by our model. We also explore the detection prospects of future experiments, assessing various configurations of the Einstein Telescope to identify the optimal setup for capturing the GWB generated by these exotic early-universe epochs.

With current GW detectors becoming more sensitive and the next-generation observatories on the way, we are closer than ever to detecting the GWB. Furthermore, recent discoveries from Pulsar Timing Arrays further support its existence, and a confident detection only seems to be a matter of time. By observing GWs across different frequency ranges, we hope to untangle the astrophysical and cosmological processes behind these signals. Ultimately, this work brings us closer to unraveling the origins of the cosmos and deepening our understanding of the fundamental processes that have shaped the Universe we live in. With this knowledge, we may one day be able to answer some of humanity's most profound questions: Where did we come from? Why are we here? And how did everything begin?

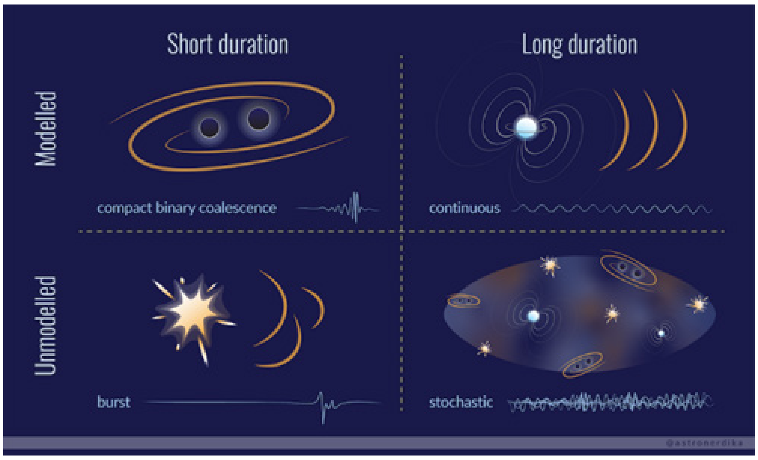


Figure 1: The four main sources of gravitational waves. (Credit: Shanika Galaudage)

Gravitation, string theory and cosmology Group

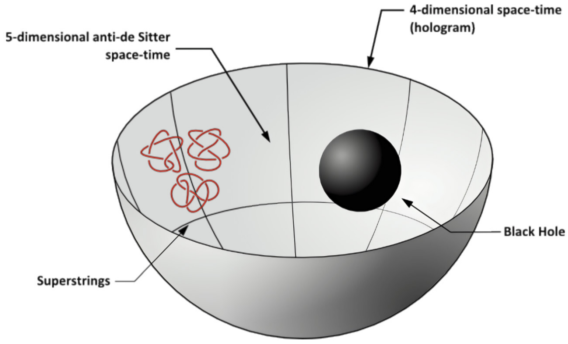
Christophe Uhlemann

Doctoral researcher | VUB

Some essential open questions in theoretical physics concern the underlying mathematical frameworks. This includes the issue of how the principles of quantum mechanics combine with general relativity, connected to questions for the microscopic description of black holes, how black holes process information, and whether/how information is preserved at a fundamental level. It also includes questions in quantum field theory, the language underlying the Standard Model of Particle Physics and many applications in condensed matter physics, where a comprehensive understanding of strong interactions and of the space of consistent quantum field theories remain elusive.

These broad issues are not tied to particular experiments. They are primarily theoretical and call for a "theoretical laboratory", where one can efficiently design and realize mathematically consistent theories which share at least qualitative features with theories relevant for practical applications and analyze them using powerful tools. Such a theory lab can be found in string theory. String theory unifies general relativity with quantum mechanics and incorporates vast spaces of quantum field theories and gravitational theories. It provides a well-equipped theoretical laboratory for studying fundamental questions in quantum field theory and quantum gravity using powerful mathematics which goes beyond what we usually have at our disposal for theories tied to particular experiments.

Useful insights which have emerged from string theory in this capacity include the microscopic accounting for the entropy of certain types of black holes, and the discovery of intriguing new quantum field theories which are intrinsically strongly coupled and whose existence defies conventional lore. A prominent tool that emerged from string theory are holographic dualities -- equivalence relations between certain conventional quantum field theories on the one hand, and certain quantum gravity theories with additional dimensions (emerging holographically) on the other.



Gravitational theory with a black hole described by a quantum field theory on a holographic screen of one dimension less [https://www.quantum-bits.org/?p=1134].

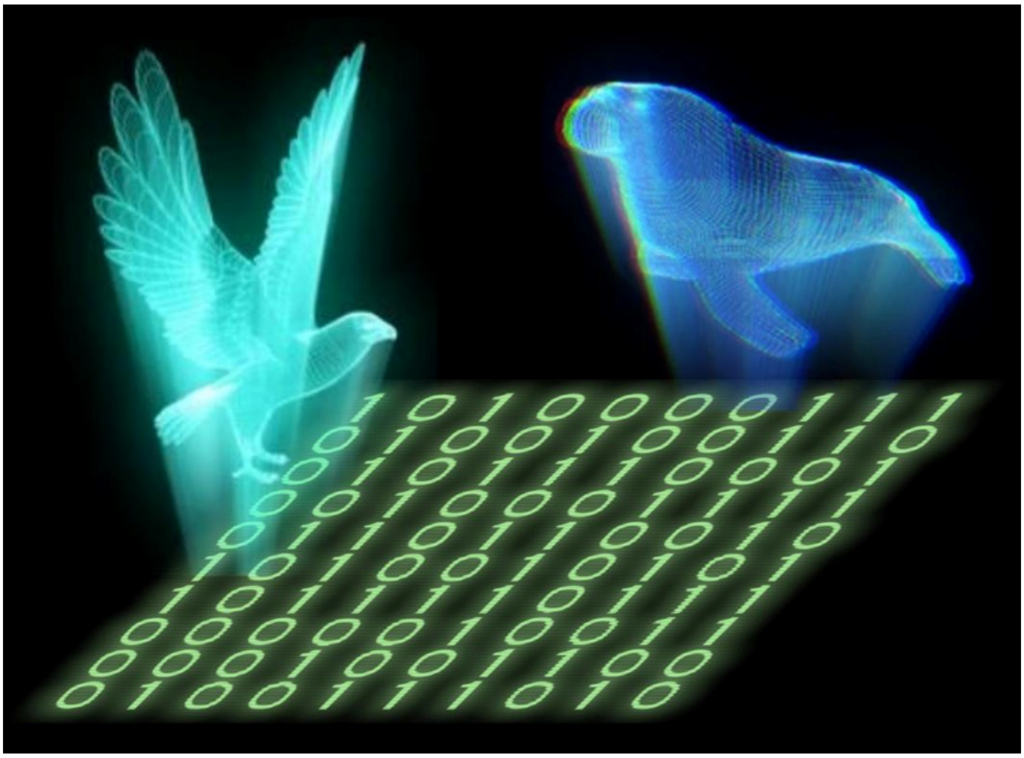
Heuristic arguments suggest that such relations should be a general feature of quantum gravity, which makes them broadly appealing. But sharp versions, where dualities relate concrete theories through a precise holographic dictionary between their observables, can be derived systematically in string theory. Within this latter setting holographic dualities can be used as a precision tool which allows us to reliably address problems which are challenging on one side through calculations on the other.

Over the last 5 years, work on black holes and the question whether information is preserved in quantum gravity has brought an extended concept of holographic duality into focus. The question whether the Hawking radiation emitted by black holes carries away information or if it is random, effectively depleting the black hole of information, has been addressed in new ways. Work on idealized models realizing black holes coupled to a non-gravitational reservoir, combined with new insights into entanglement entropy computations, has led to concrete computations showing that information is imprinted onto the Hawking radiation in a way consistent with the principles of quantum mechanics.

Initial calculations were carried out in two-dimensional models, where gravity simplifies and becomes tractable. Analogous computations in higher dimensions are challenging but possible with help from a form of holography on steroids, or “double holography”. The crux is that certain special quantum field theories can have two holographic descriptions in terms of gravitational theories which are both useful.

Gravitation, string theory and cosmology Group

Christophe Uhlemann



In double holography a single quantum field theory (the underlying code) gives rise to two holographic gravitational descriptions, one illustrated as bird and the other as walrus.

One holographic description is entirely gravitational, while a second "intermediate" description involves gravity and a strongly-coupled quantum field theory interacting with each other. The latter is where the problem is formulated, the former is where the required computations become tractable. Both emerge from the same underlying quantum field theory, through which they are connected.

Leveraging this extended notion of holography needs a reliable and detailed dictionary relating the three descriptions. The concept of double holography originated in bottom-up toy models, which are uncontrolled approximations to mathematically consistent theories, with a partial heuristic dictionary. It can, again, be made precise in string theory at the cost of higher mathematical complexity but with the benefit of a precise dictionary anchored in the underlying quantum field theory. Developing this string theory realization of double holography and applying it to black hole studies has been one part of my work in recent years. It provided computations of the entropy of Hawking radiation of 4-dimensional black holes in certain consistent theories of quantum gravity, resolved inconsistencies in the bottom-up models and clarified aspects that the latter do not capture accurately.

As a general tool, double holography has broader applications, e.g. in models for cosmology, and exploratory work is often carried out in bottom-up constructions. To further develop the string theory constructions and fully leverage them, a broad quantitative understanding of the underlying quantum field theories and their holographic descriptions is desirable. Exploring the underlying quantum field theories is thus a natural part of the program, and in recent work with Dongming He, PhD student at VUB, we made progress in this direction.

The underlying quantum field theories are of a particular mixed-dimensional nature. They are based on N=4 super-Yang-Mills theory, which is a supersymmetric cousin of QCD, the theory describing the strong nuclear force. But instead of being defined in full 3+1 dimensional Minkowski spacetime with 3 unconstrained spatial directions, the relevant theories are defined on half spaces. This naturally introduces a boundary, where the theories, crucially, interact with large numbers of lower-dimensional degrees of freedom which are confined to the boundary and form strongly-coupled 2+1 dimensional quantum field theories with independent holographic descriptions in their own right. This connects the investigation to the physics of boundaries and interfaces more generally.

In two recent works with Dongming we studied these quantum field theories using supersymmetric localization, a tool which facilitates the exact computation of certain observables in supersymmetric quantum field theories by means of auxiliary matrix models -- without assuming the perturbation theory underlying Feynman diagram approaches to quantum field theory or the discretized spacetime underlying lattice simulations. We showed that the holographic duals encode, in a precise form, saddle points dominating the matrix models, and established a tight and practically useful connection between the two descriptions. The ensuing interplay between the field theory and gravity descriptions allowed us to obtain a number of new observables (correlation functions of local operators, expectation values of Wilson-loops) for these theories. This led to non-trivial tests of the holographic dualities and to new tools which will be useful in future studies of the field theories and of double holography.

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Talks at conferences, seminars and schools

Achievements & awards

Elise Van den Bossche obtained a prestigious FWO Aspirant PhD fellowship.

Andrew Rolph obtained a prestigious FWO senior postdoctoral fellowship.

Maxim Pavlov and **Aäron Rase** were awarded the second 2-year term of their FWO Aspirant PhD fellowships.

Theses defended in 2024

Antoine Somerhausen (ULB)
"Lower-dimensional models for quantum gravity and black holes: Aspects of holographic dualities in Topological Massive Gravity"
13 September 2024 (Thesis' advisor: Prof. S. Detournay)

Kevin Turbang (VUB)
"The Stochastic Graviational-Wave Background: from Models to Observations"
4 July 2024

Quentin Vandermiers (ULB)
"Field theoretic and gravitational aspects of Warped Conformal Field Theories"
11 September 2024 (Thesis' advisor: Prof. S. Detournay)

Sofia Zhidkova (VUB)
"Generalised Dualities in M-Theory"
2 July 2024

Ricardo Argurio

Spontaneous Non-invertible Symmetry Breaking

"Symmetry Seminar" series, online
January 30, 2024

RHIND-Seminar, Heidelberg University, Heidelberg, Germany
February 12, 2024

Workshop at IBS, Daejeon, South Korea
December 4, 2024

Generalized Symmetries: a Bulk Perspective

Amsterdam String Seminar, Amsterdam University, Amsterdam, The Netherlands
March 12, 2024

University of Birmingham, Birmingham, United Kingdom
May 7, 2024

Quantum Field Theory and Symmetry: a Generalized Story
HEP@VUB Colloquium, VUB, Brussels, Belgium
March 14, 2024

Non-compact TQFTs & non-invertible symmetries
Symmetries 2024 Workshop, University of Oxford, Oxford, United Kingdom
August 14, 2024

Quantum Field Theory and Symmetry: a Generalized (and Non-Invertible) Story
Theory Colloquium – Padova University, Padova, Italy
October 23, 2024

Gravitation, string theory and cosmology Group

Talks at conferences, seminars and schools

Glenn Barnich

Lessons from DLCQ for gravity

Ruder Boskovic Institute, Mathematical Physics Group, Colloquium, Zagreb, Croatia
February 1, 2024

11th Tux workshop on Quantum Gravity, Tux, Austria
February 20, 2024

BMS representations
ESI Programme: Carollian Physics and Holography, Vienna, Austria
April 25, 2024

Asymptotic symmetries and current algebras in gravity
Seminar of the Division of Theory of Gravity and Fundamental Interactions
University of Wroclaw, Institute for Theoretical Physics, Wroclaw, Poland
May 7, 2024

Lessons from DLCQ for physics at null infinity

Workshop Gauge theories, supergravity and superstrings, Benasque, Spain
June 10, 2024

Mini-workshop on quantum gravity and holography in asymptotically flat spacetimes. Ecole Polytechnique, Paris, France
June 28, 2024

Model spaces from the point of view of constrained Hamiltonian systems
Mini-workshop Carroll Physics, asymptotic symmetries and conformal field theories, Aristotle University of Thessaloniki, Thessaloniki, Greece
September 23, 2024

Geometric actions and model spaces

Quantum Gravity Seminar, Perimeter Institute of Theoretical Physics, Waterloo, Canada
October 17, 2024

Workshop Mathematical Physics of Gravity and Symmetry, Institut Mathematiques de Bourgogne, Dijon, France
November 20, 2024

High Energy Theory Group Seminar, University of Padova, Padova, Italy
December 18, 2024

Soumyadeep Chaudhuri

Semiclassical analysis of finite cut-off JT gravity on a disk

CERN, Geneva, Switzerland
November 5, 2024

International Centre for Theoretical Sciences, Bangalore, India
December 4, 2024

Giulio Collinucci

GV invariants in non-toric local CY threefolds, some of which do not have compact curves
University of Geneva, Geneva, Switzerland
October 31, 2024

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Talks at conferences, seminars and schools

Geoffrey Compère

Memory effects in de Sitter and the Lambda-BMS group
University of Athens, Athens, Greece
March 26, 2024

Progress on the definition of asymptotically flat and de Sitter spacetimes

Institut d'astrophysique de Paris, Paris, France
April 8, 2024

Université de Paris, Paris, France
April 10, 2024

Simons Center, New York, US
April 12, 2024

Features of near-extremal black holes ULB,
Brussels, Belgium
September 6, 2024

Wavesforms for asymemetric binary coalescences
Leuven, Belgium
September 13, 2024

Ben Craps

Factorization of the Hilbert space of eternal black holes in general relativity

University of Kentucky, Lexington (online), United States
October 25, 2024

Strings Online Lisbon Workshop, Lisbon (online), Portugal
October 29, 2024

Mario de Marco

Field Theories with Extended Supersymmetry
XX Avogadro Meeting
December 20, 2024

Stéphane Detournay

Black Holes
Laser Talks, Brussels, Belgium
June 20, 2024

The Solitary One
Journée Arts-Sciences, member of the panel “De la recherche à la scène”,
Brussels, Belgium
October 18, 2024

Sudipta Dutta

Carrollian correlators from AdS Witten diagrams
Carrollian Physics and Holography, ESI, Vienna, Austria
April 9, 2024

Hannah Duval

The Stochastic Gravitational-Wave Background
University Foundation, Brussels, Belgium
June 28, 2024

Gravitation, string theory and cosmology Group

Talks at conferences, seminars and schools

Hannah Duval

Investigating cosmic histories with a stiff era through Gravitational Waves

KU Leuven, Leuven, Belgium
June 7, 2024

King's College London, London, United Kingdom
June 18, 2024

LAPP - Laboratoire d'Annecy de Physique des Particules, Annecy, France
September 18, 2024

DESY, Hamburg, Germany
September 26, 2024

Kyoto University, Kyoto, Japan
October 21, 2024

Oleg Evnin

Cosmological acceleration from regular black holes
University of Cagliari, Cagliari, Italy
April 30, 2024

Statistical field theory of random graph Laplacians
IMT Lucca, Lucca, Italy
May 6, 2024

Turbulence and integrability in resonant Hamiltonian dynamics
SISSA, Trieste, Italy
May 9, 2024

A Gaussian integral that counts regular graphs

Northeastern University (online talk), Boston, USA
May 17, 2024

University of the Philippines, Diliman, Manila, Philippines
December 16, 2024

Frank Ferrari

Jackiw-Teitelboim Gravity, Random Disks of Constant Curvature, Self-Overlapping Curves and Liouville CFT1
Département de mathématiques de l'Université de Genève, Suisse
April 30, 2024

The UV Complete Jackiw-Teitelboim Quantum Gravity Theory

Workshop Entanglement, Large N and Black Hole, Asia Pacific Center for Theoretical Physics (APCTP), POSTECH, Pohang, South Korea
May 30, 2024

Workshop The Microscopic Origin of Black Hole Entropy, Aspen Center for Physics, Aspen, Colorado, USA
June 13, 2024

Gravitation, string theory and cosmology Group

Talks at conferences, seminars and schools

Frank Ferrari

Random Disks of Constant Curvature and Jackiw-Teitelboim Quantum Gravity
Mathematics Department, Durham University, U.K.
September 4, 2024

Jackiw-Teitelboim Quantum Gravity On Finite Geometries
Workshop on Noncommutative and Generalized Geometry in String theory, Gauge theory and Related Physical Models, Corfu, Greece
September 19, 2024

Random Disks of Constant Curvature, Self-Overlapping Curves and Liouville CFT1
LaBRI (Laboratoire Bordelais de recherche en informatique), Département de mathématiques de l'Université de Bordeaux, France
October 21, 2024

Oscar Fuentealba

Simplifying (super-)BMS algebras

Université de Tours, Tours, France
February 1, 2024

Universidad Arturo Prat, Iquique, Chile
March 7, 2024

Logarithmic supertranslations and supertranslation-invariant Lorentz charges
University of Iceland, Reykjavik, Iceland
April 22, 2024

Giovanni Galati

Exploring duality symmetries, multicriticality and RG flows at c = 2
Online series of seminars “GCS Postdoc and Student Colloquium”,
March 17, 2024

On the SymTFT of Yang-Mills-Chern-Simons theory
ULB, Brussles, Belgium
April 4, 2024

Symmetries, Universes & Phases of QCD2 with an Adjoint Dirac Fermion
IHES, Bures-sur-Yvette, France
October 16, 2024

Marius Gerbershagen

Emergent spacetime from entanglement in three dimensional examples
Theory@Sea, Oostende, Belgium
May 23, 2024

Building spacetime from entanglement
KU Leuven, Leuven, Belgium
June 21, 2024

Bulk quantum corrections for non-spatial holographic entanglement
University of Southampton, Southampton, United Kingdom
September 4, 2024

Gravitation, string theory and cosmology Group

Talks at conferences, seminars and schools

Marc Henneaux

Le défi de la gravité quantique et quelques pistes actuelles pour le relever
Talk given at the Université Paris-Saclay, France
January 31, 2024

Asymptotic structure of gravity and BMS group at Spatial infinity (Balzan lecture 1)
IHES, Bures-sur-Yvette, France
February 7, 2024

Strominger's matching conditions (Balzan lecture 2)
IHES, Bures-sur-Yvette, France
February 7, 2024

BMS algebra and supertranslation-invariant Lorentz charges

Instituto de Física Teórica (IFT) UAM-CSIC, Madrid, Spain
February 20, 2024

Institut Denis Poisson, University of Tours, France
May 16, 2024

Carroll Swiftons
Workshop "Carrollian Physics and Holography", Erwin Schrödinger International Institute for Mathematics and Physics (ESI), Vienna, Austria
April 8, 2024

Asymptotic Structure of Gravity - Series of 6 lectures
14th Joburg School on String Theory, University of Pretoria, South Africa
April 29 – May 3, 2024

Asymptotic symmetries in the BRST formalism
Workshop “Gauge invariance: quantization and geometry” in memory of Igor Batalin, University of Mons (Belgium)
September 9, 2024

Asymptotic Symmetries and Algebras: a review
Online meeting “IRCHEP 1403 Iranian Conference on High Energy Physics : Deciphering the Universe Ciphers”, Institute for Research in Fundamental Sciences, Tehran; Iran
September 30, 2024

Asymptotic Symmetries in Gauge Theories with Emphasis on Gravity
Online lecture, Asia Pacific Center for Theoretical Physics, Korea
November 15, 2024

Juan Hernandez

Semiclassical black hole microstates

Southampton University, Southampton, England
May 23, 2024

Utrecht Univeristy, Utrecht, Netherlands
September 5, 2024

Gravitation, string theory and cosmology Group

Talks at conferences, seminars and schools

Xavier Nagels

Populating secluded dark sector with ultra-relativistic bubbles

King's college London, London, UK
June 19, 2024

University of Electronic Science and Technology of China, Chengdu, China (online)
July 5, 2024

Criterion for ultra-fast bubble walls: the impact of hydrodynamic obstruction

Dublin institute for advanced studies, Dublin, Ireland
May 2, 2024

VUB (BPS meeting), Brussels, Belgium
May 29, 2024

Kevin Nguyen

Holographic perspectives on gravitational scattering
Vietnam Institute for Advanced Study in Mathematics (Online), Ha Noi, Vietnam
March 26, 2024

Carrollian holography and scattering amplitudes
Ecole Polytechnique Fédérale de Lausanne, Lausanne, Suisse
May 8, 2024

Operator product expansion in carrollian CFT
Eurostrings conference, Southampton, Royaume-Uni
September 3, 2024

Maxim Pavlov

Extreme phase space localization at the lowest Landau level (gong show)
Theory@Sea, Oostende, Belgium
May 24, 2024

Andrew Rolph

Page curves and replica wormholes from random Hamiltonians

Wurzburg University, Wurzburg, Germany
April 1, 2024

Oxford University, Oxford, UK
May 1, 2024

Perimeter Institute, Waterloo, Canada
December 1, 2024

Jakob Salzer

Carrollian fields at timelike infinity
Erwin Schrödinger Institute Vienna, Vienna, Austria
April 2, 2024

Luigi Tizzano

Exploring non-invertible symmetries along the RG flow
University of Swansea, Swansea, Wales
April 17, 2024

Gravitation, string theory and cosmology Group

Talks at conferences, seminars and schools

Christoph Uhlemann

Binary AdS black holes coupled to a bath
Kavli Institute, UCAS Beijing, Beijing, China
March 7, 2024

Black hole evaporation: Beyond 1+1 dimensions
Entanglement, Thermalization and Holography, Simons Center workshop, Stony Brook, NY, USA
April 10, 2024

Exploring N=4 SYM with boundaries and defects
LMU Munich, Munich, Germany
April 25, 2024

Black holes in leaky vessels at sea
Theory at sea workshop, Ostende, Belgium
May 7, 2024

From geometric entanglement to internal space minimal surfaces
Entanglement, large N and black holes, APCTP workshop, Pohang, South Korea
May 29, 2024

Double holography as a precision tool
Aspen Center for Physics, Aspen, CO, USA
June 6, 2024

Alejandro Vilar López

Universal construction of black hole microstate
Porto University, Porto, Portugal
January 19, 2024

Shell states, Euclidean wormholes and black hole entropy
CERN, Geneva, Switzerland
April 24, 2024

Stathis Vitouladitis

A state-operator correspondence for nonlocal operators

University of Swansea, Swansea, UK
March 2024

DAMTP, University of Cambridge, Cambridge, UK
March 2024

Université Libre de Bruxelles, Brussels, Belgium
April 2024

CERN, Geneva, Switzerland
April 2024

Gifts from current algebras (in higher dimensions)

SISSA, Trieste, Italy
November 2024

Université Libre de Bruxelles, Brussels, Belgium
December 2024

Gifts from infinite-dimensional current algebras
National and Kapodistrian University of Athens, Athens, Greece
December 2024

Gravitation, string theory and cosmology Group

Publications

[1] R. Abbott et al. [LIGO Scientific, KAGRA and VIRGO], "Search for Gravitational-lensing Signatures in the Full Third Observing Run of the LIGO–Virgo Network," Astrophys. J. 970 (2024) no.2, 191 doi:10.3847/1538-4357/ad3e83 [arXiv:2304.08393 [gr-qc]].

[2] R. Abbott, ..., K. Turbang, et al. [LIGO Scientific, Virgo, KAGRA and VIRGO], "Search for Gravitational-wave Transients Associated with Magnetar Bursts in Advanced LIGO and Advanced Virgo Data from the Third Observing Run," Astrophys. J. 966 (2024) no.1, 137 doi:10.3847/1538-4357/ad27d3 [arXiv:2210.10931 [astro-ph.HE]].

[3] A. Aggarwal and G. Barnich, "Modular properties of massive scalar partition functions," JHEP 09 (2024), 127 doi:10.1007/JHEP09(2024)127 [arXiv:2407.02707 [hep-th]].

[4] A. Aggarwal and N. Gaddam, "All near-horizon symmetries of the Schwarzschild black hole in linearised gravity," JHEP 01 (2025), 031 doi:10.1007/JHEP01(2025)031 [arXiv:2309.05775 [hep-th]].

[5] J. Aguilera-Damia, R. Argurio and S. Chaudhuri, "When the moduli space is an orbifold: spontaneous breaking of continuous non-invertible symmetries,"JHEP 03 (2024), 042 doi:10.1007/JHEP03(2024)042 [arXiv:2309.06491 [hep-th]].

[6] J. Aguilera-Damia, R. Argurio, F. Benini, S. Benvenuti, C. Copetti and L. Tizzano, "Non-invertible symmetries along 4d RG flows," JHEP 02 (2024), 084 doi:10.1007/JHEP02(2024)084 [arXiv:2305.17084 [hep-th]].

[7] J. Aguilera-Damia, G. Galati and L. Tizzano, "Symmetries, universes and phases of QCD2 with an adjoint Dirac fermion," JHEP 12 (2025), 230 doi:10.1007/JHEP12(2024)230 [arXiv:2409.17989 [hep-th]].

[8] J. Aguilera-Damia, G. Galati, O. Hulik and S. Mancani, "Exploring duality symmetries, multicriticality and RG flows at c = 2," JHEP 04 (2024), 028 doi:10.1007/JHEP04(2024)028 [arXiv:2401.04166 [hep-th]].

[9] S. E. Aguilar-Gutierrez, B. Craps, J. Hernandez, M. Khramtsov, M. Knysh and A. Shukla, "Holographic complexity: braneworld gravity versus the Lloyd bound," JHEP 03 (2024), 173 doi:10.1007/JHEP03(2024)173 [arXiv:2312.12349 [hep-th]].

[10] S. E. Aguilar-Gutierrez and A. Rolph, “Krylov complexity is not a measure of distance between states or operators,” Phys. Rev. D 109 (2024) no.8, L081701 doi:10.1103/PhysRevD.109.L081701 [arXiv:2311.04093 [hep-th]].

[11] W. Y. Ai, X. Nagels and M. Vanvlasselaer, “Criterion for ultra-fast bubble walls: the impact of hydrodynamic obstruction,” JCAP 03 (2024), 037 doi:10.1088/1475-7516/2024/03/037 [arXiv:2401.05911 [hep-ph]].

[12] A. Amariti, S. Mancani, D. Morgante, N. Petri and A. Segati, “BBBW on the spindle,” SciPost Phys. 17 (2024) no.6, 154 doi:10.21468/SciPostPhys.17.6.154 [arXiv:2309.11362 [hep-th]].

[13] A. Arbalestrier, R. Argurio and L. Tizzano, “Noninvertible axial symmetry in QED comes full circle,” Phys. Rev. D 110 (2024) no.10, 105012 doi:10.1103/PhysRevD.110.105012 [arXiv:2405.06596 [hep-th]].

[14] P. Agrawal, S. Blasi, A. Mariotti and M. Nee, “Electroweak phase transition with a double well done doubly well,” JHEP 06 (2024), 089 doi:10.1007/JHEP06(2024)089 [arXiv:2312.06749 [hep-ph]].

[15] R. Argurio, F. Benini, M. Bertolini, G. Galati and P. Niro, “On the symmetry TFT of Yang-Mills-Chern-Simons theory,” JHEP 07 (2024), 130 doi:10.1007/JHEP07(2024)130 [arXiv:2404.06601 [hep-th]].

[16] A. S. Arvanitakis and D. Kanakaris, “Localisation without supersymmetry: towards exact results from Dirac structures in 3D N = 0 gauge theory,” JHEP 11 (2024), 001 doi:10.1007/JHEP11(2024)001 [arXiv:2404.14472 [hep-th]].

[17] A. Azatov, X. Nagels, M. Vanvlasselaer and W. Yin, “Populating secluded dark sector with ultra-relativistic bubbles,” JHEP 11 (2024), 129 doi:10.1007/JHEP11(2024)129 [arXiv:2406.12554 [hep-ph]].

[18] A. Azatov, G. Barni, R. Petrossian-Byrne and M. Vanvlasselaer, “Quantisation across bubble walls and friction,” JHEP 05 (2024), 294 doi:10.1007/JHEP05(2024)294 [arXiv:2310.06972 [hep-ph]].

Gravitation, string theory and cosmology Group

Publications

[19] C. Badger, H. Duval, T. Fujita, S. Kuroyanagi, A. Romero-Rodríguez and M. Sakellariadou, "Detection prospects of gravitational waves from SU(2) axion inflation," Phys. Rev. D 110 (2024) no.8, 084063 doi:10.1103/PhysRevD.110.084063 [arXiv:2406.11742 [astro-ph.CO]].

[20] V. Balasubramanian, Y. Nomura and T. Ugajin, "De Sitter space is sometimes not empty," JHEP 02 (2024), 135 doi:10.1007/JHEP02(2024)135 [arXiv:2308.09748 [hep-th]].

[21] V. Balasubramanian, A. Lawrence, J. M. Magan and M. Sasieta, "Microscopic Origin of the Entropy of Astrophysical Black Holes," Phys. Rev. Lett. 132 (2024) no.14, 141501 doi:10.1103/PhysRevLett.132.141501 [arXiv:2212.08623 [hep-th]].

[22] V. Balasubramanian, A. Lawrence, J. M. Magan and M. Sasieta, "Microscopic Origin of the Entropy of Black Holes in General Relativity," Phys. Rev. X 14 (2024) no.1, 011024 doi:10.1103/PhysRevX.14.011024 [arXiv:2212.02447 [hep-th]].

[23] G. Barni, S. Blasi and M. Vanvlasselaer, "The hydrodynamics of inverse phase transitions," JCAP 10 (2024), 042 doi:10.1088/1475-7516/2024/10/042 [arXiv:2406.01596 [hep-ph]].

[24] G. Barnich, L. Ciambelli and H. A. González, "Chiral shift symmetries as an infinite tower of subleading super-shift symmetries," JHEP 08 (2024), 029 doi:10.1007/JHEP08(2024)029 [arXiv:2405.17722 [hep-th]].

[25] G. Barnich, S. Majumdar, S. Speziale and W. D. Tan, "Lessons from discrete light-cone quantization for physics at null infinity: bosons in two dimensions," JHEP 05 (2024), 326 doi:10.1007/JHEP05(2024)326 [arXiv:2401.14873 [hep-th]].

[26] S. Blasi, F. Maltoni, A. Mariotti, K. Mimasu, D. Pagani and S. Tentori, "Top-philic ALP phenomenology at the LHC: the elusive mass-window," JHEP 06 (2024), 077 doi:10.1007/JHEP06(2024)077 [arXiv:2311.16048 [hep-ph]].

[27] S. Blasi, "Cosmological defects," PoS COSMICWISPers (2024), 018 doi:10.22323/1.454.0018

[28] G. Bossard, F. Ciceri, G. Inverso and A. Kleinschmidt, "Maximal D = 2 supergravities from higher dimensions," JHEP 01 (2024), 046 doi:10.1007/JHEP01(2024)046 [arXiv:2309.07232 [hep-th]].

[29] G. Bossard, F. Ciceri, G. Inverso and A. Kleinschmidt, “Consistent truncation of eleven-dimensional supergravity on S8×S1,” JHEP 01 (2024), 045 doi:10.1007/JHEP01(2024)045 [arXiv:2309.07233 [hep-th]].

[30] P. A. Cano, L. Machet and C. Myin, “Boson stars with non-linear sigma models,” Phys. Rev. D 109 (2024) no.4, 044043 doi:10.1103/PhysRevD.109.044043 [arXiv:2311.03433 [gr-qc]]

[31] F. Capozzi, R. Z. Ferreira, L. Lopez-Honorez and O. Mena, “CMB and Lyman-α constraints on dark matter decays to photons,” doi:10.31526/ACP.BSM-2023.2

[32] J. L. V. Cerdeira, J. Gomis and A. Kleinschmidt, “Non-Lorentzian expansions of the Lorentz force and kinematical algebras,” JHEP 01 (2024), 023 doi:10.1007/JHEP01(2024)023 [arXiv:2310.15245 [hep-th]].

[33] M. Cesàro, A. Kleinschmidt and D. Osten, “Integrable auxiliary field deformations of coset models,” JHEP 11 (2024), 028 doi:10.1007/JHEP11(2024)028 [arXiv:2409.04523 [hep-th]].

[34] S. Chakraborty, A. Gupta and M. Vanvlasselaer, “Photoproduction of heavy QCD axions in supernovae,” Phys. Rev. D 110 (2024) no.6, 063032 doi:10.1103/PhysRevD.110.063032 [arXiv:2403.12169 [hep-ph]].

[35] F. Ciceri, A. Kleinschmidt, S. Murugesan and B. Sahoo, “Torus reduction of maximal conformal supergravity,” JHEP 12 (2024), 151 doi:10.1007/JHEP12(2024)151 [arXiv:2408.06026 [hep-th]].

[36] A. Climent, R. Emparan, J. M. Magan, M. Sasieta and A. Vilar López, “Universal construction of black hole microstates,” Phys. Rev. D 109 (2024) no.8, 086024 doi:10.1103/PhysRevD.109.086024 [arXiv:2401.08775 [hep-th]].

[37] L. T. Cole, R. A. Cullinan, B. Hoare, J. Liniado and D. C. Thompson, “Integrable deformations from twistor space,” SciPost Phys. 17 (2024) no.1, 008 doi:10.21468/SciPostPhys.17.1.008 [arXiv:2311.17551 [hep-th]].

Gravitation, string theory and cosmology Group

Publications

[38] G. Compère, S. J. Hoque and E. Ş Kutluk, "Quadrupolar radiation in de Sitter: displacement memory and Bondi metric," Class. Quant. Grav. 41 (2024) no.15, 155006 doi:10.1088/1361-6382/ad5826 [arXiv:2309.02081 [gr-qc]].

[39] J. Cotler, K. Jensen, S. Prohazka, A. Raz, M. Riegler and J. Salzer, "Quantizing Carrollian field theories," JHEP 10 (2024), 049 doi:10.1007/JHEP10(2024)049 [arXiv:2407.11971 [hep-th]].

[40] B. Craps, M. De Clerck, O. Evnin and M. Pavlov, "Phase-space localization at the lowest Landau level," Phys. Rev. A 110 (2024) no.6, 063325. doi:10.1103/PhysRevA.110.063325 [arXiv:2407.07675 [cond-mat.quant-gas]].

[41] B. Craps, O. Evnin and G. Pascuzzi, "A Relation between Krylov and Nielsen Complexity," Phys. Rev. Lett. 132 (2024) no.16, 160402 doi:10.1103/PhysRevLett.132.160402 [arXiv:2311.18401 [quant-ph]].

[42] B. Craps, M. De Clerck, O. Evnin and P. Hacker, "Integrability and complexity in quantum spin chains," SciPost Phys. 16 (2024) no.2, 041 doi:10.21468/SciPostPhys.16.2.041 [arXiv:2305.00037 [quant-ph]].

[43] J. A. Damia, G. Galati, O. Hulik and S. Mancani, "Exploring duality symmetries, multicriticality and RG flows at c = 2," JHEP 04 (2024), 028 doi:10.1007/JHEP04(2024)028 [arXiv:2401.04166 [hep-th]].

[44] J. de Boer, J. Hollander and A. Rolph, "Page curves and replica wormholes from random dynamics," JHEP 07 (2024), 023 doi:10.1007/JHEP07(2024)023 [arXiv:2311.07655 [hep-th]].

[45] E. Deddo, L. A. Pando Zayas and C. F. Uhlemann, "Binary AdS black holes coupled to a bath in Type IIB," JHEP 05 (2024), 120 doi:10.1007/JHEP05(2024)120 [arXiv:2401.00511 [hep-th]].

[46] S. Detournay and Q. Vandermiers, "Geometric actions for Lower Spin Gravity," JHEP 10 (2024), 024 doi:10.1007/JHEP10(2024)024 [arXiv:2408.13198[hep-th]].

[47] S. Detournay, T. Smoes and R. Wutte, "Boundary conditions for extremal black holes from 2d gravity," SciPost Phys. 16 (2024) no.5, 141 doi:10.21468/SciPostPhys.16.5.141 [arXiv:2312.08353 [hep-th]].

[48] D. Dorigoni, M. Doroudiani, J. Drewitt, M. Hidding, A. Kleinschmidt, O. Schlotterer, L. Schneps and B. Verbeek, "Non-holomorphic modular forms from zeta generators," JHEP 10 (2024), 053 doi:10.1007/JHEP10(2024)053 [arXiv:2403.14816 [hep-th]].

[49] H. Duval, S. Kuroyanagi, A. Mariotti, A. Romero-Rodríguez and M. Sakellariadou, "Investigating cosmic histories with a stiff era through gravitational waves," Phys. Rev. D 110 (2024) no.10, 103503 doi:10.1103/PhysRevD.110.103503 [arXiv:2405.10201 [gr-qc]].

[50] F. Ecker, D. Grumiller, M. Henneaux and P. Salgado-Rebolledo, "Carroll swiftons," Phys. Rev. D 110 (2024) no.4, L041901 doi:10.1103/PhysRevD.110.L041901 [arXiv:2403.00544 [hep-th]].

[51] C. Eloy and G. Larios, "Charting the conformal manifold of holographic CFT2's," SciPost Phys. 17 (2024) no.4, 123 doi:10.21468/SciPostPhys.17.4.123 [arXiv:2405.17542 [hep-th]].

[52] O. Evnin and W. Horinouchi, "A Gaussian integral that counts regular graphs," J. Math. Phys. 65 (2024) no.9, 093301 doi:10.1063/5.0208715 [arXiv:2403.04242 [cond-mat.stat-mech]].

[53] O. Evnin, E. Joung and K. Mkrtchyan, "Democratic Lagrangians from topological bulk," Phys. Rev. D 109 (2024) no.6, 066003 doi:10.1103/PhysRevD.109.066003 [arXiv:2309.04625 [hep-th]].

[54] G. Facchinetti, L. Lopez-Honorez, Y. Qin and A. Mesinger, "21cm signal sensitivity to dark matter decay," JCAP 01 (2024), 005 doi:10.1088/1475-7516/2024/01/005 [arXiv:2308.16656 [astro-ph.CO]].

[55] K. Farnsworth, K. Hinterbichler and O. Hulik, Phys. Rev. D 110 (2024) no.4, 045011 doi:10.1103/PhysRevD.110.045011 [arXiv:2402.12430 [hep-th]].

[56] J. Figueroa, G. Giribet, A. Neira-Gallegos, J. Oliva and M. Oyarzo, "Overflying nilpotent horizons," Eur. Phys. J. C 84 (2024) no.11, 1215 doi:10.1140/epjc/s10052-024-13578-9 [arXiv:2404.18378 [hep-th]].

Gravitation, string theory and cosmology Group

Publications

[57] C. Fletcher et al. [Fermi Gamma-Ray Burst Monitor Team, LIGO Scientific, Virgo and KAGRA], "A Joint Fermi-GBM and Swift-BAT Analysis of Gravitational-wave Candidates from the Third Gravitational-wave Observing Run," Astrophys. J. 964 (2024) no.2, 149 doi:10.3847/1538-4357/ad1eed [arXiv:2308.13666 [astro-ph.HE]].

[58] O. Fuentealba and M. Henneaux, "The BMS group in D = 6 space-time dimensions," J. Phys. A 57 (2024) no.13, 135402 doi:10.1088/1751- 8121/ad30ce [arXiv:2312.12627 [hep-th]].

[59] O. Fuentealba, M. Henneaux and J. Mas, "Non-minimal couplings to U(1)-gauge fields and asymptotic symmetries," JHEP 09 (2024), 180 doi:10.1007/JHEP09(2024)180 [arXiv:2407.06376 [hep-th]].

[60] P. B. Genolini and L. Tizzano, "Comments on Global Symmetries and Anomalies of 5d SCFTs," Commun. Math. Phys. 405 (2024) no.11, 255 doi:10.1007/s00220-024-05139-8 [arXiv:2201.02190 [hep-th]].

[61] S. Geukens and J. Hong, "Subleading analysis for S3 partition functions of N = 2 holographic SCFTs," JHEP 06 (2024), 190 doi:10.1007/JHEP06(2024)190 [arXiv:2405.00845 [hep-th]].

[62] Y. Gouttenoire, S. Trifinopoulos, G. Valogiannis and M. Vanvlasselaer, "Scrutinizing the primordial black hole interpretation of PTA gravitational waves and JWST early galaxies," Phys. Rev. D 109 (2024) no.12, 123002 doi:10.1103/PhysRevD.109.123002 [arXiv:2307.01457 [astro-ph.CO]].

[63] Harsh, S. J. Hoque, S. P. Kashyap and A. Virmani, "de Sitter Teukolsky waves," Class. Quant. Grav. 41 (2024) no.22, 225011 doi:10.1088/1361-6382/ad8437 [arXiv:2405.10777 [gr-qc]].

[64] F. Hassler, O. Hulik and D. Osten, Phys. Rev. D 110 (2024) no.12, 126022 doi:10.1103/PhysRevD.110.126022 [arXiv:2409.00176 [hep-th]].

[65] E. Have, K. Nguyen, S. Prohazka and J. Salzer, "Massive carrollian fields at timelike infinity," JHEP 07 (2024), 054 doi:10.1007/JHEP07(2024)054 [arXiv:2402.05190 [hep-th]].

[66] D. He and C. F. Uhlemann, "Solving N = 4 SYM BCFT matrix models at large N ," JHEP 12 (2024), 164 doi:10.1007/JHEP12(2024)164 [arXiv:2409.13016 [hep-th]].

[67] M. Henneaux, "Corvino-Schoen theorem and supertranslations at spatial infinity," IJMPA 39 (2024) no.36, 2447007 doi:10.1142/S0217751X24470079 [arXiv:2306.12505 [gr-qc]].

[68] O. Hulik, E. Malek, F. Valach and D. Waldram, "Y-algebroids and E7(7)× R+-generalised geometry," JHEP 03 (2024), 034 doi:10.1007/JHEP03(2024)034 [arXiv:2308.01130 [hep-th]].

[69] G. N. Koutsokostas, S. Sypsas, O. Evnin, T. P. Horikis and D. J. Frantzeskakis, "Nonlinear instability and solitons in a self- gravitating fluid," Math. Methods Appl. Sci. 47 (2024) no.16, 12388-12404 doi:10.1002/mma.9912 [arXiv:2312.16577 [nlin.PS]].

[70] M. Knysh, H. Liu and N. Pinzani-Fokeeva, "New horizon symmetries, hydrodynamics, and quantum chaos," JHEP 09 (2024), 162 doi:10.1007/JHEP09(2024)162 [arXiv:2405.17559 [hep-th]].

[71] L. Küchler, G. Compère, L. Durkan and A. Pound, "Self-force framework for transition-to-plunge waveforms," SciPost Phys. 17 (2024) no.2, 056 doi:10.21468/SciPostPhys.17.2.056 [arXiv:2405.00170 [gr-qc]].

[72] M. Lalleman, K. Turbang, T. A. Callister and N. Van Remortel, "Estimating the redshift dependence of the BBH population using joint CBC and GWB analysis," PoS TAUP2023 (2024), 114 doi:10.22323/1.441.0114

[73] M. Lalleman, K. Turbang, T. A. Callister and N. Van Remortel, "Estimating the redshift dependence of the binary black hole population: combining gravitational-wave detections with limits on the stochastic background," PoS EPS-HEP2023 (2024), 088 doi:10.22323/1.449.0088

[74] L. Lopez-Honorez, "Future 21cm constraints on dark matter energy injection: Application to ALPs," PoS CORFU2023 (2024), 111 doi:10.22323/1.463.0111 [arXiv:2406.15378 [astro-ph.CO]].

[75] K. Nguyen, "Carrollian conformal correlators and massless scattering amplitudes," JHEP 01 (2024), 076 doi:10.1007/JHEP01(2024)076 [arXiv:2311.09869 [hep-th]].

Gravitation, string theory and cosmology Group

Publications

[76] A. I. Renzini, A. Romero-Rodriguez, C. Talbot, M. Lalleman, S. Kandhasamy, K. Turbang, S. Biscoveanu, K. Martinovic, P. Meyers and L. Tsukada, et al. “pygwb: a Python-based library for gravitational-wave background searches,” J. Open Source Softw. 9 (2024) no.94, 5454 doi:10.21105/joss.05454

[77] K. Turbang, M. Lalleman, T. A. Callister and N. van Remortel, “The Metallicity Dependence and Evolutionary Times of Merging Binary Black Holes: Combined Constraints from Individual Gravitational-wave Detections and the Stochastic Background,” Astrophys. J. 967 (2024) no.2, 142 doi:10.3847/1538-4357/ad3d5c [arXiv:2310.17625 [astro-ph.HE]].

[78] M. Vanvlasselaer, “Baryogenesis with relativistic bubble walls,” PoS CORFU2023 (2024), 049 doi:10.22323/1.463.0049 [arXiv:2402.14468 [hep-ph]].

[79] D. Wolpert, J. Korbel, C. Lynn, F. Tasnim, J. Grochow, G. Kardeş, J. Aimone, V. Balasubramanian, E. de Giuli and D. Doty, et al. “Is stochastic thermodynamics the key to understanding the energy costs of computation?,” Proc. Nat. Acad. Sci. 121 (2024), e2321112121 doi:10.1073/pnas.2321112121 [arXiv:2311.17166 [cond-mat.stat-mech]].

[80] A. G. Abac et al. [LIGO Scientific, Virgo,, KAGRA and VIRGO], “Observation of Gravitational Waves from the Coalescence of a 2.5−4.5 M⊙ Compact Object and a Neutron Star,” Astrophys. J. Lett. 970 (2024) no.2, L34 doi:10.3847/2041-8213/ad5beb [arXiv:2404.04248 [astro-ph.HE]].

[81] A. G. Abac et al. [LIGO Scientific, KAGRA and VIRGO], “A Search Using GEO600 for Gravitational Waves Coincident with Fast Radio Bursts from SGR 1935+2154,” Astrophys. J. 977 (2024) no.2, 255 doi:10.3847/1538-4357/ad8de0 [arXiv:2410.09151 [astro-ph.HE]].

[82] A. G. Abac ..., H. Duval, ..., A. Sevrin ..., K. Turbang et al. [LIGO Scientific, KAGRA and VIRGO], “A Search Using GEO600 for Gravitational Waves Coincident with Fast Radio Bursts from SGR 1935+2154,” Astrophys J. 977 (2024) no.2, 255 doi:10.3847/1538-4357/ad8de0 [arXiv:2410.09151 [astro-ph.HE]].

[83] A. G. Abac ..., H. Duval, ..., A. Sevrin, ..., K. Turbang et al. [LIGO Scientific, Virgo,, KAGRA and VIRGO], “Observation of Gravitational Waves from the Coalescence of a 2.5−4.5 M Compact Object and a Neutron Star,” Astrophys. J. Lett. 970 (2024) no.2, L34 doi:10.3847/2041-8213/ad5beb [arXiv:2404.04248 [astro-ph.HE]].

[84] A. G. Abac, ..., K. Turbang et al. [KAGRA, LIGO Scientific and VIRGO], "Ultralight vector dark matter search using data from the KAGRA O3GK run," Phys. Rev. D 110 (2024) no.4, 042001 doi:10.1103/PhysRevD.110.042001 [arXiv:2403.03004 [astro-ph.CO]].

[85] A. G. Abac et al. [LIGO Scientific, KAGRA and VIRGO], "Search for Eccentric Black Hole Coalescences during the Third Observing Run of LIGO and Virgo," Astrophys. J. 973 (2024) no.2, 132 doi:10.3847/1538-4357/ad65ce [arXiv:2308.03822 [astro-ph.HE]].

Preprints

[86] P. Akara-pipattana and O. Evnin, "Statistical field theory of random graphs with prescribed degrees," [arXiv:2410.11191 [cond-mat.stat-mech]].

[87] P. Akara-pipattana and O. Evnin, "Hammerstein equations for sparse random matrices," [arXiv:2410.00355 [cond-mat.dis-nn]].

[88] G. Anastasiou, I. J. Araya, P. Bueno, J. Moreno, R. Olea and A. Vilar López, "Higher-dimensional Willmore energy as holographic entanglement entropy," [arXiv:2409.19485 [hep-th]].

[89] A. Antinucci, C. Copetti, G. Galati and G. Rizi, "Topological Constraints on Defect Dynamics," [arXiv:2412.18652 [hep-th]].

[90] S. Antonini, V. Balasubramanian, N. Bao, C. Cao and W. Chemissany, "Non-isometry, State-Dependence and Holography," [arXiv:2411.07296 [hep-th]].

[91] R. Argurio, A. Collinucci, G. Galati, O. Hulik and E. Paznokas,"Non-Invertible T-duality at Any Radius via Non-Compact SymTFT," [arXiv:2409.11822 [hep-th]].

[92] R. Argurio, A. Collinucci, S. Mancani, S. Meynet, L. Mol and V. Tatitscheff, "Inherited non-invertible duality symmetries in quiver SCFTs," [arXiv:2409.03694 [hep-th]].

Gravitation, string theory and cosmology Group

Preprints

[93] R. Argurio, A. Collinucci, G. Galati, O. Hulik and E. Paznokas, "Non-Invertible T-duality at Any Radius via Non-Compact SymTFT," [arXiv:2409.11822 [hep-th]].

[94] A. Bagchi, P. Dhivakar and S. Dutta, "3D Stress Tensor for Gravity in 4D Flat Spacetime," [arXiv:2408.05494 [hep-th]].

[95] V. Balasubramanian, B. Craps, J. Hernandez, M. Khramtsov and M. Knysh, "Counting microstates of out-of-equilibrium black hole fluctuations,"[arXiv:2412.06884 [hep-th]].

[96] V. Balasubramanian, B. Craps, J. Hernandez, M. Khramtsov and M. Knysh, "Factorization of the Hilbert space of eternal black holes in general relativity," [arXiv:2410.00091 [hep-th]].

[97] V. Balasubramanian, J. M. Magan, P. Nandi and Q. Wu, "Spread complexity and the saturation of wormhole size," [arXiv:2412.02038 [hep-th]].

[98] V. Balasubramanian, M. J. Kang, C. Murdia and S. F. Ross, "Signals of multiparty entanglement and holography," [arXiv:2411.03422 [hep-th]].

[99] V. Balasubramanian, R. N. Das, J. Erdmenger and Z. Y. Xian, "Chaos and integrability in triangular billiards," [arXiv:2407.11114 [hep-th]].

[100] S. Blasi, L. Calibbi, A. Mariotti and K. Turbang, "Gravitational waves from cosmic strings in Froggatt-Nielsen flavour models," [arXiv:2410.08668 [hep-ph]].

[101] S. Blasi and A. Mariotti, "QCD Axion Strings or Seeds?," [arXiv:2405.08060 [hep-ph]].

[102] E. Boffo, P. A. Grassi, O. Hulik and I. Sachs, "On Superparticles and their Partition Functions," [arXiv:2402.09868 [hep-th]].

[103] M. Cataldi, A. Mariotti, F. Sala and M. Vanvlasselaer, "ALP leptogenesis," [arXiv:2407.01667 [hep-ph]].

[104] S. Chakraborty, G. Compère and L. Machet, "Tidal Love numbers and quasi-normal modes of the Schwarzschild-Hernquist black hole," [arXiv:2412.14831 [gr-qc]].

[105] S. Chakraborty, S. J. Hoque and A. Virmani, "On supertranslation invariant Lorentz charges," [arXiv:2407.18536 [gr-qc]].

[106] A. Chaney and C. F. Uhlemann, "BMN-like sectors in 4d N = 4 SYM with boundaries and interfaces," [arXiv:2408.12651 [hep-th]].

[107] S. Chaudhuri and F. Ferrari, "Dirichlet Scalar Determinants On Two-Dimensional Constant Curvature Disks," [arXiv:2405.14958 [hep-th]].

[108] S. Chaudhuri and F. Ferrari, "Finite cut-off JT and Liouville quantum gravities on the disk at one loop," [arXiv:2404.03748 [hep-th]].

[109] L. T. Cole, R. A. Cullinan, B. Hoare, J. Liniado and D. C. Thompson, "Gauging The Diamond: Integrable Coset Models from Twistor Space," [arXiv:2407.09479 [hep-th]].

[110] G. Compère, S. J. Hoque and E. Ş Kutluk, "The SO(1, 4) flux-balance laws of de Sitter at quadrupolar order," [arXiv:2411.16215 [gr-qc]].

[111] J. Cotler, K. Jensen, S. Prohazka, M. Riegler and J. Salzer, "Soft gravitons in three dimensions," [arXiv:2411.13633 [hep-th]].

[112] B. Craps, O. Evnin and G. Pascuzzi, "Multiseed Krylov complexity," [arXiv:2409.15666 [quant-ph]].

[113] Q. Decant, A. Dimitriou, L. L. Honorez and B. Zaldivar, "Simulation-based inference on warm dark matter from HERA forecasts," [arXiv:2412.10310 [astro-ph.CO]].

[114] E. Despontin, S. Clesse, A. Escrivà and C. Joana, "Were you born in an aborted primordial black hole?," [arXiv:2401.09408 [astro-ph.CO]].

[115] S. Detournay, J. Figueroa and A. Vilar López, "Asymptotic T-duality in three dimensions," [arXiv:2412.16136 [hep-th]].

[116] D. Dorigoni, M. Doroudiani, J. Drewitt, M. Hidding, A. Kleinschmidt, O. Schlotterer, L. Schneps and B. Verbeek, "Canonicalizing zeta generators: genus zero and genus one," [arXiv:2406.05099 [math.QA]].

[117] S. Dutta, I. M. Rasulian, M. M. Sheikh-Jabbari and H. Yavartanoo, "Towards Quantizing Null p-branes: Light-Cone Gauge Analysis and Physical Hilbert Space" [arXiv:2412.12436 [hep-th]].

Gravitation, string theory and cosmology Group

Preprints

[118] O. Evnin and D. Krioukov, “Ensemble inequivalence and phase transitions in unlabeled networks,” [arXiv:2411.02739 [cond-mat.stat-mech]].

[119] O. Evnin and W. Horinouchi, “First return times on sparse random graphs,” [arXiv:2408.10530 [cond-mat.dis-nn]].

[120] F. Ferrari, “Random Disks of Constant Curvature: the Lattice Story,” [arXiv:2406.06875 [hep-th]].

[121] F. Ferrari, “Jackiw-Teitelboim Gravity, Random Disks of Constant Curvature, Self-Overlapping Curves and Liouville CFT1,” [arXiv:2402.08052 [hepth]].

[122] O. Fuentealba and M. Henneaux, “Logarithmic matching between past infinity and future infinity: The massless scalar field,” [arXiv:2412.05088 [gr-qc]].

[123] M. Gerbershagen, J. Hernandez, M. Khramtsov and M. Knysh, “Holographic dual of Bures metric and subregion complexity,” [arXiv:2412.08707 [hep-th]].

[124] M. Gerbershagen and D. He, “Bulk quantum corrections to entwinement,” [arXiv:2410.21458 [hep-th]].

[125] P. A. Grassi and O. Hulik, “BV Formalism and Partition Functions,” [arXiv:2410.18285 [hep-th]].

[126] M. Hatsuda, O. Huĺık, W. D. Linch, W. D. Siegel, D. Wang and Y. P. Wang, “Strings and membranes from A-theory five brane,” [arXiv:2410.11197 [hep-th]].

[127] L. Iacobacci and K. Nguyen, “Celestial decomposition of Wigner’s particles,”[arXiv:2411.19219 [hep-th]].

[128] G. Lhost and G. Compère, “Approach to the separatrix with eccentric orbits,” [arXiv:2412.04249 [gr-qc]].

[129] A. Mariotti, X. Nagels, A. Rase and M. Vanvlasselaer, “DW-genesis: baryon number from domain wall network collapse,” [arXiv:2411.13494 [hep-ph]].

[130] G. Raman ..., H. Duval, ..., K. Turbang et al. [Swift-BAT/GUANO, Swift, LIGO Scientific, Virgo and KAGRA], “Swift-BAT GUANO follow-up of gravitational-wave triggers in the third LIGO-Virgo-KAGRA observing run,” [arXiv:2407.12867 [astro-ph.HE]].

[131] K. Turbang, “The stochastic gravitational wave background : from models to observation”

[132] M. Vanvlasselaer, “Populating dark sectors with relativistic bubble walls,” [arXiv:2412.05653 [hep-ph]].

[133] M. Vanvlasselaer, “Photo-production of axions and neutrinos in compact objects,” [arXiv:2409.13618 [hep-ph]].

[134] A. G. Abac et al. [LIGO Scientific, VIRGO and KAGRA], “Search for gravitational waves emitted from SN 2023ixf,” [arXiv:2410.16565 [astro-ph.HE]].

[135] A. G. Abac et al. [LIGO Scientific, VIRGO and KAGRA], “Search for continuous gravitational waves from known pulsars in the first part of the fourth LIGO-Virgo-KAGRA observing run,” [arXiv:2501.01495 [astro-ph.HE]].

[136] A. G. Abac, ..., H. Duval, ..., A. Sevrin, ..., K. Turbang et al. [LIGO Scientific, VIRGO and KAGRA], “Search for gravitational waves emitted from SN 2023ixf,” [arXiv:2410.16565 [astro-ph.HE]].

Books and collective works published in 2024

[137] A. Somerhausen, “Lower-dimensional models for quantum gravity and black holes: Aspects of holographic dualities in Topological Massive Gravity,” PhD Thesis

[138] Q. Vandermiers, “Field theoretic and gravitational aspects of Warped Conformal Field Theories,” PhD Thesis

Institute of astronomy and astrophysics

Group of Nicolas Chamel, Stéphane Goriely, Alain Jorissen, Thibault Merle, Wouter Ryssens, Lionel Siess, Sophie Van Eck

Discovery of a New Superfluid State of Matter in Dead Stars

Astrophysical observations of transiently accreting neutron stars in binary systems suggest the existence of a new superfluid state inside these stellar remnants. **Nicolas Chamel, FNRS Senior Research Associate at the Institute of Astronomy and Astrophysics – Faculty of Sciences** – and **Valentin Allard**, one of his PhD students, have published their research on the subject in *Physical Review Letters*.

Neutron stars continue to surprise astrophysicists. Recently, observations by Nicolas Chamel and Valentin Allard of these stars in transient accretion within binary systems have suggested the presence of a new superfluid state inside these dead stars. The researchers published their findings in *Physical Review Letters*.

Neutron stars are the compact remnants of supernova explosions marking the end of stellar evolution for stars much more massive than the Sun. Initially extremely hot, they cool rapidly, and after a few days, their densely packed neutrons may become superfluid.

Unlike ordinary fluids, superfluids can only rotate through the formation of quantum vortices. Neutron stars can be spun up to very high frequencies by accreting matter from a stellar companion.

Under such conditions, **Nicolas Chamel** and **Valentin Allard** have shown that neutron superfluidity can transition into a new state induced by the formation of quantum vortices, in which some neutrons remain in a normal (non-superfluid) state.

The researchers discovered that this peculiar state, never previously considered, can naturally explain the late-time cooling observations of neutron stars in low-mass X-ray binaries after an accretion episode ends. This finding suggests that the interpretation of other neutron star-related phenomena may need to be revised.

In summary, this breakthrough opens new avenues for the study of neutron stars and could transform our understanding of these fascinating celestial objects.

Gapless Neutron Superfluidity Can Explain the Late Time Cooling of Transiently Accreting Neutron Stars
V. Allard and N. Chamel, Phys. Rev. Lett. 132, 181001 – Published 29 April 2024

Institute of astronomy and astrophysics

Unlocking the Mystery of Heavy Elements in the Universe

The origin of elements heavier than iron is one of the great mysteries of astrophysics. About half of these elements are thought to be created through the rapid neutron-capture process (r-process), which occurs in extreme cosmic events. One of the most promising sites for this process is the collision of two neutron stars, known as a neutron star merger (NSM). In August 2017, a groundbreaking discovery provided a crucial piece of the puzzle. The LIGO detectors captured the first-ever gravitational waves from a neutron star merger (event GW170817). Soon after, telescopes around the world observed a bright explosion, called a kilonova (KN), designated as AT2017gfo. The light from this KN strongly suggested the presence of newly formed heavy elements. To fully understand these events, scientists must study how light interacts with the material ejected from NSMs. This depends on a property called opacity – how transparent or opaque the ejected material is to light, which in turn shapes the kilonova's appearance – its light curve (brightness as a function of time) and spectra. However, there is a major challenge – opacity calculations require detailed atomic data for heavy elements, much of which is still unknown. By improving these data, researchers can better interpret KN observations and reveal how the universe forges its heaviest elements.

What we study

The work conducted by **Gururaj Wagle** at Institut d'Astronomy et d'Astrophysique de l'ULB, in collaboration with **Stephane Goriely** and **Sophie Van Eck**, focuses on computing large-scale atomic data and opacity values for all heavy elements ranging from Calcium (atomic number, Z = 20) to Lawrenium (Z = 103), with special attention to lanthanides (Z = 57 - 71) and actinides (Z = 89 - 103) is recently accepted for publication (DePrince et al. 2025, A&A, accepted). These calculations cover typical conditions in kilonova ejecta, from one day to a week after a neutron star merger, when the ejected material is still bright and observable. To achieve this, we employed sophisticated computer models based on a well-established approach called the pseudo-relativistic Hartree-Fock (HFR) method. We find that lanthanide opacities are higher than previously estimated (see Fig. 1). However, one surprising outcome of our work is that contrary to past assumptions, lanthanides are not necessarily the dominant contributors to overall kilonova opacity. In our study, we compare the impact on KN light curves of considering such atomic- physics based opacity data instead of typical crude approximations in the literature (see Fig. 2). Additionally, our study highlights the importance of considering the full composition of the ejecta when determining its opacity, rather than treating elements in isolation.

Why this matters

Using detailed, physics-based opacity models instead of rough approximations allows for much more accurate predictions of kilonova light. This helps astronomers interpret real observations and refine our understanding of how neutron star mergers create the universe's heaviest elements. By improving these models, we take a step closer to solving the cosmic mystery of how the elements around us – from gold to uranium – were forged in the most extreme environments in the universe.

Sharing our findings

To support future research, we have compiled all our atomic data and opacity tables into a publicly available database, providing a valuable resource for the scientific community.

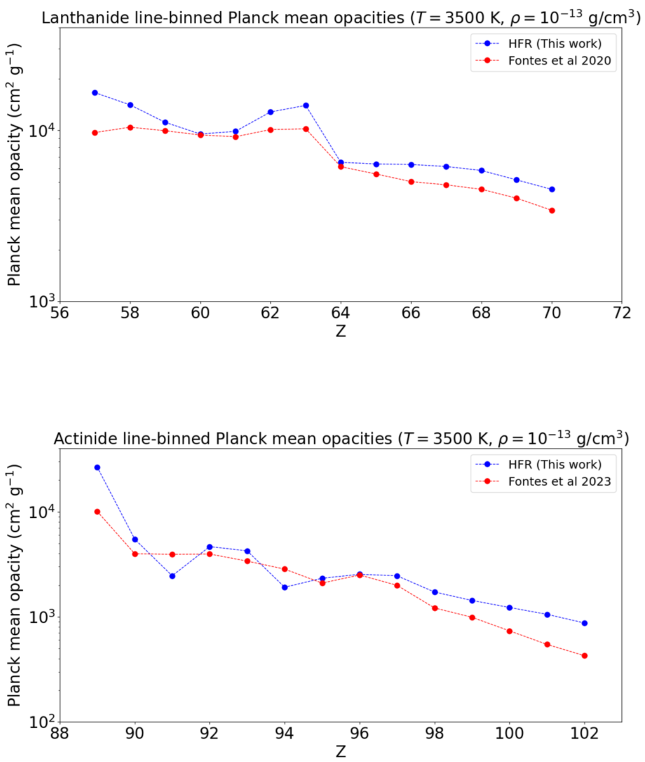

Figure 1: Planck line-binned opacities for Lanthanides and Actinides at temperature of T = 3500 K and density of ρ = 10-13 g cm-3 computed using HFR method in comparison with the one computed by Fontes et al.1.

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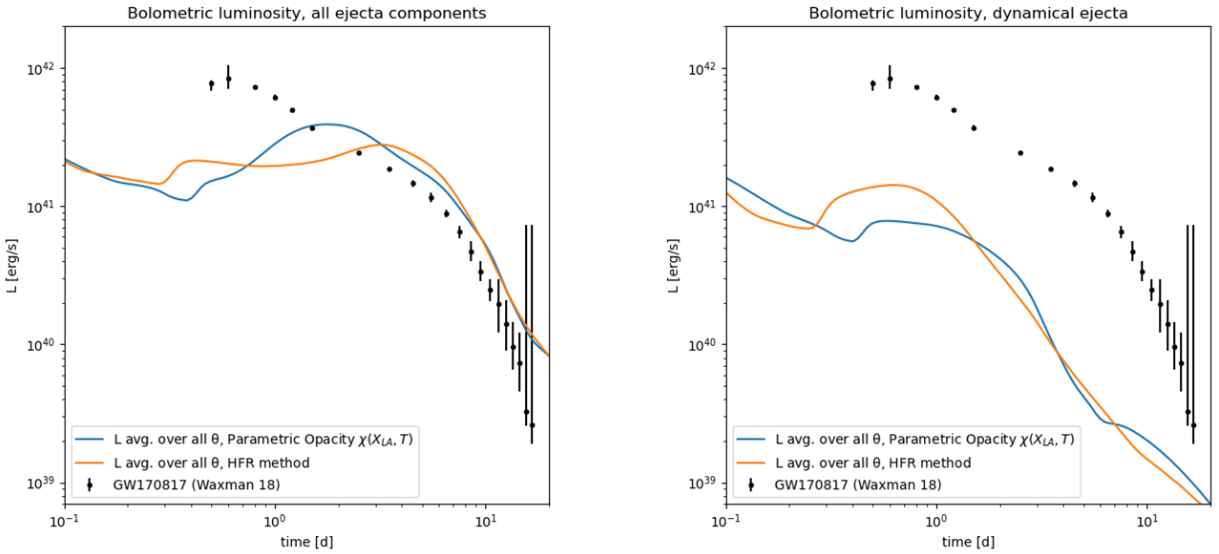


Figure 2: Comparison of light curves for a crude parametric opacity function defined by[3] to our opacity data, for a NS merger model obtained with the KN scheme developed in[2]. The left panel shows the comparison for all the ejecta components including the prompt dynamical component, the ejecta from the NS-torus system, and the disk wind stemming from the black-hole torus remnant; while the right panel shows the comparison for the dynamical ejecta component alone. The observed bolometric luminosity of AT2017gfo[4] is shown by solid circles for reference.

References

[1] Deprince, J., Wagle, G., Ben Nasr, S., et al. 2024, arXiv e-prints, arXiv:2412.16688

[2] Fontes, C. J., Fryer, C. L., Hungerford, A. L., Wollaeger, R. T., & Korobkin, O. 2020, MNRAS, 493, 4143

[3] Just, O., Goriely, S., Janka, H. T., Nagataki, S., & Bauswein, A. 2022, MNRAS, 509, 1377

[4] Just, O., Kullmann, I., Goriely, S., et al. 2022, MNRAS, 510, 2820

[5] Waxman, E., Ofek, E. O., Kushnir, D., & Gal-Yam, A. 2018, MNRAS, 481, 3423

General chemistry research group (ALGC)

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

ALGC´s research activities focus on fundamental and applied aspects of quantum chemistry. The group consists of two research subgroups performing complementary and synergistic research, i.e. the *Chemical Theory group* (F. De Proft, M. Alonso and F. De Vleeschouwer, P. Geerlings) and the *Materials Modeling group* (F. Tielens, I. Tranca). The *Chemical Theory Group* develops and implements chemical concepts and theories for challenging applications, involving the exploration of chemical reactivity in complex environments and molecular properties as well as the rational design of molecular compounds. The *Materials Modeling Group* investigates the physicochemical properties of solids and solid/liquid interfaces using state-of-the-art computational chemistry tools, including DFT and classical methods.

ALGC investigates both fundamental aspects as well as applications, the latter often in direct collaboration with experimental groups. A broad variety of substrates, ranging from atoms, small and medium-size molecules, polymers to solids and materials are thereby treated.

In this report, we highlight a few recent studies illustrating the broad and diverse research activities of ALGC in both fundamental and applied quantum chemistry.

Chemical reactivity: reaction coordinate partitioning and effect of external variables on chemical reactivity concepts

The theoretical scrutiny of chemical reactivity using concepts from density functional theory ("Conceptual DFT") remains one of the most important research lines of ALGC. In a recent study,[1] we have proposed a partitioning of the intrinsic coordinate of an elementary reaction step into three segments, the so-called Pre-Transition State, Transition State, and Post-Transition State regions and subsequently investigated the most important factors that dictated each segment. We found that in both Pre-TS and Post-TS regions, steric effects are the dominant factors, whereas in the TS region, it is the intrinsic electrophilic and nucleophilic propensity of the transition state structure that governs the reactivity. The wide applicability of this approach was shown by a validation for a total of 37 organic and inorganic reactions. In our view, this work provides an important effort to establish a general principle to appreciate different stages of reaction processes governed by different effects. This new insight should enhance conceptual understanding and thus the predictive power of theoretical applications, especially in the endeavor of discovering and designing better catalysts for future chemical processes.

General chemistry research group (ALGC)

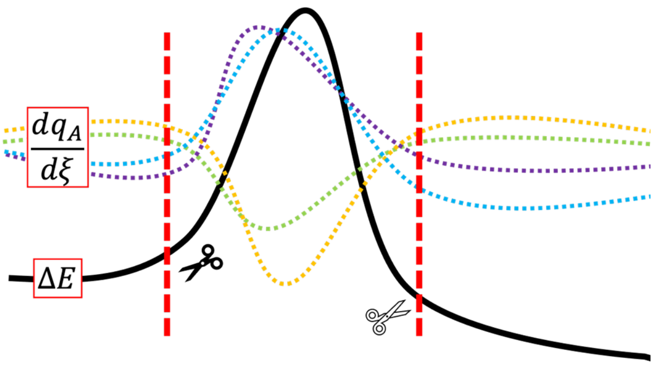


Figure 1: Graphical abstract, reproduced from [1], showing the Intrinsic Reaction Coordinate partitioning into 3 regions using charge fluctuation descriptors; important reactivity changes are observed within the TS region (area between the vertical long dotted red lines), whereas the outer regions do not show these fluctuations but are determined by steric factors.

In recent years, the ALGC has also been working on the extension of the reactivity indices from DFT to include the effect of external factors, such as e.g. electric and magnetic fields, mechanical forces and pressure. This research was recently reviewed in an invited perspective paper in Chemical Science;[2] also the inclusion of temperature in this reactivity framework was reviewed.[2]

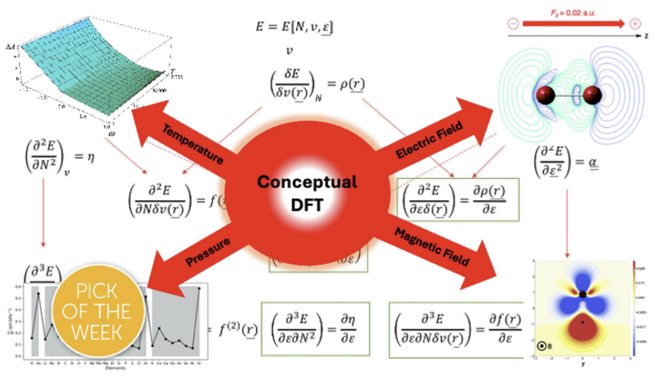


Figure 2: Graphical abstract highlighting the inclusion of different external factors in conceptual DFT, reproduced from the perspective paper in Chemical Science.[2] This perspective paper was chosen “Pick of the week” by the journal.

In our endeavor to simulate the effect of external pressure on chemical reactivity, we have recently compared two static models (XP-PCM and GHOSTSHYP) to apply isotropic pressure to single molecules, focusing on the equilibrium bond length and electric dipole moment of diatomic molecules. Equilibrium bond lengths under pressure were evaluated, showing that a reasonable agreement between GOSTSHYP and XP-PCM exists although some discrepancies persist. A Taylor series analysis introduced elsewhere was then applied to rationalize the observed trends in terms of the bond surface. Finally, the dipole moment was shown to be highly sensitive to the cavity definition and qualitative agreement necessitates the use of an adapted procedure that we have introduced in this study.[3]

Modelling self-healing polymer networks based on reversible covalent Diels-Alder bonds

We are currently studying covalent adaptable polymer networks having crosslinked, reversible Diels-Alder (DA) bonds with the aim to improve the self-healing or recyclability abilities of these materials, in collaboration with the Physical Chemistry and Polymer Science (FYSC) group of the VUB. By modifying the DA chemistry, the kinetics and reversibility of these crosslinks can be tuned. Our DFT modelling of 130 Diels-Alder reactions demonstrated that the reaction can be conditioned for a broad spectrum of applications, with bond formation and breaking at desired temperature ranges as shown by simulated conversion curves. This work serves as a guide for the smart selection of suitable DA chemistry for sustainable material applications.[4] The results of this work will be used as benchmark data for the development of a reactive force field used in molecular dynamics (MD) simulations that allows the modelling of the forward and retro Diels-Alder kinetics for both endo and exo stereochemistry. We already succeeded in parametrizing ReaxFF for the retro-DA reaction between furan and maleimide, including correct *endo:exo* ratio behavior, temperature and polymer backbone effects.[5] Currently, we are focusing on reparametrizing the force field for the forward and reverse kinetics of a small set of DA reactions. The eventual goal of the MD studies is to examine the resulting material behavior during the healing process and to predict macroscopic properties such as the glass transition temperature and yield strength of the polymer.

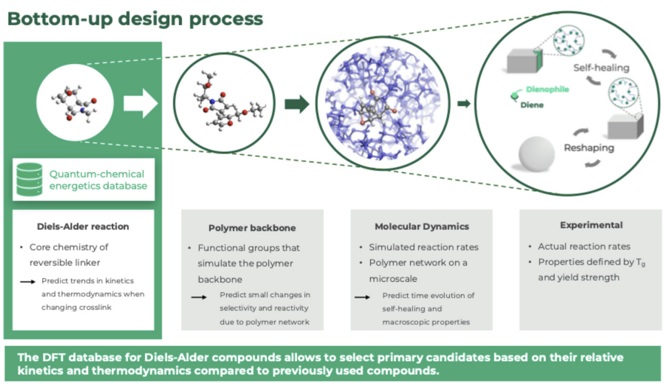


Figure 3: Schematic overview of the computational multiscale model that aids in the understanding and development of covalent adaptable networks based on the Diels-Alder reaction. Reproduced from [4].

General chemistry research group (ALGC)

Elucidating the driving forces of the NLO response of functionalized hexaphyrins

Hexaphyrin-based molecular switches can interconvert between two states having distinct nonlinear optical (NLO) properties, the ON and OFF states. We showed that the NLO contrast between those states can be highly tuned by introducing substituents and/or core-modifications.[6] The question arose as to why certain functionalized hexaphyrin-based switches yield more enhanced NLO responses for their ON states than others. Exploiting our extensive dataset of functionalized hexaphyrins collected over the years, we proposed a 6-fold cross-validated kernel-ridge-regression model with the aim to identify the driving forces of the first hyperpolarizability related to the hyper-Rayleigh scattering. Key input features were orbital based, electronic and charge-transfer based in nature, with the HOMO-LUMO energy gap being the most dominant. Through explainable machine-learning via the Shapley additive explanations (SHAP) analysis, we were able to elucidate the distinct NLO behavior of different redox states upon functionalization. This knowledge is particularly valuable in the design of new NLO switches.[7]

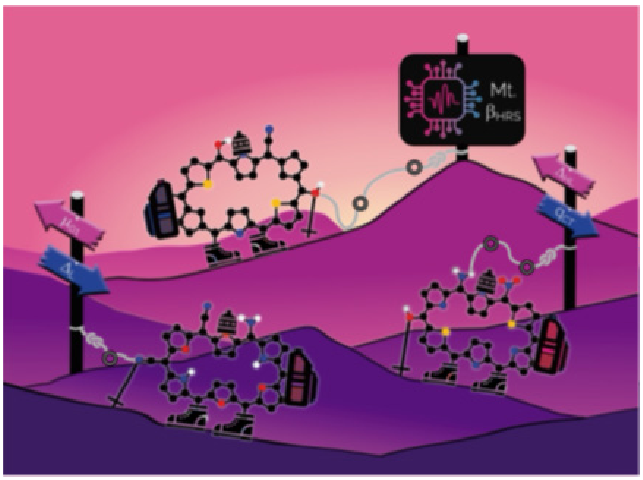


Figure 4: Front Cover image for the work “Deciphering Nonlinear Optical Properties in Functionalized Hexaphyrins via Explainable Machine Learning”. Reproduced from [7].

Effect of size and charge on Hückel and Baird aromaticity in [N] annulenes

In our long-standing interest on the description of various types of aromaticity, we recently examined the changes in Hückel and Baird aromaticity of [*N*]annulenes as the ring size increases from *N* = 12 to 66.[8] We propose a multidimensional approach integrating energetic, electronic, magnetic, structural and reactivity descriptors to analyze comprehensively the aromatic behavior of neutral and charged [*N*]annulenes in their singlet and triplet states. Our findings reveal that both neutral and charged [*N*]annulenes adhere to the Hückel and Baird rules. Nevertheless, for larger ring sizes, these rules diminish in significance, and the distinction between the aromaticity descriptors of [*N*]annulenes with 4*n* and 4*n*+2 π-electrons becomes less and less pronounced.

Figure 5: Graphical abstract depicting our approach to ascertain the effect of size and charge on Hückel and Baird aromaticity in [*N*]annulenes. Reproduced from [8].

General chemistry research group (ALGC)

Aromaticity in the spectroscopic spotlight of hexaphyrins

Spectroscopic properties are commonly used in the experimental evaluation of ground- and excited-state aromaticity in expanded porphyrins. In this paper, we have investigated if the defining photophysical properties still hold for a diverse set of hexaphyrins with varying redox states, topologies, peripheral substitutions, and core-modifications.[9] By combining TD-DFT calculations with several aromaticity descriptors and chemical compound space maps, the intricate interplay between structural planarity, aromaticity, and absorption spectra is elucidated. Our results emphasize that the general assumption that antiaromatic porphyrinoids exhibit significantly attenuated absorption bands as compared to aromatic counterparts does not hold even for the unsubstituted hexaphyrin macrocycles. To connect the spectroscopic properties to the hexaphyrins' aromaticity behavior, we analyzed chemical compound space maps defined by the various aromaticity indices. The intensity of the Q-band is not well described by the macrocyclic aromaticity. Instead, the degeneracy of the frontier molecular orbitals, the HOMO–LUMO gap, and the $|\Delta HOMO-\Delta LUMO|^2$ values appear to be better indicators to identify hexaphyrins with enhanced light-absorbing abilities in the near-infrared region. Regions with highly planar hexaphyrin structures, both aromatic and antiaromatic, are characterized by an intense B-band. Hence, we advise using a combination of global and local aromaticity descriptors rooted in different criteria to assess the aromaticity of expanded porphyrins instead of solely relying on the absorption spectra.

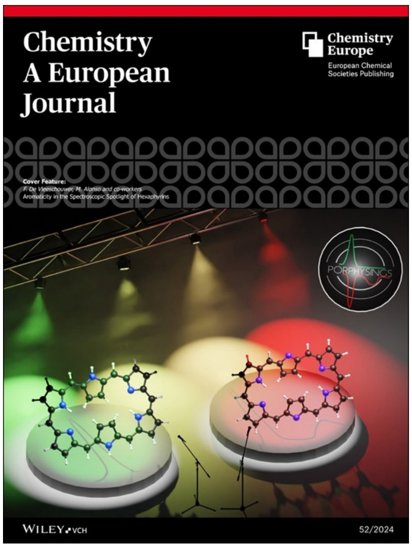


Figure 6: Cover image highlighting the work on the impact of aromaticity on the spectroscopic properties of hexaphyrin macrocycles. Reproduced from [9].

Similarities and differences in benzene reduction with Ca, Sr, Yb and Sm: Strong evidence for tetra-anionic benzene

Inverse sandwich benzene complexes are prone to metal oxidation state ambiguities. Coordinated benzene ligands can be neutral, di-anionic or, often controversially discussed, even tetra-anionic. The formal charge on benzene is correlated to assignment of the metal oxidation state which generally poses a problem. In this work,[10] we take advantage of the structural similarities found when comparing Ca^{II} with Yb^{II}, and Sr^{II} with Sm^{II} complexes. While an excellent overlap is found between the Ca/Yb inverse sandwich structures, striking differences emerge for the Sr/Sm pair. The much shorter Sm–N and Sm–C_6H_6 distances are strong evidence for a Sm^{III}–benzene^{-4}–Sm^{III} assignment. This was further supported by NMR spectroscopy, magnetic susceptibility, reactivity and comprehensive computational investigation. While the bonding in lanthanide complexes is typically considered predominantly ionic, our bonding analyses indicate that the π* energy levels of benzene are sufficiently high to interact with vacant lanthanide orbitals. This interaction introduces some covalent character, which plays an important role in stabilizing the highly charged benzene^{4-} ligands. The combination of lanthanide metals and bridging benzene in this unprecedented complex can function as a strongly reducing electron reservoir.

Based on comparisons between alkaline-earth and lanthanide metals, we provide strong evidence for the formal formation of a Sm^{III}–benzene^{4-}–Sm^{III} complex.

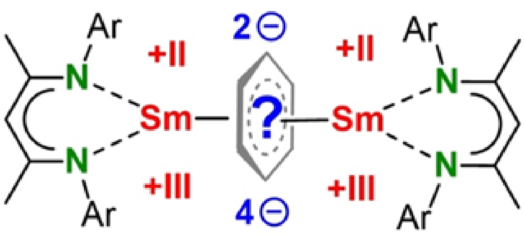


Figure 7: Graphical abstract depicting the complexity to assign oxidation states in lanthanide inverse sandwich complexes. Reproduced from [10].

General chemistry research group (ALGC)

Characterization of Plastics Using Raman Spectroscopy: A Theoretical Study on Polystyrene

Plastic materials are widely used in modern society, but their environmental and health impacts raise significant concerns. To better understand and mitigate these issues, it is essential to characterize plastics at every stage of their lifecycle, from production to degradation. Key properties such as structure, size, and texture play a critical role in determining their behavior and interactions with the environment. Raman spectroscopy has emerged as a powerful tool for such characterization due to its speed, robustness, and sensitivity to nanoscale and amorphous particles. However, its application to plastic materials requires a thorough understanding of the Raman response of reference materials, an area where systematic assessments remain scarce.

This study was conducted within the framework of the EU2020 project CHARISMA, which focuses on advancing material characterization techniques. As part of this initiative, our research group was responsible for developing accurate Raman spectra calculations for reference systems. A precise understanding of the Raman response of well-characterized materials is essential for the broader application of this technique in plastic analysis, particularly in addressing environmental and industrial challenges. To fill this gap, theoretical calculations were employed to generate ab initio Raman spectra for polystyrene, a widely used reference polymer.[11] The objective was to elucidate the origins of spectral peaks and assess their consistency across different polymeric structures, thereby enhancing the reliability of Raman spectroscopy for plastics characterization.

To achieve this, both linear ordered polymeric and finite amorphous models of polystyrene were analyzed using the CRYSTAL computational package. A careful benchmarking of computational settings ensured the accuracy of the obtained spectra. The analysis revealed key spectral peaks that remain invariant across models, serving as reliable calibration points, while others exhibit structure-dependent variations, making them useful for polymer identification. The findings confirm that Raman spectroscopy is a highly effective technique for plastic characterization, provided that a detailed analysis of signal origin is conducted. By ensuring a deeper understanding of the Raman response, this study contributes to the objectives of CHARISMA by providing validated computational tools that enhance the accuracy of material characterization across various industries. These results have broad implications for environmental monitoring, industrial applications, and the development of sustainable materials.

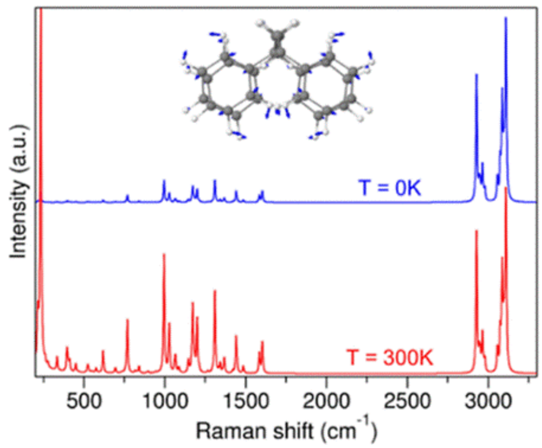


Figure 8: Graphical abstract illustrating the computation of Raman spectra for polystyrene.

Can graphene quantum Dots power the next generation of fuel cells?

In the pursuit of a sustainable hydrogen economy, enhancing fuel cell efficiency is essential. Catalysts play a pivotal role in augmenting their performance and are the subject of intense research. In the polymer electrolyte fuel cells (PEMFC), the rate determining process is the oxygen reduction reaction (ORR), even when the best catalyst is used - Pt based materials. This catalyst high cost and limited availability further drive the search for alternative materials. Could graphene quantum dots (GQDs) and nanoclusters (GNCs) offer a viable alternative? The zero-dimensional GQDs/GNCs attract interest in this field due to their adjustable band gap, highly exposed surface, and pronounced edge effects, which can be tailored through variations in size, shape, surface functionality, and doping.

In this study [12] we used the computational approaches of Density Functional Theory (DFT) and Universal Machine Learning Potentials Molecular Dynamics (uMLP-MD) to systematically investigate the ORR activity of GQDs/GNCs of different sizes (C13–C114), shapes (triangular, hexagonal, rhombohedral), and edge terminations (zigzag, armchair). Theoretical onset overpotential calculations suggest that the zigzag edges of all triangular GQDs/GNCs (C13–C46) as well as of the largest investigated rhombohedral shapes (C48, C70) show strong catalytic potential for ORR.

General chemistry research group (ALGC)

Furthermore, we establish a correlation between band gaps, spin densities, and p-band centers of edge carbon atoms with the adsorption energies of ORR intermediates (HOO*, O*, HO*), revealing that lower band gaps correspond to stronger adsorption and enhanced ORR performance. Additionally, we compare implicit and explicit solvation models, incorporating a machine-learning-assisted explicit water model. The results indicate that explicit solvation stabilizes ORR intermediates more effectively than implicit approaches, slightly increasing the onset overpotential.

These insights advance our understanding of the intrinsic electrocatalytic properties of GQDs/GNCs, highlighting their edges viability as efficient fuel cell catalysts without the need for doping.

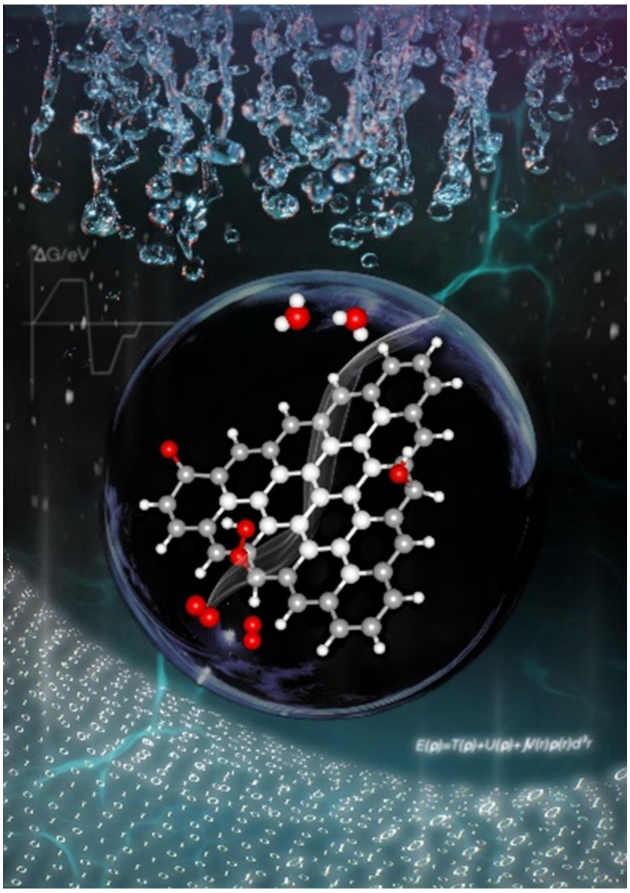


Figure 9: picture highlighting the research of the oxygen reduction reaction on the edges of graphene nanoclusters.

References

[1] Wang, S. Liu, M. Lei and F. De Proft, "Steric Effect and Intrinsic Electrophilicity and Nucleophilicity from Conceptual Density Functional Theory and Information-Theoretic Approach as Quantitative Probes of Chemical Reactions". Invited contribution to the Special Collection in Chemistry – A European Journal "Frontiers in Chemical Bonding and Aromaticity" on the occasion of the 60th Birthday of Prof. Miquel Solà (Guest Editors: A. Stasyuk, J. Poater and H. Ottoson), 30, e202401295 (2024).

[2] M. Franco-Pérez, F. Heidar-Zadeh, P. W. Ayers, F. De Proft, A. Vela, J. L. Gazquez and P. Geerlings, "Temperature and External Fields in Conceptual Density Functional Theory". Chemical Science 15, 20090 (2024).

[3] J. Eeckhoudt, M. Alonso, P. Geerlings and F. De Proft, "Bond lengths and Dipole Moments Of Diatomic Molecules under Isotropic Pressure with the XP-PCM and GOSTSHYP Models", Journal of Chemical Theory and Computation 20, 7430 (2024).

[4] L. Vermeersch, R. Verhelle, N. Van den Brande and F. De Vleeschouwer, "Breaking Down the Building Blocks: Quantum Chemical Analysis of Diels-Alder Reactions for Future Self-Healing and Recyclable Polymer Networks". Macromolecules 58, 32 (2025). Cover feature.

[5] L. Vermeersch, T. Wang, N. Van den Brande, F. De Vleeschouwer and A. C. T. van Duin, "Computational Insights into Tunable Reversible Network Materials: Accelerated ReaxFF Kinetics of Furan-Maleimide Diels-Alder Reactions for Self-Healing and Recyclability". Journal of Physical Chemistry A 48, 10431 (2024).

[6] (a) E. Desmedt, D. Smets, T. Woller, M. Alonso and F. De Vleeschouwer, "Designing Hexaphyrins for High-Potential NLO Switches: the Synergy of Core-Modifications and Meso-Substitutions". Physical Chemistry Chemical Physics 25, 17128 (2023). Back cover. (b) E. Desmedt, L. S. Gimenez, F. De Vleeschouwer and M. Alonso, "Application of Inverse Design Approaches to the Discovery of Nonlinear Optical Switches". Molecules 28, 7371 (2023).

[7] Eline Desmedt, Michiel Jacobs, Mercedes Alonso, Freija De Vleeschouwer, Deciphering Nonlinear Optical Properties in Functionalized Hexaphyrins via Explainable Machine Learning. Physical Chemistry. Chemical Physics 27, 1256 (2025). Front cover.

General chemistry research group (ALGC)

[8] L. Van Nyvel, M. Alonso and M. Solà, "Effect of Size and Charge on Hückel and Baird Aromaticity in [N]Annulenes". Chemical Science, Advance Article. DOI:10.1039/D4SC08225G (2025).

[9] E. Desmedt, I. Casademont-Reig, R. Monreal-Corona, F. De Vleeschower and M. Alonso, "Aromaticity in the Spectroscopic Spotlight of Hexaphyrins". Chemistry – A European Journal 30, e202401933 (2024). Back cover.

[10] S. Kumar Thakur, N. Roig, R. Monreal-Corona, J. Langer, M. Alonso and S. Harder, "Similarities and Differences in Benzene Reduction with Ca, Sr, Yb and Sm: Strong Evidence for Tetra-anionic Benzene". Angewandte Chemie International Edition 63, e202405229 (2024). Hot Paper.

[11] B. Taudul, F. Tielens and M. Calatayud, "Raman Characterization of Plastics: A DFT Study of Polystyrene". Journal of Physical Chemistry B 128, 4243 (2024).

[12] D. L. Isac, R. I. Jalba, S. G. Soriga, Y. Zhao, F. Tielens, I. Tranca and I. C. Man, "Computational Investigation of the Oxygen Reduction Reaction on the Edges of Differently-Sized, Shaped And Terminated Graphene Nanoclusters". Carbon 222, 118942 (2024).

Laboratory of Polymer Chemistry

Group of Yves Geerts and Guillaume Schweicher

Molecular structure and composition determine largely the supramolecular order of materials and therefore their physical properties. Materials made of organic molecules are of particular interest because their molecular structure can be tuned at will for studying a variety of phenomena. Furthermore, organic molecules are hold together in solids by relatively weak Van der Waals interactions that compete with thermal agitation. As a result, organic crystals exhibit rich dynamics and even phase transitions at temperatures close to ambient conditions. Phase transitions are of particular interest for deepening the understanding of structure property relationships because thermodynamic quantities, such as enthalpy and entropy, often varies discontinuously around them. Symmetries also change abruptly at these transitions. However, the link between molecular structure and crystal packing remains elusive due to polymorphism, which refers to the existence of multiple crystal forms for a given compound. In the frame of an international collaboration, our group demonstrated an unprecedented structure property relationship for thirteen organic crystals engineered to embody molecular fragments undergoing specific nanoscale motion anticipated to drive cooperative order-disorder phase transitions. By combining polarized optical microscopy coupled with a heating/cooling stage, differential scanning calorimetry, X-ray diffraction, low-frequency Raman spectroscopy, and calculations (density functional theory and molecular dynamics), we proved the occurrence of cooperative transitions in all the crystalline systems, and demonstrated how both the molecular structure and lattice dynamics play crucial roles in these peculiar solid-to-solid transformations. These results introduce an efficient strategy to design polymorphic molecular crystalline materials endowed with specific molecular-scale lattice and

Laboratory of Polymer Chemistry

macroscopic dynamics. The fundamental role of symmetries in the structure and properties of materials, in particular, and in physics in general, is best illustrated by chiral symmetry breaking. The coherence of helical structure formation during the crystallization of molecular structures was studied in the frame of a collaboration with researchers at New York University. Here, coherence is shown to increase as the twist period decreases for seven molecular crystals grown from the melt. This dependence was correlated to crystallite fiber thickness and length, as well as crystallite branching frequency, a parameter that was extracted from scanning electron micrographs, and supported by numerical simulations. This work illustrates the emergence of complexity in crystallization processes that arises in the extra variable of helicoidally radial twisting. The patterns analyzed here reveal how the added complexity in crystal growth influences the electronic and optical properties of thin films. Yves Geerts collaborated also with Laurence Rongy and Yannick De Decker from the Chemistry Department of ULB on the unsolved question of the molecular origin of life on Earth that is intimately rooted in chiral symmetry breaking. In their study, they demonstrated that having enantiomers with different diffusion coefficients can bias the final enantiomeric composition of reactive systems, up to complete deracemization. This result is significant because it provides a mechanism for chiral selection and amplification that relies only on diffusion asymmetries, a hypothesis for the homochirality of biomolecules that was not considered yet. In complement of above-mentioned studies and as part of a continued effort of exploring heat, charge, and spin transport, we investigated the heat transport at molecular scale through a combined experimental and theoretical study of the thermoelectric properties of molecular junctions. The thermal conductance was found to be consistent with two interfacial thermal resistances introduced by the alkyl chains, which reduce the phononic thermal transport in the molecular junction.

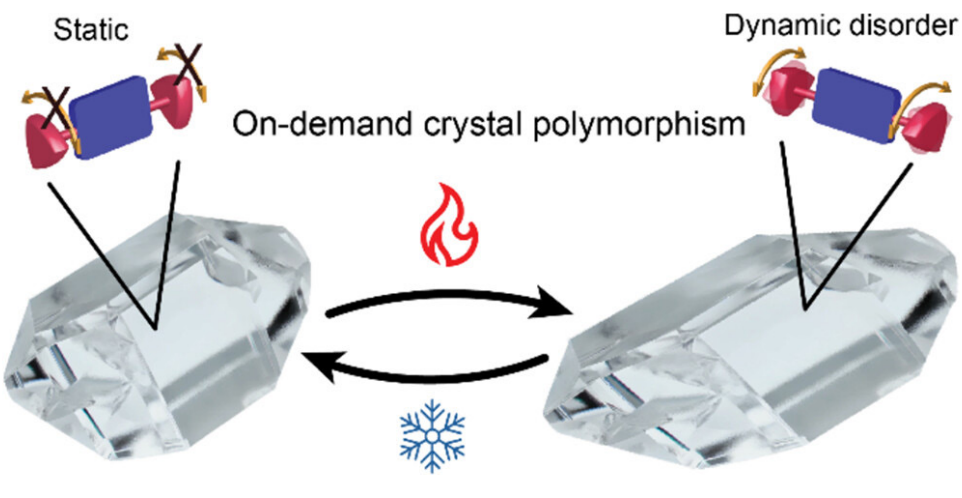


Figure 1. Illustration of the engineering of the molecular structure of organic compounds for tuning their phase transitions

References

[1] "Two Isomeric Thienoacenes in Thin Films: Unveiling the Influence of Molecular Structure and Intermolecular Packing on Electronic Properties", Christos Gatsios, Maximilian Dreher, Patrick Amsalem, Andreas Opitz, Remy Jouclas, Yves Geerts, Gregor Witte, and Norbert Koch, *J. Phys. Chem. C* 2024, *128*, 21228-21236.

[2] *"Thin film crystallization of oligoethylene glycol-benzothieno benzothiophene: Physical vapor deposition versus spin coating"* Ann Maria James, Mindaugas Gicevicius, Sebastian Hofer, Benedikt Schrode, Oliver Werzer, Félix Devaux, Yves Henri Geerts, Henning Sirringhaus, Roland Resel, *J. Cryst. Growth* 2024*, 627*, 127539.

[3] *"Structural Order and Thermal Behavior of Ph-BTBT-10 Monolayer Phases"*, Elena Ferrari, Lorenzo Pandolfi, Guillaume Schweicher, Yves Geerts, Tommaso Salzillo, Matteo Masino, Elisabetta Venuti, *J. Phys. Chem. C* 2024*, 128*, 4258-4264.

[4] "On the importance of crystal structures for organic thin film Transistors", Guillaume Schweicher, Susobhan Das, Roland Resel, Yves Geerts, *Acta Cryst.* 2024*, C80*, 601-611.

[5] *"Toward On-Demand Polymorphic Transitions of Organic Crystals via Side Chain and Lattice Dynamics Engineering"*, Luca Catalano,* Rituraj Sharma, Durga Prasad Karothu, Marco Saccone, Oren Elishav, Charles Chen, Navkiran Juneja, Martina Volpi, Remy Jouclas, Hung-Yang Chen, Jie Liu, Guangfeng Liu, Elumalai Gopi, Christian Ruzie, Nicolas Klimis, Alan R. Kennedy, T. Kyle Vanderlick, Iain McCulloch, Michael T. Ruggiero, Pance Naumov, Guillaume Schweicher, Omer Yaffe, and Yves H. Geerts, *J. Am. Chem. Soc.* 2024*, 146*, 31911-31919.

[6] Chirality refers to objects, molecules or particles than cannot be superimposed to their mirror images.

[7] *"Coherence in Polycrystalline Thin Films of Twisted Molecular Crystals"*, Yongfan Yang, Alexander G. Shtukenberg, Hengyu Zhou, Christian Ruzié, Yves Henri Geerts, Stephanie S. Lee, and Bart Kahr, Chem. Mater. 2024, 36, 881-891.

[8] "Differences in enantiomeric diffusion can lead to selective chiral amplification" Jean Gillet, Yves Geerts, Laurence Rongy, Yannick De Decker, *PNAS* 2024*, 121*, e2319770121

[9] "Thermoelectric Properties of Benzothieno-Benzothiophene Self-Assembled Monolayers in Molecular Junctions" Sergio Gonzalez-Casal, Remy Jouclas, Imane Arbouch, Yves Henri Geerts, Colin van Dyck, Jerôme Cornil, and Dominique Vuillaume, *J. Phys. Chem. Lett.* 2024*, 15*, 11593-11600

Chemical Engineering research group

Group of Gert Desmet

Molecular separations and identifications: finding the needle in the haystack

Rooted in chemical engineering, with a long standing specialization in microfluidics and analytical separation science (chromatography, DNA hybridization assays, microfluidic membrane separations...), the Desmet group is reputed for the development of novel analytical separation devices, as well as for its know-how on the modeling and understanding of flow effects in laminar flow systems. The group is also internationally reputed for its know-how on miniaturization and has over the last 20 years established an extensive set of microfluidics capabilities.

Recently, our group has developed a novel approach to produce high-performance substrates for Surface-Enhanced Raman Spectroscopy (SERS). This a technique that can amplify Raman signals by several orders of magnitude by adsorbing molecules on a nanostructured surface, offering extreme detection sensitivities, down to the single-molecule level. The novel approach to produce is based on an in-house developed triboelectrification-driven self-assembly process that is capable of arraying dry colloidal powder in a locally ordered monolayer (**Fig. 1**) in a few seconds. By optimizing particle size and gold coating thickness, we found that self-assembled particles sized 400 nm and 500 nm with a 50 nm gold layer achieved enhancement factors (EF) as high as 50 million— outperforming state-of-the-art commercial substrates by at least one order of magnitude. These results highlight triboelectrification's ability to efficiently and cost-effectively produce homogeneous monolayers, offering a promising alternative to more complex or expensive methods and unlocking the opportunity for large-scale SERS substrate production with biosensing, diagnostics and chemical detection applications.

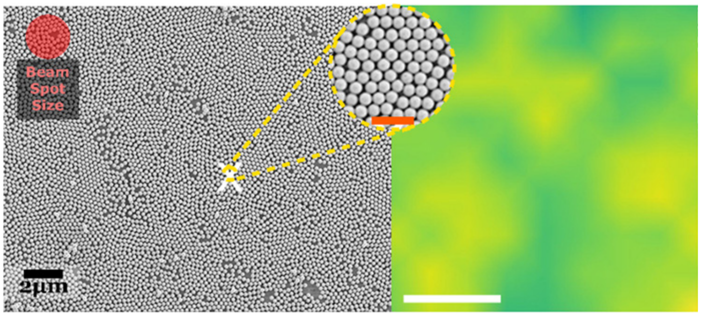


Figure 1. SEM image and corresponding Raman intensity distribution maps for the 1608 cm-1 peak of trans-1,2-bi-(4-pyridyl) ethylene of a monolayer of 300 nm silica particles coated with a 35nm gold layer. The white scale bars represent 10 µm, while the orange ones in the insets represent 1µm.

Chemical Engineering research group

We also developed novel concept to produce ordered beds of spherical particles in a suitable format for liquid chromatography. In this concept, referred to as the micro-groove column concept, spherical particles are either positioned individually (single-layer column) or stacked (multi-layer column) in micromachined pockets (**Fig. 2**) that form an interconnected array of micro-grooves acting as a perfectly ordered chromatographic column. As a first step towards realizing this concept, we report on the breakthrough we realized by obtaining a solution to uniformly fill the micro-groove arrays with spherical particles. We show this can be achieved in a few sweeps using a dedicated rubbing approach wherein a particle suspension is manually rubbed over a silicon chip. In addition, numerical calculations of the dispersion in the newly introduced column format have been carried out and demonstrate the combined advantage of order and reduced flow resistance the newly proposed concept has over the conventional packed bed. For fully-porous particles, the minimal plate height h_{min} decreases from h_{min} = 1.9 for the best possible packed bed column to around h_{min} =1.0 for the microgroove array.

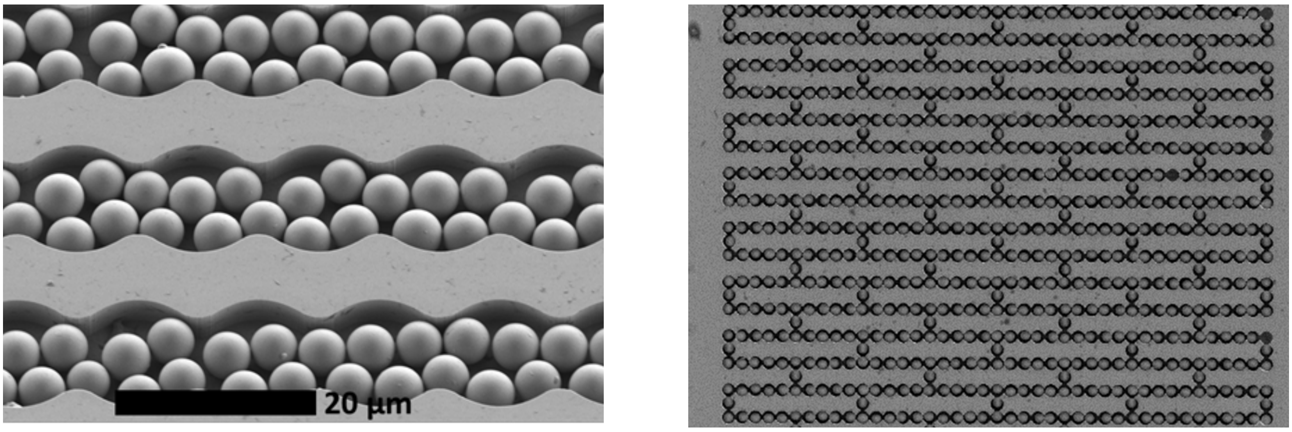


Figure 2. SEM images of two different possible variants of the newly proposed microgroove array column concept allowing to array liquid chromatography particles in perfectly ordered patterns, as opposed to the random packing configuration wherein they are crammed together in conventional liquid chromatography columns.

Recently, we also developed a desire to make chromatographic instruments more intelligent because chromatographic problem solving, commonly referred to as method development (MD), is a hugely complex task, given the many operational parameters that need to be optimized and their large effect on the elution times of individual sample compounds. We developed a deep reinforcement learning algorithm with Proximal Policy Optimization (PPO) that can autonomously propose a gradient elution profile with which all components in a given sample are individually resolved (**Fig. 3**), without the need for any prior knowledge about the sample.

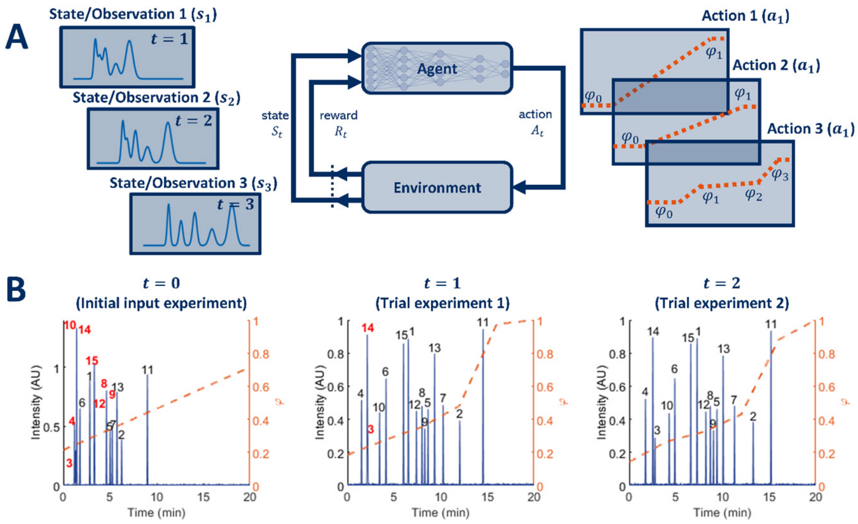


Figure 3. A) Simplified scheme illustrating the operation of the developed deep reinforcement learning algorithm, indicating the sequence of actions, states and rewards B) Exemplary episode illustrating the RL-based chromatographic method development of a 5-segment gradient separation of a sample containing 15 components

The Robert Brout and 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 at ULB and VUB, provided they have a brilliant curriculum;
- The Robert Brout Prizes, to be awarded to the best students finishing their master studies in physics at ULB and VUB, provided they have a brilliant curriculum.

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

Laureates

In 2024, the prizes have been awarded to:

Anaïs Defossez
Prix Brout, ULB

Sébastien Robert
Prix Brout, ULB

Elise Van den Bossche
Prix Brout, VUB

Jannes Loonen
Prix Brout, VUB

Clara Octors
Prix Prigogine, ULB

Manon Hermans
Prix Prigogine, ULB

Louis Arthur M Van Nyvel
Prix Prigogine, VUB

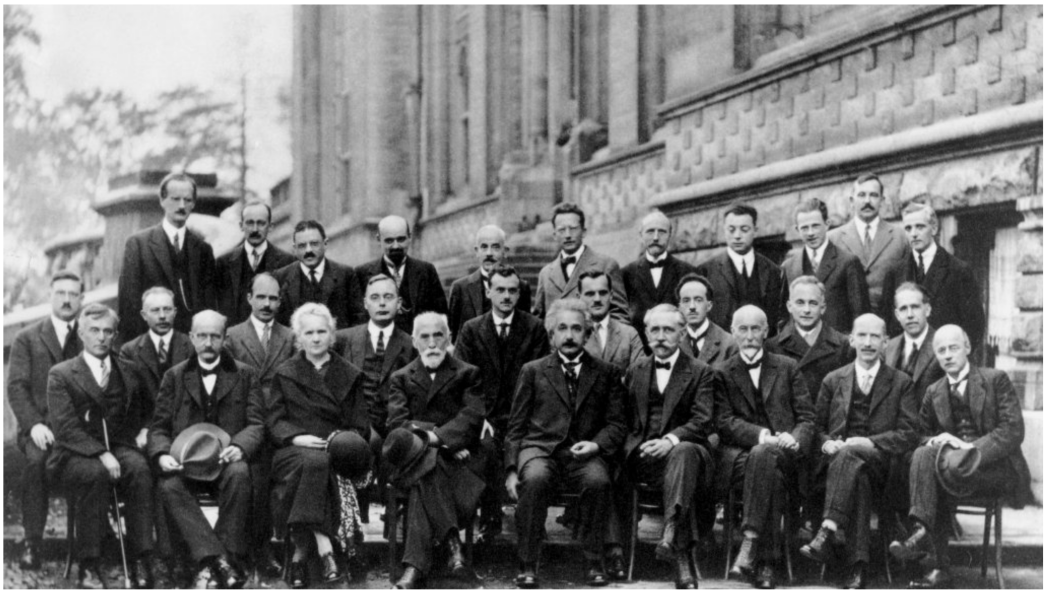
06

APPENDICES

Press and newspaper

L'Écho – 13.04.2024

Les Conseils scientifiques Solvay mettent le cap sur la biologie



Conférence Solvay sur la mécanique quantique en 1927, avec notamment Albert Einstein, Marie Curie, Max Planck ou encore Heindrik Lorentz. ©BELGA

CHRISTIAN DU BRULLE

13 avril 2024 01:00

Plus d'un siècle après le premier Conseil de physique et de chimie, les Instituts Solvay innovent. Cette semaine, trente scientifiques ont rendez-vous à Bruxelles pour un tout premier Conseil de biologie.

"*J'aime la science et j'attends d'elle le progrès de l'humain.*" Ernest Solvay

En 1911, le premier Conseil de physique, initié par ses soins, voyait le jour à Bruxelles. Une réunion de haut vol qui accueillait les plus grands noms de l'époque et (futurs) prix Nobel, comme **Albert Einstein, Marie Curie, Max Planck ou encore Maurice de Broglie, Heindrik Lorentz.**

Un siècle plus tard, les Conseils de physique et de chimie accueillent une nouvelle initiative des Instituts Solvay (ULB et VUB). Le premier Conseil de biologie se tiendra pendant trois jours à Bruxelles, du 18 au 20 avril. Avec des ambitions à la hauteur de celles portées par ses illustres prédécesseurs.

"La biologie est à l'aube d'une véritable nouvelle révolution, comme l'était la physique quantique lors du Conseil de 1911."

Jean-Marie Solvay

Président des Instituts Solvay

"C'est à la suite du Conseil de physique de 2017, consacré à la biophysique, qu'on s'est rendu compte de **l'engouement des participants pour la biologie**", explique Jean-Marie Solvay, président des Instituts. "Le physicien théoricien **Lars Brink**, parmi d'autres, était particulièrement enthousiaste. Le directeur des Instituts, le Pr Marc Henneaux, également. Nous avons tout de suite été convaincus. **La biologie est à l'aube d'une véritable nouvelle révolution, comme l'était la physique quantique lors du Conseil de 1911**. Nous avons donc décidé de lancer un nouveau type de Conseils Solvay, un Conseil dédié à la biologie."

Plusieurs années ont été nécessaires pour faire murir le projet. **"On l'a beaucoup préparé"**, **concède le physicien Marc Henneaux**, prix Francqui en 2001, et directeur des Instituts Solvay. "Et je pense que ce sera un succès scientifique. J'en suis même convaincu!"

Press and newspaper

L'Écho – 13.04.2024

Le Prince Philippe rencontre les participants du 24e Conseil de Physique Solvay en 2008.
©Photo News

Boucler un cycle de trois ans

La question du meilleur moment pour organiser ce nouveau rendez-vous a très vite trouvé une réponse. Quand lancer ce nouveau Conseil? **Ceux de physique et de chimie sont chacun organisés tous les trois ans.** Dans ce cycle, il y avait donc une année "creuse". **La biologie vient tout naturellement y prendre sa place**.

"Il a également fallu trouver les financements indispensables à son organisation et aux activités liées, comme la mise sur pied de chaires permettant d'inviter des biologistes", reprend le Pr Henneaux. **"La famille Solvay a d'emblée été présente, de même que la firme UCB, et d'autres sponsors"**.

Enfin, il a surtout fallu identifier la personne la plus indiquée pour présider le comité scientifique de ce nouveau rendez-vous. C'est le président qui donne les impulsions scientifiques, qui détermine le programme, qui dresse la liste des spécialistes à inviter.

Thomas Lecuit, professeur au Collège de France et directeur du Centre Turing des Systèmes Vivants (Institut de biologie du développement de Marseille), a accepté de relever ce défi. Avec quelques autres scientifiques d'horizons divers, membres de son comité, le choix du thème de ce premier Conseil de biologie a été arrêté: **"The organisation and dynamics of biological computation"**.

”Le but de cette réunion est de faire progresser notre compréhension des modes de transmission de l’information et de son traitement par les systèmes biologiques“

Thomas Lecuit

Président du Comité Scientifique du Conseil de Biologie

La communication au sein du vivant

“Mon champ de recherche porte sur le développement, et en particulier la morphogenèse”, précise Thomas Lecuit. “J’étudie les **processus mécaniques impliqués dans les changements de formes du vivant**, les forces à l’oeuvre. En particulier ce qui gouverne l’évolution de l'ensemble des cellules qui forment un embryon ou un organe. Des travaux qui sont par nature interdisciplinaires et qui touchent en ce sens autant à la biologie qu’à la physique”.

Et la computation dans ce contexte? La réponse à cette question prend la forme des interrogations qui seront au coeur des travaux des invités du Conseil. **Comment les cellules communiquent-elles entre elles?** Comment traitent-elles l’information en provenance des autres cellules? D’ailleurs, qu'est-ce que l'information en biologie? Et on ne parle pas ici d’ADN ni de neurosciences.

“Le but de cette réunion est de **faire progresser notre compréhension des modes de transmission de l’information** et de son traitement par les systèmes biologiques”, résume le Pr Lecuit. “La compréhension de la morphogenèse occupait déjà le mathématicien **Alan Turing**, en 1954. Des travaux depuis précisés par des biologistes, tels Lewis Wolpert et Francis Crick dans les années septante”.

“Je souhaite, avec ce premier Conseil de biologie soit un lieu de réflexion et d'échange collectif et interdisciplinaire.”

Thomas Lecuit

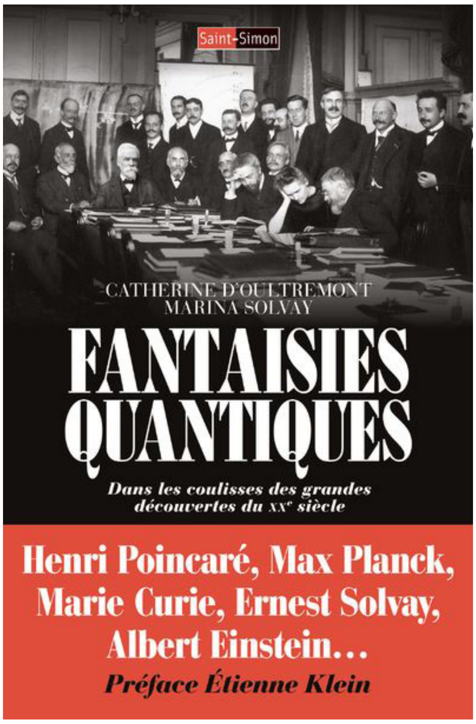
Président du Comité Scientifique du Conseil de Biologie

Press and newspaper

L'Écho – 13.04.2024

Un format qui a fait le succès des Conseils Solvay

Voilà qui explique pourquoi les invités de ce Conseil sont issus de multiples disciplines. Il y aura des physiciens, des biologistes, des statisticiens, des chimistes... **"Des spécialistes qui n'ont peut-être pas encore l'habitude de travailler ensemble mais qui pourraient, de manière collégiale, faire avancer nos connaissances fondamentales dans ce domaine"**, estime Marc Henneaux.



Le format des Conseils Solvay est propice à ce genre d'échanges. On est effectivement loin, ici, du déroulement d'un congrès scientifique classique.

«J'ai voulu faire autre chose. Un réunion ambitieuse, audacieuse, mais aussi, évidemment, intéressante, utile et réaliste», détaille le Pr Lecuit.

"D'abord en invitant un petit nombre de participants. **Nous ne serons qu'une trentaine au total**. Nos travaux vont refléter ce qui se passe actuellement en biologie. Ensuite, je souhaite, avec ce premier Conseil de biologie, qu'on n'y vienne pas pour parler de ses derniers résultats scientifiques, comme on le fait à nombre de conférences, mais plutôt que ce soit un **lieu de réflexion et d'échange collectif et interdisciplinaire**, autour d'une thématique centrale en biologie".

"Les participants à cette réunion vont ainsi **alterner des périodes en séances plénières et des discussions par sous-groupes**", précise-t-il. "L'idée est de faire des allers-retours. S'isoler en sous-groupes pendant quelques heures permet d'approfondir les questions. Pour ensuite faire émerger et remonter vers l'ensemble des participants un certain nombre de points de vue, de "découvertes", d'éclaircissements, d'idées à partager".

"On a toujours privilégié des recherches très en **amont par rapport aux applications lors des Conseils Solvay**, en physique comme en chimie", abonde le Pr Henneaux. "Ce sera la même chose cette semaine avec le Conseil de biologie. Si vous êtes trop près des applications, vous n'allez pas changer le monde", souligne-t- il.

“L’engagement scientifique d’Ernest Solvay reposait sur l’idée que le bien-être général ne peut résulter que d’un développement unifié des sciences physiques, naturelles et sociales appelées selon lui à se fondre en une **“science universelle”**”, rappelle Marina Solvay, présidente des archives des Instituts Solvay.

“Dès 1893, il disait: j’ai entrevu dans les voies nouvelles de la science des directions que j’ai suivies, des problèmes qui n’en forment à mes yeux qu’un seul. C’est d’abord un problème de physique générale, la constitution de la matière dans le temps et dans l’espace; puis un problème de physiologie, le mécanisme de la vie **depuis ses manifestations les plus humbles jusqu’aux phénomènes de la pensée**.”

Avec l'organisation du premier Conseil de biologie, sa vision va enfin aborder cette dimension du vivant. L’esprit d’Ernest n’a pas fini de souffler sur Bruxelles.

Un événement public, dimanche, à Bruxelles

Les Conseils Solvay s’adressent à des spécialistes. Les organisateurs les doublent cependant systématiquement d’un événement gratuit et ouvert à tous. Ce sera cette année **à Flagey, le dimanche 21 avril**

Deux exposés et une table ronde sont au programme. **Anthony Hyman**, directeur de l’Institut Max- Planck à Dresde, discutera de la vie sociale de la cellule, soit les mécanismes physiques et chimiques permettant la transmission de l’information au niveau cellulaire.

Stephanie Palmer, professeure à l’Université de Chicago, embrayera avec un exposé intitulé “Seeing what’s coming”, centré sur les mécanismes d’anticipation de notre cerveau. Les exposés seront suivis par une table ronde à laquelle participeront les Professeurs **Thomas Lecuit** (président du premier Conseil de biologie), **Cédric Blanpain** (ULB), **Adrienne Fairhall** (Université de Washington), **Anthony Hyman** (Institut Max-Planck), **Stephanie Palmer** (Université de Chicago), **Aleksandra Walczak** (ENS, France) et **Eric Wieschaus** (Prix Nobel de médecine 1995, Université de Princeton). Les exposés sont en anglais. Une traduction simultanée en français et néerlandais sera disponible.

L’inscription à l’événement s’effectue via le site www.solvayinstitutes.be.

Press and newspaper

La libre – 3.04.2024

Après plus d'un siècle, les mythiques congrès Solvay s'ouvrent à la biologie

Sciences Le 1er conseil a pour thème: "Le XXIe siècle sera celui de la biologie".

Avec des invités prestigieux comme Albert Einstein, Marie Curie ou Robert Oppenheimer, les congrès scientifiques Solvay ont marqué l'histoire des sciences et de la Belgique. Pendant plus d'un siècle, ils ont été limités à la physique et à la chimie. À partir de cette année, ils s'ouvrent à la biologie. Ces discussions scientifiques rassemblant les plus grands savants d'une discipline ont été imaginées par l'industriel Ernest Solvay en 1911. Ces conférences agrémentées de débats ont réuni de nombreux Prix Nobel et ont notamment contribué à l'établissement de la physique quantique dans les années 1920.

Exauçant un "précieux souhait d'Ernest Solvay", les Instituts de recherche Solvay organiseront le premier conseil de biologie du 18 au 20 avril. L'explication de ce choix? "*Le XXI' siècle sera celui de la biologie. Nous sommes à l'aube d'une révolution thérapeutique. De nombreux experts s'accordent à penser que notre compréhension du monde vivant va connaître des avancées considérables, et ce grâce au travail en synergie des biologistes, chimistes, physiciens, mathématiciens et statisticiens. Ce bond dans la biologie quantitative ouvrira la porte à de nouvelles avancées thérapeutiques.*"

> Pendant plus d'un siècle, les congrès scientifiques Solvay ont été limités à la physique et à la chimie. À partir de cette année, ils s'ouvrent à la biologie.

Un "acteur majeur"

La biologie quantitative, qui brasse des "datas", consiste à utiliser des techniques mathématiques, statistiques ou informatiques pour étudier les organismes vivants et ensuite de construire des modèles prédisant leur fonctionnement. Exemple concret: étudier comment se façonne et croît un cœur humain, en utilisant de l'imagerie 3D, la simulation par ordinateur et l'analyse statistiques de données, le tout pour aider à réparer cet organe vital après un infarctus.

Ce conseil est une façon pour la Belgique, de devenir "un acteur majeur" du développement de ce champ de recherche à l'international, selon les Instituts Solvay.

Les systèmes vivants “calculent”

La conférence s'intéressera en particulier à la discipline appelée calcul biologique, à la pointe de la science. Celui-ci se base sur l'idée que les systèmes vivants eux aussi peuvent “calculer”. Par exemple, on peut considérer que les cellules de notre corps sont comme des logiciels, “programmées” pour exécuter des fonctions spécifiques à des moments précis. Si nous arrivions à comprendre les calculs biologiques (cela peut se faire à l'aide d'outils informatiques), cela transformerait notre com-préhension du comportement des cellules. Si nous comprenons ces programmes, nous pourrions les déboguer” en cas de problème. Pour faire découvrir ces nouveaux champs de recherche et notamment la question du traitement de l'information par le génome, les cellules et les tissus, l'après-midi du 21 avril, à Flagey, sera ouvert au grand public.

La spécialiste de la biologie quantitative et du calcul biologique Stephanie Palmer, de l'Université de Washington, parlera notamment de la façon dont notre cerveau anticipe et “calcule” le futur. Des visions prédictives exceptionnelles: pensons par exemple à la joueuse de tennis Serena Williams capable, dès que l'information est perçue par les cellules rétiniennes de l'œil, peut anticiper en moins d'une fraction de seconde le point précis de rattrapage et de relance de la balle vers l'adversaire...

Sophie Devillers

Press and newspaper

Daily Science – 15.04.2024

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

LE PREMIER CONSEIL SOLVAY DE BIOLOGIE SE TIENT À BRUXELLES

15 AVRIL 2024

par Christian Du Brulle

Après les fameux Conseils Solvay de physique initiés dès 1911 par l'industriel belge Ernest Solvay, puis ceux de chimie, Bruxelles accueille le tout premier Conseil Solvay de biologie Une réunion scientifique internationale de haut vol, au format très différent des congrès scientifiques classiques. Et qui s'ouvre également au public, le dimanche 21 avril.

"Les invités, une trentaine de participants au total, ne sont pas là pour présenter leurs dernières avancées personnelles. Il s'agit plutôt de discuter ensemble, et pendant trois jours, du 18 au 20 avril, de problématiques transversales autour du thème du Conseil", annonce d'emblée le Pr Marc Henneaux, directeurs des Instituts Solvay.

Pour cette première réunion placée sous le signe de la biologie, il sera surtout question de communication. L'intitulé de ce premier Conseil? "The organisation and dynamics of biological computation".

Circulation de l'information dans les systèmes biologiques

Comment les cellules, communiquent-elles entre elles? Et comment traitent-elles l'information en provenance des autres cellules? "Le but est de faire progresser, par un travail multidisciplinaire, notre compréhension des modes de transmission de l'information et de son traitement par les systèmes biologiques", indique le Pr Thomas Lecuit, président du comité scientifique de ce premier Conseil de biologie.

Professeur au Collège de France et directeur du Centre Turing des Systèmes Vivants, à Marseille ses recherches portent sur la question générale de l'origine des formes en biologie du développement et sur la nature de l'information dans ce contexte.

"L'information, c'est un terme très général qui signifie beaucoup de choses différentes", précise Thomas Lecuit. "Quand on s'adresse à des biologistes, ils disent que l'information, c'est évidemment l'ADN, la génomique. Un autre genre d'information classique en biologie recouvre tout le champ des neurosciences. C'est l'information que traite le cerveau. Mais, en réalité, l'information est quelque chose de beaucoup plus central et d'universel en biologie. Pour les cellules, à toutes les échelles de temps et d'espace, il existe des flux d'information à la fois prélevée ou extraite dans l'environnement et dans le système biologique lui-même. Cette information est traitée de l'intérieur, transformée, transmise, mémorisée, etc. C'est de cela dont il va être question."

Press and newspaper

Daily Science – 15.04.2024

“Il y a aussi des questions centrales en biologie sur ce qu’est l’information, ou encore comment elle se déploie de façon dynamique dans des systèmes aux propriétés particulières. L’information est un concept central en biologie pour lequel il manque encore une définition. C’est pour cela que j’ai choisi cette thématique pour le premier Conseil Solvay de biologie.”

Voilà qui explique pourquoi les invités de ce Conseil sont issus de multiples disciplines. Il y aura des physiciens, des biologistes, des statisticiens, des chimistes. “Des spécialistes qui n’ont peut-être pas encore l’habitude de travailler ensemble, mais qui pourraient, de manière collégiale, faire avancer nos connaissances fondamentales dans ce domaine”, estime Pr Marc Henneaux, directeur des Instituts Solvay (ULB et VUB).

“Ce Conseil devrait permettre à la biologie fondamentale des faire des bonds en avant, ouvrant potentiellement la porte à des applications thérapeutiques nouvelles pour le bien de l’humanité.”

Un événement public à Flagey

Si les Conseils Solvay s’adressent à des spécialistes, les organisateurs les doublent systématiquement d’un événement gratuit ouvert à tous. Cet événement public se tiendra dimanche 21 avril, à Flagey (Ixelles). Deux exposés et une table ronde sont au programme

Anthony Hyman, directeur de l’Institut Max-Planck à Dresde, parlera des mécanismes physiques et chimiques permettant la transmission de l’information au niveau cellulaire. Stephanie Palmer, professeure à l’Université de Chicago, embrayera avec un exposé intitulé “Seeing what’s coming”, centré sur les mécanismes d’anticipation de notre cerveau.

Ces exposés seront suivis par une table ronde à laquelle participeront les Professeurs Thomas Lecuit (président du premier Conseil de biologie), Cédric Blanpain (ULB), Adrienne Fairhall (Université de Washington), Anthony Hyman (Institut Max-Planck), Stephanie Palmer (Université de Chicago), Aleksandra Walczak (ENS, France) et Eric Wieschaus (Prix Nobel de médecine 1995, Université de Princeton).

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Het Nieuwsblad – 17.04.2024

Eerste Solvayraad voor Biologie moet revolutionaire ontwikkeling van vakgebied ontketenen

Archiefbeeld: Flagey Studio 4 in Brussel, waar de publieke zitting zal plaatsvinden. — © BELGAIMAGE

Met de oprichting van de eerste Solvayraad voor Biologie willen de Solvay-instituten verbonden aan de Vrije Universiteit Brussel (VUB) en de Université Libre de Bruxelles (ULB) een revolutie in het vakgebied ontketenen. De eerste Solvayraad voor Biologie vindt plaats van 18 tot 20 april in het Brusselse Flagey, met als hoogtepunt een publieke zitting op 21 april. Dat meldt VUB in een persbericht.

Het is de eerste keer sinds de ontstaansgeschiedenis van de Solvayraden dat er een dergelijke wetenschappelijke top wordt georganiseerd voor de biologische wetenschappen. Bezieler Ernest Solvay was in het begin van de 20ste eeuw, na de oprichting van de Solvayraden voor Biologie en Fysica, al gewonnen voor een dergelijke biologische mondiale wetenschappelijke topbijeenkomst, maar dat bleek toen nog niet levensvatbaar. Vandaag liggen die kaarten anders, zo stelt VUB-onderzoeker Alessio Rocci.

Press and newspaper

Het Nieuwsblad – 17.04.2024

Men vond nooit een voldoende reden om een Solvayraad voor Biologie te organiseren. Veel experts zijn het er nu over eens dat we aan het begin staan van een nieuwe revolutie in ons begrip over de levende wereld", denkt de doctoraal onderzoeker.

Volgens Rocci bevinden we ons momenteel op een kruispunt in de biologische geschiedenis, waarbij het werk van verschillende biologen, scheikundigen, natuurkundigen, computerwetenschappers en statistici convergeert en samenvloeit. Die evolutie effent het pad voor een eventuele internationale "kwantumsprong" in de biologische wetenschappen.

Sinds 1911

De wereldwijde wetenschappelijke primeur moet in de voetsporen treden van de Solvayraden die in de 20ste en 21ste eeuw reeds verscheidene doorbraken hebben geforceerd in de vakgebieden fysica en chemie. In 1911 nam Ernest Solvay het initiatief om internationale topwetenschappers uit te nodigen voor een internationale wetenschappelijke raad om actuele kwesties van de moleculaire en kinetische theorie op te helderen.

> **"Veel experts zijn het er nu over eens dat we aan het begin staan van een nieuwe revolutie in ons begrip over de levende wereld"**
>
> **Alessio Rocci**
>
> VUB-onderzoeker

Twintig vooraanstaande fysici verzamelden in Brussel voor een eerste "Conseil de Physique". Onder meer vooraanstaand Leids fysicus en theoreticus Hendrik Lorentz nam eraan deel. De samenwerking tussen Solvay en Lorentz mondde uit in de oprichting van het Solvay Instituut voor Natuurkunde in 1912. De bijeenkomst en daaruit voortvloeiende wetenschappelijke discussies vormden meteen ook de voedingsbodem en inspiratiebron voor het werk van tal van fysici wereldwijd. Onder hen ook Frans wiskundige en universalist Henri Poincaré, gekend als grondlegger van de wiskundige chaostheorie en het Poincaré-vermoeden, een beroemd probleem uit de wiskunde.

Nobelprijswinnaars

Een jaar later richtte Ernest Solvay ook het internationaal instituut voor scheikunde op. Na de Eerste Wereldoorlog, in 1922 om precies te zijn, werd een allereerste Solvayraad voor Chemie georganiseerd. Een maand later stierf de Belgische industrieel en oprichter van de wereldvermaarde internationale onderzoeksinstituten. Maar daarmee niet zijn idealen.

Solvay liet een belangrijke wetenschappelijke erfenis na. "De Solvayraden sloegen eerst een brug tussen de natuurkunde en de scheikunde, en daarna ook tussen de scheikunde en andere wetenschappen", vervolgt Rocci. Aan de Solvayraden namen ook talloze Nobelprijswinnaars deel, onder wie Marie Curie, Albert Einstein, Schrödinger, of recenter: Mann, Gross en Englert.

Wereldtop in Brussel

De eerste Solvayraad voor Biologie brengt 35 internationale experten samen voor een internationaal wetenschappelijk comité. De raad wordt voorgezeten door de Fransman Thomas Lecuit, directeur van het Turing Center for Living Systems.

Op het programma staan lezingen van vooraanstaande wetenschappers: de winnaar van de Breakthrough Prize in Life Sciences uit 2023 Anthony Hyman zal het hebben over informatieoverdracht in het lichaam op cellulair niveau, professor Stephanie Palmer, verbonden aan de Universiteit van Chicago, doet in haar lezing "Seeing What's Coming" de anticipatiemechanismen van het menselijke brein uit de doeken.

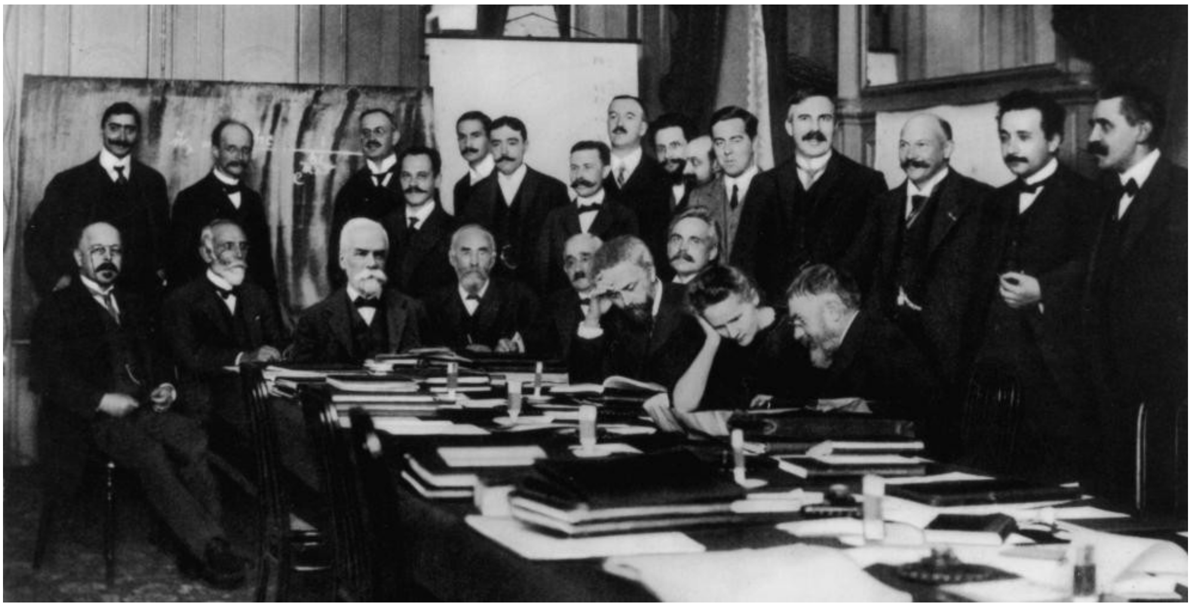
"Met deze eerste Solvayraad voor Biologie knopen de Solvay Instituten aan bij een indrukwekkende traditie", zegt VUB-rector Jan Danckaert. "Elke wetenschapper kent twee familienamen: Nobel en Solvay. De Solvayraden brengen al meer dan een eeuw de wereldtop van de wetenschap naar Brussel."

Press and newspaper

VUB – 17.04.2024

Eerste Solvayraad voor Biologie in de geschiedenis

Internationale Solvay Instituten voegen belangrijke tak toe aan grote wetenschappelijke traditie



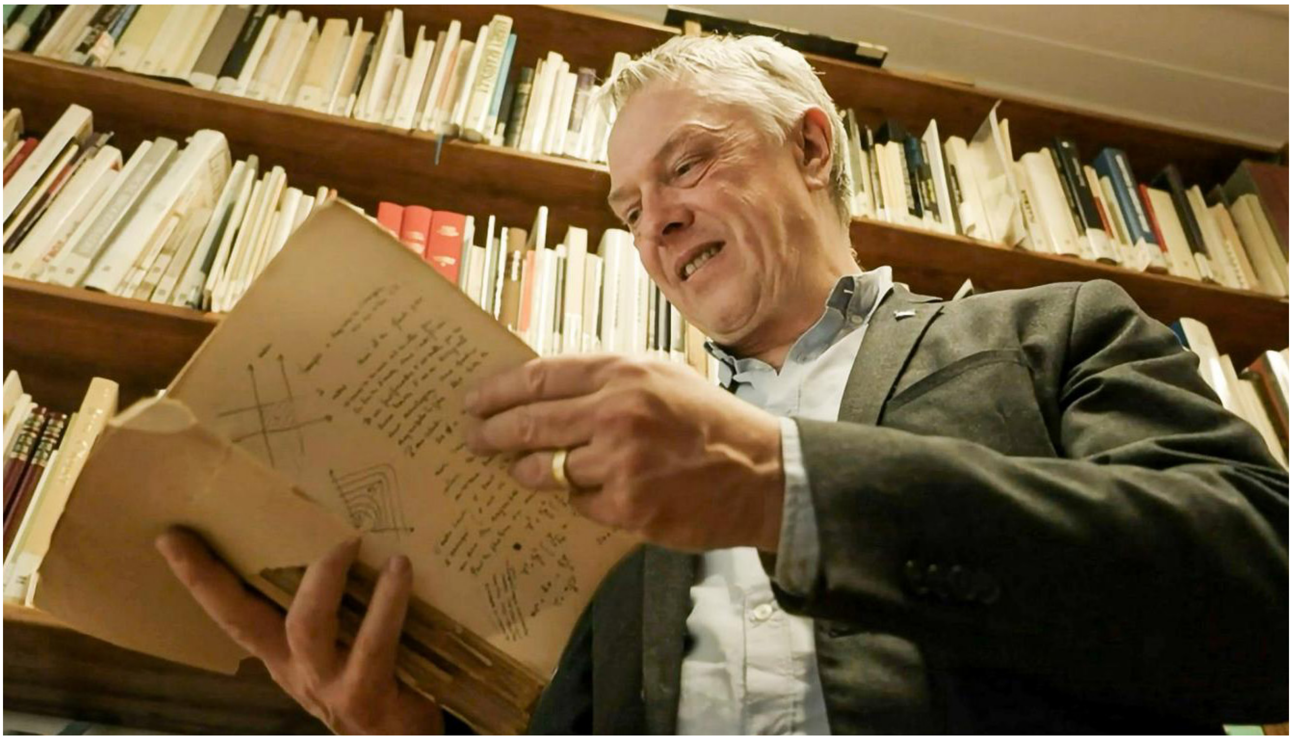
De eerst Solvay Conferentie in 1911 in Brusselse hotel Metropole met grote namen als Hendrik Lorentz, Max Planck en Albert Einstein. Foto: Solvay Archief

Op 15 juni 1911 ontvingen twintig vooraanstaande natuurkundigen een "Uitnodiging voor een Internationale Wetenschappelijke Raad om actuele kwesties van de moleculaire en kinetische theorie op te helderen". De uitnodiging was vertrouwelijk en ondertekend met "E. Solvay". Vandaag de dag wordt de Raad die van 30 oktober tot 3 november 1911 in Brussel werd gehouden beschouwd als de eerste internationale conferentie over de fysica in de geschiedenis en wordt zijn belang voor de vooruitgang van de wetenschap wereldwijd erkend. Na de Eerste Wereld-oorlog, in 1922, begon een tweede wetenschappelijk comité met het organiseren van de Solvay Conferences on Chemistry. Dit jaar, van 18 tot 20 april, is er voor het eerst ook een Solvayraad voor Biologie, die op zondag 21 april zijn apotheose kent met een evenement voor het grote publiek in Flagey. VUB-onderzoeker Alessio Rocci blikt terug op het ontstaan van de Solvay-raden en bereidt samen met Franklin Lambert een boek voor over de impact ervan op de kwantumrevolutie.

21 april 2024: Publieke lezingen

Met de eerste Solvayraad voor Bioloogie knopen de International Solvay Instituten aan bij een grote en uiterst belangrijke wetenschappelikje traditie. Grote kanonnen wordenuit de kast gehaald, met onder andere een reeks lezingen door topwtenschappers tijdens het publieke event op zondag 21 april in Flagey.

“Het idee van een “Internationale Wetenschappelijke Raad” werd in 1910 gelanceerd door Walther Nernst, de directeur van het Instituut voor Fysische Scheikunde aan de Universiteit van Berlijn”, zegt VUB-postdoctoraal onderzoeker Alessio Rocci. Rocci werkt met het Solvay Archief, bewaard aan de ULB, onder toezicht van rector en fysicus Prof. Jan Danckaert. “De timing van het plan bleek cruciaal. Tien jaar waren verstreken sinds Planck de elementaire kwanta had vooropgesteld om de straling die voorwerpen uitstralen als ze opgewarmd worden te kunnen verklaren. Later bleek dat de zgn. hypothese van Planck ook een heel aantal andere fysische fenomenen kon verklaren.”



VUB-rector en natuurwetenschapper Jan Danckaert bezocht de de archieven van de Internationale Solvay Instituten.

Press and newspaper

VUB – 17.04.2024

Ernest Solvay was een industrieel, maar ook een uitvinder, filantroop en de oprichter van onderzoeks-instituten voor fysica en chemie die nu zijn naam dragen. “Solvay was echter veel meer dan een beschermheer van de wetenschap”, zegt Rocci. “Gedreven door passie wijdde hij zich aan wetenschappelijk onderzoek. Hij vatte zijn onderzoeksprogramma destijds samen door drie richtingen en drie problemen te benadrukken, die er in zijn ogen maar één vormden. Er was volgens Solvay een probleem in de fysica: wat zijn materie, ruimte en tijd? Er was een probleem met de kennis over de fysiologie: hoe zit het mechanisme van het leven in elkaar, vanaf de meest nederige verschijningsvorm tot en met de verschijnselen van het menselijk denken? Er was volgens Solvay ook een probleem, complementair aan de eerste twee: hoe zit het met de evolutie van het individu en in een sociale context?”

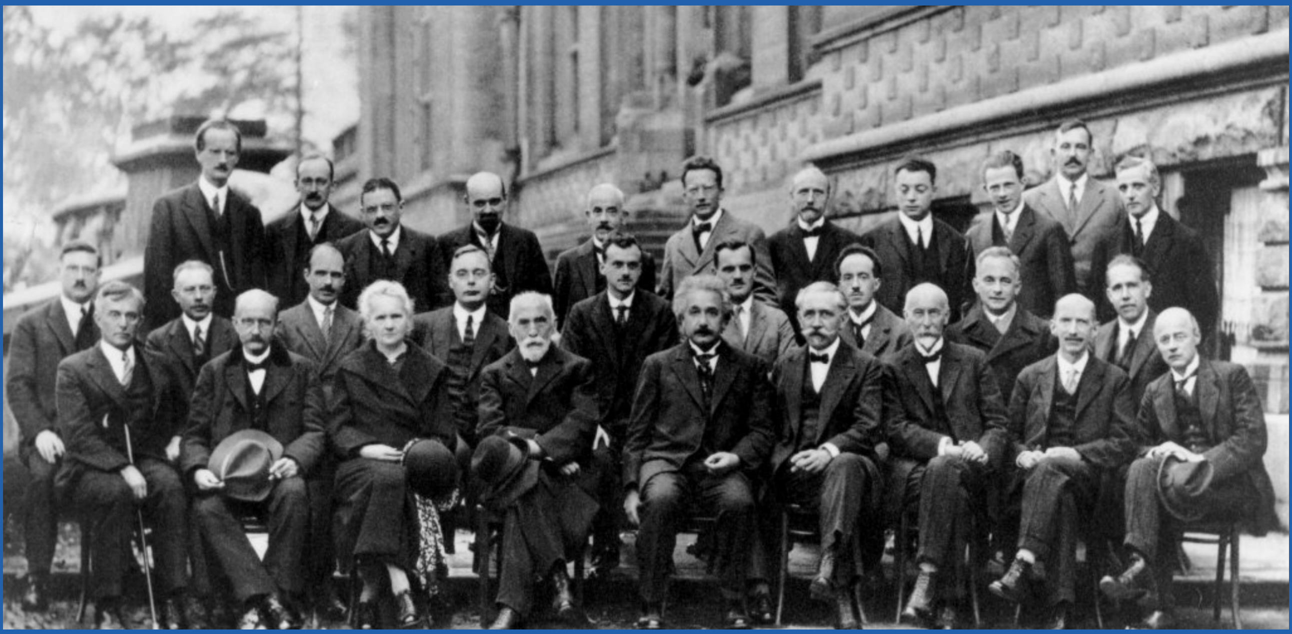
Walter Nernst vond dus een vruchtbare bodem bij E. Solvay toen hij voorstelde om een kleine selecte groep topwetenschappers bijeen te brengen en de eerste “*Conseil de Physique*” te organiseren in 1911. De scheikundige Wilhelm Ostwald presenteerde in dezelfde periode een project voor een Internationaal Instituut voor Scheikunde aan Solvay.

”Vele Nobelprijswinnaars werden geregeld uitgenodigd om deel te nemen.“

Het idee van Nernst bleek het meest effectief. Onder andere Henri Poincaré werd erg geïnspireerd door de discussies van de eerste *”Conseil de Physique”* in 1911. “Voor Solvay was de echte revelatie zijn ontmoeting met voorzitter Hendrik A. Lorentz uit Leiden, de grote meester van de theoretische fysica, die de leiding had over de debatten en die door iedereen werd bewonderd en gerespecteerd”, zegt Rocci. “Hier was een man die kon helpen bij de uitvoering van een plan dat de industrieel na aan het hart lag: de toekenning van onderzoekssubsidies aan wetenschappers uit de hele wereld en de organisatie van terugkerende Raden voor Natuurkunde en Scheikunde.”

De samenwerking tussen Solvay en Lorentz leidde tot de geboorte van het Internationale Solvay Instituut voor Natuurkunde in mei 1912. “Ons huidige begrip van de geschiedenis van Solvay’s project en zijn ontwikkelingen is dat het, via de discussies op de Raden, het kennisproces over de kwantumfysica versnelde. Door het toekennen van subsidies aan internationale laboratoria kon de kwantumtheorie verder uitgewerkt worden.”

De Solvayraden stonden en staan nog steeds hoog aangeschreven bij de wetenschappers. “Vele Nobelprijswinnaars werden geregeld uitgenodigd om deel te nemen: Marie Curie, Einstein, Bohr, Heisenberg, Schrödinger, Feynman en meer recent Gell-Mann, Gross en Englert, om er een paar te noemen”, zegt Rocci. “Velen van hen werden vereeuwigd op groepsfoto’s in het decor van het Leopoldpark in Brussel.”



De Solvay Conferentie van 1927 wordt beschouwd als een van de meest memorabele ooit. Deze foto is genomen in het Brusselse Leopoldpark.

Solvay richtte ook een internationaal instituut voor scheikunde op in 1913 en na de Eerste Wereldoorlog, in 1922, begon een tweede wetenschappelijk comité met het organiseren van de Solvay Chemistry Councils. Solvay stierf een maand later. "De nieuwe raden sloegen eerst een brug tussen natuurkunde en scheikunde en daarna ook tussen scheikunde en andere wetenschappen", zegt Rocci. "Net als de natuurkunderaden kwamen Nobelprijswinnaars uit de scheikunde bijeen op de scheikunde-bijeenkomsten, waar ze een forum kregen om hun baanbrekende ontdekkingen te bespreken, zoals de studie van Watson en Crick uit 1953 over de structuur van DNA."

Voor Solvay was biologie één van dé domeinen die evengoed een Solvayraad verdienden. Hij drong daar ook op aan, zoals we weten uit de archiefdocumenten over de vergaderingen van het Internationaal Wetenschappelijk Comité van de Raden van de Scheikunde. "Tot nu was het er niet van gekomen", zegt Rocci. "Men vond nooit een voldoende reden om ze te organiseren. Nu zijn veel experts het erover eens dat we aan het begin staan van een nieuwe revolutie in ons begrip van de levende wereld, dankzij het convergerende werk van biologen, scheikundigen, natuurkundigen, computerwetenschappers en statistici. Zij analyseren data en bouwen modellen die in wiskundige termen zijn geformuleerd. Wiskunde is de essentiële taal die door alle wetenschappelijke theorieën wordt gedeeld. Dankzij dat werk kan de fundamentele biologie kwantumsprongen maken en mogelijk de deur openen naar nieuwe therapeutische toepassingen ten bate van de mensheid."

Press and newspaper

VUB – 17.04.2024

De eerste Solvay Conferentie voor Biologie vindt plaats in het iconische Flageygebouw.

De Solvay Instituten willen een belangrijke speler zijn in de ontwikkeling van de biologie van de 21e eeuw, net zoals ze dat zijn geweest voor fysica en chemie. Dat resulteert vanaf dit jaar in de eerste Biologieraad, naar het unieke model van de Raden voor Fysica en Chemie. De eerste Solvayraad voor Biologie loopt van 18 tot 20 april en zal worden voorgezeten door professor Thomas Lecuit van het Collège de France, directeur van het Turing Center for Living Systems. "De raad, getiteld The Organization and Dynamics of Biological Computation, zal 35 experten bijeenbrengen die geselecteerd zijn door een internationaal wetenschappelijk comité. De Raad wil op multidisciplinaire wijze ons begrip bevorderen van de manier waarop informatie door biologische systemen wordt overgedragen en verwerkt. Het onderzoek van Thomas Lecuit over de algemene vraag naar de oorsprong van vormen in de biologie en de aard van morfogenetische informatie, is een perfect voorbeeld van transdisciplinariteit: belangrijke bijdragen aan het begrip van morfogenese werden voor het eerst voorgesteld door de beroemde wiskundige Alan Turing in 1954 en vervolgens verfijnd door de biologen Lewis Wolpert en Francis Crick in de jaren 1970."

Ook voor de Biologieraad worden de grote kanonnen uit de kast gehaald, met onder andere een reeks lezingen door topwetenschappers tijdens het publieke event op zondag 21 april in Flagey. Anthony Hyman, directeur van het Max Planck Instituut in Dresden en winnaar van de prestigieuze *Breakthrough Prize in Life Sciences* (2023), zal het hebben over de fysische en chemische mechanismen van informatieoverdracht op cellulair niveau in zijn lezing *Het sociale leven van een cel*.

"Elke wetenschapper kent twee familienamen: Nobel en Solvay."

Dankzij Stephanie Palmer, professor aan de Universiteit van Chicago, die de lezing *"Seeing What's Coming"* geeft, zullen we de anticipatiemechanismen van onze hersenen begrijpen. Hoe beoordeelt Serena Williams de beste plaats om de bal van haar tegenstander te vangen en terug te slaan, en dat allemaal in minder dan een fractie van een seconde...?

Het parcours van Solvay, de ontwikkeling en de geschiedenis van de Raden en de Internationale Solvay Instituten worden momenteel onderzocht aan de Vrije Universiteit Brussel (VUB) via haar deelname aan het *Solvay Science Project*, een samenwerking tussen de twee Brusselse universiteiten VUB en ULB. Het Solvay Science Project diende als basis voor de verspreiding van de geschiedenis van de Raden en maakte deel uit van het voorstel om het Solvay-Archief op te nemen in het Memory of the World Register van UNESCO, een erkenning die er vorig jaar ook officieel kwam.

"Met de eerste Solvayraad voor Biologie knopen de Solvay Instituten aan bij een toch wel indrukwekkende en lange traditie", besluit VUB-rector Jan Danckaert. "Elke wetenschapper kent twee familienamen: Nobel en Solvay. De Solvay Raden brengen al meer dan een eeuw de wereldtop van de wetenschap naar Brussel. Ik nodig iedereen die gebeten is door wetenschappen uit om zondag naar Flagey te trekken voor een unieke inkijk in dat erg belangrijke gebeuren. Of je kan de geschiedenis van de Solvay raden online bestuderen via de website van het *Solvay Science Project*."

Wordt verwacht: boek over impact van Ernest Solvay's project op de eerste kwantumrevolutie

Alessio Rocci is postdoctoraal fellow aan de VUB dankzij het Fonds voor natuurwetenschappen in de samenleving, dat werd opgericht door VUB-alumna **Krist'l van Ouytsel.** Rocci werkt samen met **Franklin Lambert**, gepensioneerd hoogleraar aan de VUB en voormalig lid van de Solvay Instituten. Lambert publiceerde al een boek met Frits Berends over de geschiedenis van de eerste raden getiteld Einstein's Witches' Sabbath and the Early Solvay Councils. Het onvertelde verhaal.

Rocci en Lambert bereiden nu een boek voor over de impact van Ernest Solvay's Project op de eerste kwantumrevolutie.

Press and newspaper

VUB – 21.04.2024


2024 Solvay-lezingen: biologie

Met de eerste Solvayraad voor Biologie knopen de Internationale Solvay Instituten aan bij een grote en uiterst belangrijke wetenschappelijke traditie. Grote kanonnen worden uit de kast gehaald, met onder andere een reeks lezingen door topwetenschappers tijdens het publieke event op zondag 21 april in Flagey.

Solvay Biologieraad

De Solvay Instituten willen een belangrijke speler zijn in de ontwikkeling van de biologie van de 21e eeuw, net zoals ze dat zijn geweest voor fysica en chemie. Dat resulteert vanaf dit jaar in de eerste Biologieraad, naar het unieke model van de Raden voor Fysica en Chemie. De eerste Solvayraad voor Biologie loopt van 18 tot 20 april en zal worden voorgezeten door professor Thomas Lecuit van het Collège de France, directeur van het Turing Center for Living Systems. De Solvayraad zelf is besloten.

Publieke lezingen

Op 21 april vindt in Flagey een publiek event plaats. Op het programma staan verschillende lezingen van vooraanstaande wetenschappers:

- **Anthony Hyman**, directeur van het Max Planck Instituut in Dresden en winnaar van de prestigieuze Breakthrough Prize in Life Sciences (2023), zal het hebben over de fysische en chemische mechanismen van informatieoverdracht op cellulair niveau in zijn lezing Het sociale leven van een cel.

- Dankzij **Stephanie Palmer**, professor aan de Universiteit van Chicago, die de lezing Seeing What's Coming geeft, zullen we de anticipatiemechanismen van onze hersenen begrijpen. Hoe beoordeelt Serena Williams de beste plaats om de bal van haar tegenstander te vangen en terug te slaan, en dat allemaal in minder dan een fractie van een seconde.

Eerste Solvayraad voor Biologie in de geschiedenis

Op 15 juni 1911 ontvingen twintig vooraanstaande natuurkundigen een "Uitnodiging voor een Internationale Wetenschappelijke Raad om actuele kwesties van de moleculaire en kinetische theorie op te helderen". De uitnodiging was vertrouwelijk en ondertekend met "E. Solvay". Vandaag de dag wordt de Raad die van 30 oktober tot 3 november 1911 in Brussel werd gehouden beschouwd als de eerste internationale conferentie over de fysica in de geschiedenis en wordt zijn belang voor de vooruitgang van de wetenschap wereldwijd erkend. Na de Eerste Wereldoorlog, in 1922, begon een tweede wetenschappelijk comité met het organiseren van de Solvay Conferences on Chemistry. Voor Solvay was biologie één van dé domeinen die evengoed een Solvayraad verdienden. Hij drong daar ook op aan, zoals we weten uit de archiefdocumenten over de vergaderingen van het Internationaal Wetenschappelijk Comité van de Raden van de Scheikunde.

"Tot nu was het er niet van gekomen", zegt VUB-postdoctoraal onderzoeker Alessio Rocci. Rocci werkt met het Solvay Archief, bewaard aan de ULB, onder toezicht van Rector en fysicus Prof. Jan Danckaert."Men vond nooit een voldoende reden om ze te organiseren. Nu zijn veel experts het erover eens dat we aan het begin staan van een nieuwe revolutie in ons begrip van de levende wereld, dankzij het convergerende werk van biologen, scheikundigen, natuurkundigen, computer-wetenschappers en statistici. Zij analyseren data en bouwen modellen die in wiskundige termen zijn geformuleerd. Wiskunde is de essentiële taal die door alle wetenschappelijke theorieën wordt gedeeld. Dankzij dat werk kan de fundamentele biologie kwantumsprongen maken en mogelijk de deur openen naar nieuwe therapeutische toepassingen ten bate van de mensheid."

Lees meer over de geschiedenis van de Solvayraden

De eerst Solvay Conferentie in 1911 in Brusselse hotel Metropole met grote namen als Hendrik Lorentz, Max Planck en Albert Einstein. Foto: Solvay Archief

Press and newspaper

Le 1/4h Sciences - 18 April 2024

La Première – Info

Premier Conseil Solvay de biologie

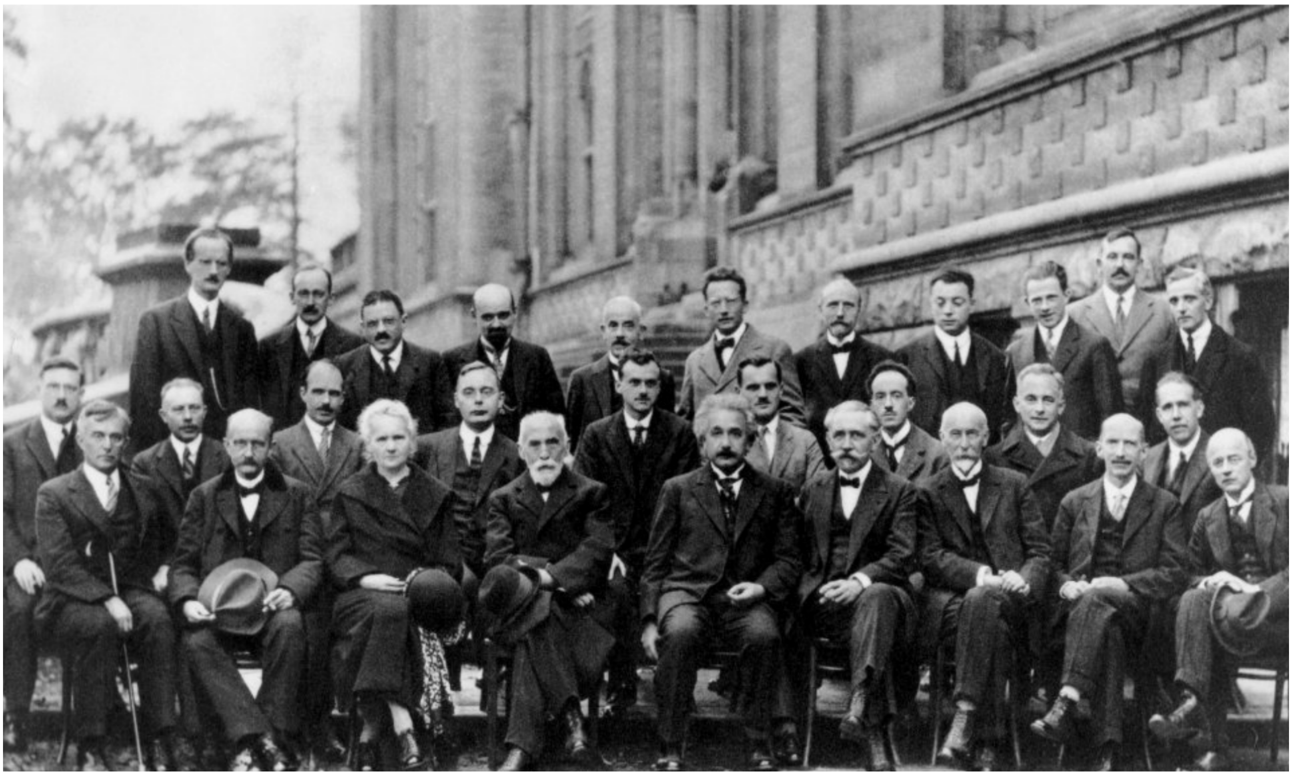
Le 1/4h Sciences – Le top mondial de la science du vivant est à Bruxelles jusqu'à dimanche pour le premier Conseil Solvay de biologie. Éclairage avec Johanne Montay. On en parle avec Marina Solvay, l'arrière arrière-petite-fille d'Ernest Solvay et le professeur Marc Henneaux, directeur des Instituts Solvay.

Inauguration Parc Leopold

The organizer Yves Leenaerts describes the event for us.

L'initiative est partie d'un groupe d'amis datant d'études d'agronomie à l'ULB, MM. Michel Thuy, Philippe De Staercke et Jean Fonteyne, de mes fils Nathan, Adrien, Alexandre et moi-même, Yves Leenaerts.

Au début il y a des lectures de vulgarisation et la mention unanime dans les livres et revues consultés de l'importance décisive pour le développement de la physique quantique du **Congrès Solvay de physique de 1927.** Ensuite, la constatation que rien ne rappelait l'événement, là où a été prise une des photos les plus célèbres de l'histoire des sciences, avec les participants au congrès, sur les marches du lycée Emile Jacqmain (anciennement occupé par l'Institut de Physiologie), dans le parc Léopold à Bruxelles.



C’est cela qui a déclenché l’envie de faire poser un panneau commémoratif.

En plus d’un hommage aux participants du congrès, nous souhaitions promouvoir la vulgarisation de la physique quantique: à cet effet, trois QR codes figurent sur le panneau:

- L’un renvoie au Solvay Science Project (nous avions eu un contact téléphonique avec Mme Marina Solvay qui avait signalé ce site comme source historique sur les congrès Solvay depuis 1911)

- Les deux autres aux versions en français et en anglais d’une chaîne youtube, *scienceclic*, plus précisément sur la série intitulée “Le Monde Quantique”.
  Cette chaîne YouTube est réalisée par M. Alessandro Roussel, un diplômé de physique et mathématiques qui est aussi un vulgarisateur et vidéaste hors-pair.

Inauguration Parc Leopold

Je tiens à remercier toutes les personnes ayant rendu ce projet possible:

M. Jean-Marie Solvay a immédiatement accepté de participer au financement à travers les Instituts Internationaux Solvay de Physique et de Chimie. Avec en complément, une cagnotte en ligne que nous avons lancé.

M. Philippe Mahillon du Studio Barabas, qui a réalisé par après le panneau, nous a conseillés pour trouver un modèle conforme, de qualité, à un prix raisonnable.

Pour les démarches administratives: le professeur Pasquale Nardone (professeur de physique de l'ULB et vulgarisateur) a appuyé notre demande auprès de Mme Zoubida Jellab, échevine de la Ville de Bruxelles. Nous avons aussi été aidés et guidés par Mme Juliette Leboulleux, travaillant dans le cabinet de l'échevine et Mme Catherine Leclercq, des services de l'urbanisme.

Le texte proposé pour le panneau a été révisé par le Pr Nardone, déjà cité et le Pr Marc Henneaux (directeur des Instituts Solvay), les traductions en anglais et néerlandais ont été vérifiées par Mmes Linda Mauperon et Adinda Bruneau.

Lors de l'inauguration, M. Jean-Marie Solvay et M. Jacques Houard, physicien, ont pris la parole deux anciennes élèves du lycée Jacqmain, Mlles Anna et Justine ont dévoilé le panneau.

Parmi le public se trouvaient notamment Mme Agnès Hermans, directrice du Lycée Jacqmain et Mme Natty Anulewicz, Chef de service adjoint des espaces verts de la Ville de Bruxelles.

La fanfare des Chasseurs de Prinkères, dirigée par M. André Vital, nous a accompagnés.

From the archives

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
2019	Computational Modeling: From Chemistry to Materials to Biology
2022	Chemistry Challenges of the 21st Century

Chairs of the International Scientific Committee for Chemistry

1922 – 1939	Sir William Pope Cambridge, UK
1945 – 1958	Paul Karrer 1937 Nobel Laureate in Chemistry Zurich, Switzerland
1958 – 1988	Alfred Ubbelohde London, UK
1989 – 2011	Stuart Rice Chicago, USA
2011 – 2022	Kurt Wüthrich 2002 Nobel Laureate in Chemistry Zurich, Switzerland and La Jolla, USA
2022 – present	Ben Feringa 2016 Nobel Laureate in Chemistry Groningen, The Netherlands

From the archives

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

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

2022 The Physics of Quantum Information

2023 The Structure and Dynamics of Disordered

From the archives

Chairs of the International Scientific Committee for Physics

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

Solvay conferences on Biology

2024 The organisation and dynamics of biological computation

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 (Zurich 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

From the archives

Solvay Public Lectures

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 (Zurich 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)

20 October 2019 | "Frontiers of Chemistry"

"Optical microscopy: the resolution revolution"
by Stefan Hell, (Max Planck Institute, Öttingen, Germany)
2014 Nobel Laureate in Chemistry

"To get to know biological molecules, freeze them and photograph them!"
by Eva Nogales (UC Berkeley, USA)

12 September 2021 | "Physics, Chemistry and Life Sciences"

"How personalised is your immune repertoire?"
by Aleksandra Walczak (ENS, Paris, France)

"Why we cannot make artificial life in a laboratory"
by Bert Meijer (Eindhoven, The Netherlands)

From the archives

Solvay Public Lectures

12 September 2021 | "Physics, Chemistry and Life Sciences"

"Steps towards complex matter: chemistry!"
by Jean-Marie Lehn (Strasbourg, France)
1987 Nobel Laureate in Chemistry

24 October 2021

"Exoplanets or the Quest for Life around Another Sun"
by Michaël Gillon (Liège University, Belgium)

22 May 2022 | "The New Quantum Revolution"

"The Strangeness and the power of quantum physics"
by Serge Haroche (Collège de France, Paris)

"Quantum computing and the entanglement frontier"
by John Preskill (Caltech, USA)

16 October 2022

"Water Harvesting from Air Anytime Anywhere"
by Omar Yaghi (Berkeley, USA)

"What is Life?"
by Paul Nurse (Crick Institute, UK)

22 October 2023 | "Complex systems and collective behaviors"

"Computational optimization: from glasses to black holes"
by Leticia Cugliandolo (Sorbonne Université, Paris)

"How many candies are in that jar? A dynamical phase transition"
by Paul Chaikin (New York University)

The international Solvay Chairs in Physics and in Chemistry

Syensqo Chairs in Chemistry by the International Solvay Institutes

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

2015 Andreas Manz, Saarbrücken, Germany

2016 Raymond Kapral, Toronto, Canada

2017 Richard Henderson, 2017 Nobel Laureate in Chemistry, Cambridge, UK

2018 Ben Feringa, 2016 Nobel Laureate in Chemistry, U. of Groningen, The Netherlands

2019 Gernot Frenking, Philipps-U. Marburg, Germany

2020 Joanna Aizenberg, Harvard, USA

2021 Omar Yaghi, Berkeley, USA

2022 Daniel Jacob, Harvard University, USA

2023 Ehud Gazit, Tel-Aviv University, Israel

2024 Markus Antonietti, Potsdam, Germany

From the archives

The international Solvay Chairs in Physics and in Chemistry

Jacques Solvay Chairs in Physics

2006 Ludwig Faddeev, Saint-Petersburg, Russia

2007 Michael Berry, Bristol, UK

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

2009 Valery Rubakov, Moscow, Russia

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

2011 Nathan Seiberg, Princeton, USA

2012 Jan Zaanen, Leiden, The Netherlands

2013 Gian Giudice, CERN, Switzerland

2014 Viatcheslav F. Mukhanov, LMU Munich, Germany

2015 Peter Zoller, Innsbruck, Austria

2016 Dam Thanh Son, Chicago, USA

2017 Uri Alon, Rehovot, Israel

2018 Bernard Derrida, Collège de France, France

2019 Gary Gibbons, Cambridge, UK

2020 Roger Blandford, Stanford University, USA

2021 Jean Dalibard, Collège de France, France

2022 Juna Kollmeier, Canadian Institute for Theoretical Astrophysics, Toronto, Canada

2023 Subir Sachdev, Harvard University, USA

2024 Samaya Nissanke, Amsterdam, The Netherlands

2011 Solvay Centenary Chair

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

From the archives

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 1977 Nobel Laureate in Chemistry Professor ULB
2003 - 2004	André Jaumotte Honorary Rector and Honorary President ULB
2004 - present	Marc Henneaux Professor ULB and Collège de France

Colophon

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