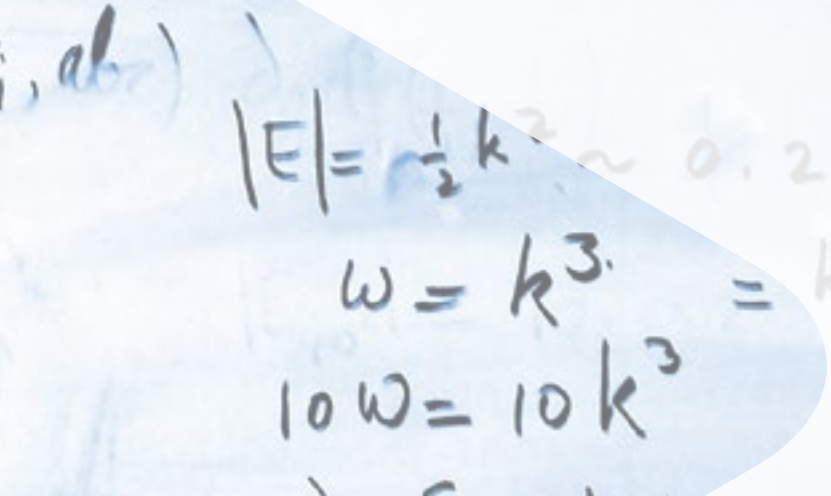
Annual Report **2018**

Delta
Institute for Theoretical Physics



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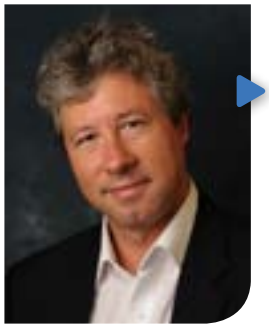


It is with pleasure and pride that I present to you the annual report 2018 of the Delta Institute for Theoretical Physics. For theoretical physics worldwide 2018 was a special year because of the passing away of one of the greatest theoretical physicists of the 20th century: Stephen Hawking. Honouring his scientific legacy, the Netherlands Royal Academy of Arts and Sciences organised a wonderful symposium in which several Delta ITP members participated. The symposium in the public library of Amsterdam was oversubscribed and reminded us of the amazing depth and creativity of Hawking's work, let alone his exceptional character.

For the Dutch theoretical physics community 2018 was also a special year with the announcement and award ceremony of the 21st Lorentz Medal to Juan Martín Maldacena. The award ceremony in the Fall celebrated Maldacena's groundbreaking contributions over the last two decades, which has seen amazing applications connecting different branches of theoretical physics, and is one of the core elements in the research program of Delta ITP.

For Delta ITP the year 2018 was the last year that two new PhD projects could be initiated, representing the start of moving towards the end of the Zwaartekracht funding in 2022. This is a natural moment to start thinking about the Delta ITP strategy beyond 2022. The installation of the Scientific Advisory Committee at the end of 2018 is part of this renewed emphasis on the future of Delta ITP that will become more important in the years to follow. Over the years Delta ITP has proven its strength in both providing a unified and collaborative program and at the same time allowing for an innovative and diverse range of high quality researchers and projects. This is highlighted again in the 2018 annual report. The achievements cover a wide range of topics, backgrounds and stages of careers. In the future we hope to further strengthen this 'unity through diversity' element of the Delta ITP consortium.

The year 2018 saw the arrival of two very talented Delta ITP fellows: Tanja Hinderer and Vincenzo Alba. Unfortunately Delta ITP also had to say goodbye to one of its core junior faculty members Enrico Pajer, who has chosen to play a leading role in the cosmology effort at DAMTP Cambridge. A search is currently ongoing to fill the position that has opened up. In closing I would like to invite everybody to start thinking about new and fresh ideas regarding the future of Delta ITP, beyond the end of the Zwaartekracht funding in 2022. Delta ITP is in a strong and unique position thanks to all of you. I am looking forward collecting all your plans and suggestions!

Erik Verlinde, chair of Delta ITP

Changes among Delta board members

A new **Supervisory Board** was installed in the fall of 2018. For continuity reasons, the position of Eric Eliel (Leiden University) as chairman was extended with approval of the CvB of the University of Amsterdam. Stefan Vandoren (Utrecht University) is replacing Henk Dijkstra, and Paul de Jong (University of Amsterdam) is replacing Daniel Bonn in the Supervisory Board.

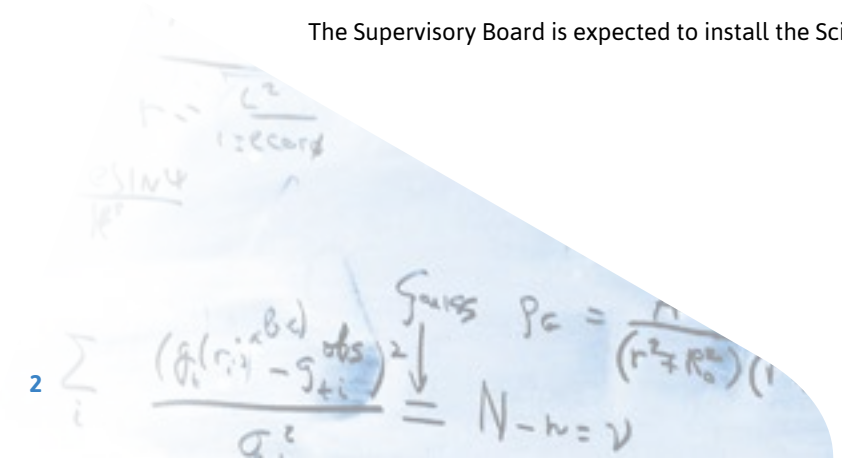
In the **Educational Board,** Lars Fritz (Utrecht University) replaced Enrico Pajer (Utrecht University), who left Delta ITP in the summer of 2018.

The new McKinsey representative in the **Industry Advisory Council** (after Jurjen Koksma left) is Christiaan Zwart, Fall 2018.

In the fall of 2018, four distinguished scientists were invited to join the Delta **Scientific Advisory Council**, as recommended in the mid-term review. All four of them accepted. They are:

- **Prof. Gert Schön** (chair)
  Karlsruhe University, Institut für Theoretische Festkörperphysik.
- **Prof. Luis Álvarez-Gaumé**
  director of the Simons Centre for Geometry and Physics, Stony Brook University.
- **Prof. Ruth Gregory**
  Durham University, Institute for Particle Physics Phenomenology.
- **Prof. Dov Levine**
  Technion University, Dept of Physics.

The Supervisory Board is expected to install the Scientific Advisory Council in the Spring of 2019.



New Delta staff and fellows

New Delta Fellows

Vincenzo Alba
Amsterdam (Fall 2018) - Condensed Matter Theory.

"My research interests lie at the interface between statistical mechanics, condensed matter physics, quantum information, and mathematical physics. In my research I combine theoretical tools borrowed from these areas with state-of-the-art numerical methods. The goal is to study universal aspects of quantum many-body systems both at equilibrium and out-of-equilibrium. An important general aim of my research is to understand how statistical mechanics and thermodynamics emerge from the out-of-equilibrium dynamics of isolated quantum systems.

Entanglement is the cornerstone to this research because it is a witness of the quantum wavefunction complexity. Understanding its dynamics and its scaling properties is one of the main goals of my research. This has the potential to provide a general explanation for why simple descriptions, such as statistical mechanics, hydrodynamic approaches, and numerical methods can be so effective to describe many-body quantum states."

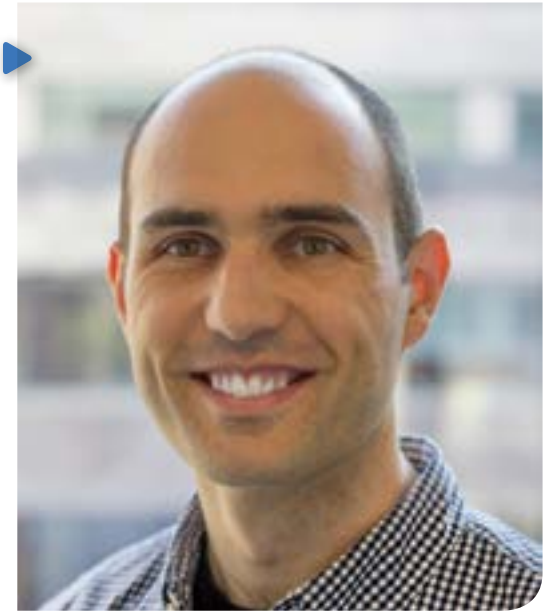
Tanja Hinderer
Amsterdam (Summer 2018) - Gravitational-Wave Physics.

"My research focuses on modeling the gravitational waves from merging black holes and neutron stars. Black holes consist solely of strongly curved spacetime according to General Relativity while neutron stars are the densest stable material objects known in the universe, with matter compressed by gravity to up to several times the nuclear density where all four fundamental forces are simultaneously important. Understanding such objects, their cosmological context, astrophysical environment, and the nonlinear, dynamical gravity driving their mergers have been longstanding scientific frontiers and are among the core themes in the Delta ITP's mission.

Gravitational waves are now available as a new tool to elucidate these questions. Interpreting the signals and extracting the source physics relies on cross-correlating the data with theoretical models that must accurately describe all relevant physical effects. My research develops such models using various analytical methods, thus providing essential inputs for capitalizing on the enormous science potential with gravitational waves."

Delta alumni

In 2018 Delta ITP had to say goodbye to **Enrico Pajer**, who was hired in 2013 as a core Delta ITP junior faculty member in the area of theoretical cosmology. At that time Enrico (previously at Princeton University and Cornell University) was a rising star in the exciting field of cosmology, who combined very broad (observational) knowledge with state-of-the-art formal theoretical string cosmology. As Delta ITP faculty he further developed to become a world leader in the field of theoretical cosmology. Specifically his innovative work on applying effective field theory techniques to both cosmological inflation and large-scale structure models stands out.



In 2015 Enrico received a prestigious Vidi grant from the Netherlands Organisation for Scientific Research (NWO).Over the 5 years that he was a Delta ITP faculty member he supervised 5 postdocs and 4 PhD students. He was involved in 3 joint Delta ITP research projects. Enrico also served on the Delta ITP educational board, being an important force in the development and execution of the annual Delta ITP Advanced Topics educational program.

Delta ITP severely regrets seeing Enrico leave, but congratulates him with his new position as University Lecturer at DAMTP, Cambridge. We wish him al the best with this important step in his career, becoming one of the leading cosmologists in Cambridge. We thank him for his significant contributions to help build Delta ITP to become a world-leading consortium in theoretical physics.

Triangle meetings

The Delta triangle meetings are a regular series of events sponsored (partly) by Delta ITP with the objective of bringing together the theoretical physics communities in Amsterdam, Leiden, Utrecht and sometimes our sister nodes Groningen, Brussels (ULB and VUB), and Leuven. The main themes of these triangle meetings cover the wide field of Delta research: holography and its applications to different physical systems, cosmology, and quantum/topological matter.

Holography

*Among the invited speakers were world-leading scientists like **Tom Hartman**, **Tadashi Takayanagi** and **Horacio Casini**.*

30 November, Utrecht.
Speakers: Blaise Gouteraux (Ecole Polytechnique, Paris) and Fridrik Freyr Gautason (KU Leuven).

26 October, Amsterdam.
Speakers: Sergei Dubovsky (NYU) and Wilke van der Schee (Utrecht University).

28 September, Leiden.
Speakers: Niels Obers (Niels Bohr Institute, Kopenhagen) and Umut Gursoy (Utrecht University).

1 June 2018 Groningen.
Speakers: Tadashi Takanayagi (Yukawa Institute for Theoretical Physics (YITP), Kyoto University, Horacio Casini (CONICET and Instituto Balseiro, Bariloche, Argentina), Michal Heller (MPI for Gravitational Physics, Potsdam) and Ben Craps (Vrije Universiteit Brussel).

20 April, Utrecht.
Speakers: Brian Willett (KITP, Santa Barbara) and Gui Pimentel (University of Amsterdam).

23 March, Amsterdam.
Speakers: Jared Kaplan (Johns Hopkins University) and Aurelio Romero-Bermudez (Leiden University).

23 February, Leiden.
Speakers Tomonori Ugajin (KITP Santa Barbara) and Miguel Montero (Utrecht University).

19 January, Brussels, Belgium.
Speakers: Ofer Aharony (Weizmann Institute of Science, Israel), Rodolfo Russo (Queen Mary, University of London), Tom Hartman (Cornell University) and Alejandra Castro (University of Amsterdam).

Theoretical Cosmology Meetings

Several renowned speakers visited the theoretical cosmology meetings, such as ***Andrew Tolley*** *and* ***Liam McAllister****.*

12 January, Groningen
Speakers: Andrew Tolley (Imperial College), Enrico Pajer (Utrecht University) and Daan Meerburg (Cambridge and Groningen University).

9 **March, Utrecht**
Speakers: Cristiano Germani (Barcelona University) and Diederik Roest (Groningen University).

6 April, Leiden
Speakers: José Juán Blanco Pillado (UPV-EHU Bilbao) and Krzysztof Turzynski (U. Warsaw).

8 June, Groningen
Speakers: Djuna Croon (Dartmouth College), Tomi Koivisto (Nordita), and Anupam Mazumdar (Groningen University).

9 November, Leiden
Speakers: Will Kinney (Buffalo University), Andrii Magalich (Leiden University), and Fabio Finelli (INAF, Bologna).

7 December, Amsterdam
Speakers: Rafael Porto (DESY & ICTP Sao Paulo) and Liam McAllister (Cornell). This meeting was combined with Daniel Baumann's inaugural lecture for his appointment as full professor at the University of Amsterdam.

Quantum and Topological Matter

Among the most prominent speakers were ***Duncan Haldane*** *(Nobel Prize 2016) and* ***Tom Lubensky*** *(Lorentz professor 2018).*

2 March, Amsterdam
Speakers: Eoin Quinn (University of Amsterdam), Tom Price (Utrecht University) and Alexander Chudnovskiy (Hamburg).

4 May, Leiden
Speakers: Theo Nieuwenhuizen (University of Amsterdam), Gerwin van Dalum (Utrecht University), Jette van der Broeke (Utrecht University) and Tom Lubensky (University of Pennsylvania & Leiden).

4 September, Utrecht
Special Topological Triangle Meeting with Prof. Duncan Haldane (Princeton, Nobel Prize 2016), organised by Delta Board member Cristiane Morais Smith. Speakers: Kareljan Schoutens (University of Amsterdam), Cristiane Morais Smith (Utrecht University), Vladimir Gritsev (University of Amsterdam), Chuan Li (University of Twente), Jasper van Wezel (University of Amsterdam), Lars Fritz (Utrecht University) and Duncan Haldane (Princeton).

23 November, Amsterdam
Speakers: Emil Yuzbashyan (Rutgers University, USA), Jiri Minar (University of Amsterdam, QuSoft) and Axel Cortes Cubero (Utrecht University).

Gerard 't Hooft and Duncan Haldane (right) showing their Nobel Prize Medals during the Special Topological Triangle Meeting, 4 sept. 2018..

Workshops

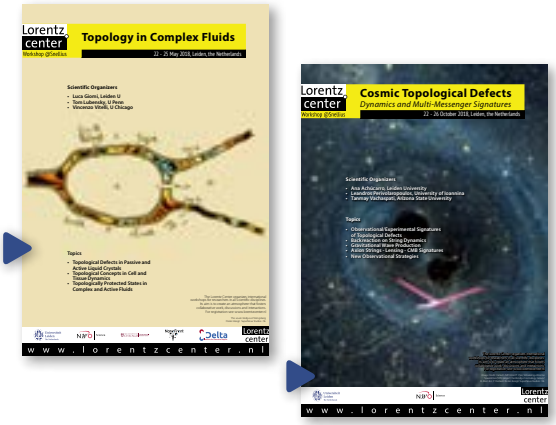
Delta ITP operates a continuous call for mini-workshop proposals that cover the broad area of research themes that are part of the Delta programme. The typical amount provided is 5k Euro per application.

In 2018 Delta ITP (partially) funded the following workshops:

Strange metals and holography (Nijmegen, 2 - 4 January 2018), Koenraad Schalm. This workshop also served as the kick-off meeting of the joint FOM program to pursue the experimental verification of holographic theory in so-called 'strange metals'.

Topology in complex fluids, (Leiden, 22 - 25 May 2018), Luca Giomi. Co-organiser and keynote speaker was Tom Lubensky (Un. of Pennsylvania), the 2018 Lorentz professor in Leiden.

Cosmological Topological Defects: dynamics and multi-messenger signatures (Leiden, 22 - 26 October 2018), Ana Achúcarro.



Talent management

The training of the most talented students is of great importance for the successful continuation of the Delta ITP scientific programme. Ultimately, the upcoming generations of PhD students and postdocs will have to execute most of the research set forth in our ambitions.

Twice a year, Delta ITP provides a course on Advanced Topics in Theoretical Physics, aimed at PhD students and advanced master students. Lectures are given by Delta ITP staff members, and sometimes by visiting professors. The courses, each consisting of three modules given by different lecturers, are embedded in the educational program of the Dutch Research School of Theoretical Physics DRSTP.

Spring 2018: Spontaneous Symmetry Breaking
With lectures by Jasper van Wezel (UvA), Alexey Boyarsky (UL), and Irene Valenzuela (UU).

Fall 2018: Topological methods in theoretical physics
With lectures by Vladimir Gritsev (UvA), Ana Achúcarro (UL), and Vladimir Juricic (NORDITA, Stockholm).

In the spotlight

President of the Royald Netherlands Academy of Arts and Sciences Prof. Wim van Saarloos presented the Lorentz Medal to Prof. Juan Maldacena.

Lorentz Medal for Juan Maldacena

Theoretical physicist Juan Martín Maldacena, professor at the Institute for Advanced Study in Princeton, has been awarded the 2018 Lorentz Medal for his pioneering and innovative work in theoretical physics over the past two decades. His publication on the AdS/CFT correspondence is the most frequently cited article in the field of high energy physics.

The Royal Netherlands Academy of Arts and Sciences established the Lorentz Metal on 11 December 1925 on the occasion of the 50th anniversary of the doctorate of Hendrik Antoon Lorentz (1853-1928), Nobel Prize winner and father of theoretical physics in the Netherlands. The Lorentz Medal is awarded every four years to a researcher who has made groundbreaking contributions to theoretical physics. Of the 21 laureates of the Lorentz Medal, eleven have gone on to win Nobel prizes.

The medal was awarded to Juan Maldacena on 19 November 2018, on the occasion of which a symposium, '**Views on Space-Time**', was organised.

On Wednesday 21 November 2018, Juan Maldacena presented his work in the famous Colloquium Ehrenfestii in Leiden, '**Wormholes and entangled states**'.

Dutch Brazilian collaboration

In May 2018, **Cristiane Morais Smith** (Utrecht University) got a project approved for a collaboration between Brazil and the Netherlands (CAPES/NUFFIC) - the only project approved in Physics. It's a joint project with the Federal Univeristy of Rio Grande do Norte, with Tommaso Macri as the Brazilian Project Leader and Cristiane Morais Smith as the Dutch Project Leader. Several PhD's and postdocs from Brazil will come to her group during the next years.

Leiden physicist Carlo Beenakker received an honorary doctorate from the Bogoliubov Institute for Theoretical Physics in Kiev

For many years, physicists at Leiden University have had a close relationship with colleagues in the Ukraine. As a token of recognition for this cooperation, **Carlo Beenakker** received an honorary doctorate from the Bogoliubov Institute for theoretical physics in Kiev in October 2018.

Beenakker is a member of an international advisory committee of the Ukrainian ministry of sciences and therefore visits the country on a regular basis. Beenakker: "*I'm always happy to visit the Bogoliubov Institute, which is a school of extremely good students. The working conditions in Ukraine are not easy, but they succeed to maintain a high level of science.*"

Carlo Beenakker among 2018 Highly Cited Researchers list

Leiden physicist Carlo Beenakker appeared on **the 2018 Highly Cited Researchers list**, which was announced on 28 November 2018 by Clarivate Analytics. This list recognizes world-class researchers selected for their exceptional research performance, demonstrated by production of multiple highly cited papers that rank in the top 1% by citations for field and year in Web of Science.

Science & Cocktails, Amsterdam edition

In September 2018 the very first edition of the Amsterdam series of **Science & Cocktails** took place. Theoretical physicist **Jacomé Armas** (University of Amsterdam) took his brainchild to Amsterdam, after nearly a decade of successful and awarded editions in Copenhagen, Johannesburg and Brussels. At the stage of Paradiso theatre in downtown Amsterdam, Jacomé Armas serves the audience a sparkling mix of science, dry ice cocktails and music. In the Fall of 2018, Robbert Dijkgraaf (IAS, Princeton) was the first to perform on the sold-out Paradiso stage. Together with a vibrant audience of more than 800 people, he took a dive deep into **string theory, black holes and the laws of Nature.** Science & Cocktails/the Amsterdam edition will be a monthly returning event.

On the Origin of Structure in the Universe; Inaugural Lecture by Daniel Baumann

Daniel Baumann, who was appointed professor of Theoretical Cosmology at the University of Amsterdam's Faculty of Science in 2016, held his inaugural lecture on 7 December 2018. The chair in Theoretical Cosmology is meant to strengthen the UvA's Institute of Physics and is closely connected to the research priority area Gravitation and Astroparticle Physics Amsterdam (GRAPPA).

Baumann obtained his doctorate from Princeton University in 2008, after which he worked as a postdoctoral researcher at Harvard University and at the Institute for Advanced Study in Princeton. Since 2011, he has been a faculty member at Cambridge University's Department of Applied Mathematics and Theoretical Physics (DAMTP).

Daniel Baumann works on a wide range of topics in theoretical cosmology. One of the main goals of his research is to uncover the fundamental origin of the structure of the universe. He is an expert on the theory of cosmological inflation, which proposes that cosmological structures were produced by quantum fluctuations in a period of rapid expansion. As professor of Theoretical Cosmology at the UvA, Baumann started a new cosmology group to investigate the physics of the early universe and to determine new ways in which these ideas can be tested in future observations.

In addition to his research work, Baumann is also a passionate lecturer as well as a great speaker for lay audiences.

Over the course of his career, Baumann has been the recipient of various awards and grants, including a prestigious ERC starting grant (2012), and a Vidi Grant from the Netherlands Organization for Scientific Research NWO in 2017.

Featured publications

Proposed Spontaneous Generation of Magnetic Fields by Curved Layers of a Chiral Superconductor
T. Kvorning, T. H. Hansson, Anton Quelle, and Cristiane Morais Smith, in *Physics Review Letters 120*.
doi.org/10.1103/PhysRevLett.120.217002.

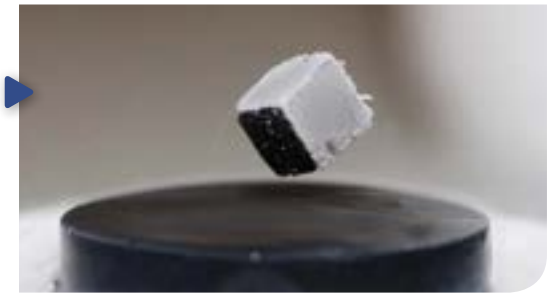
Primordial black holes from inflation and quantum diffusion
Matteo Biagetti, Gabriele Franciolini, Alex Kehagias, andAntonio Riotto, in *Journal of Cosmology and Astroparticle Physics, Volume 2018, July 2018*, JCAP07(2018)032.
doi.org/10.1088/1475-7516/2018/07/032.

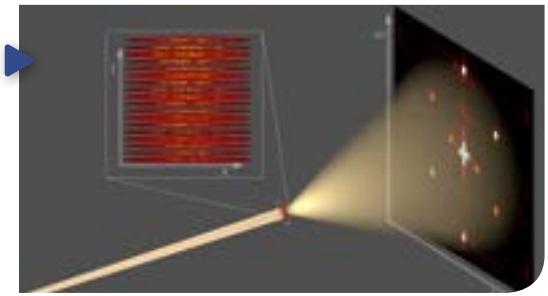
Soft theorems for shift-symmetric cosmologies
Bernardo Finelli, Garrett Goon, Enrico Pajer, and Luca Santoni, in *Phys. Rev. D 97, 063531, March 2018*.
doi.org/10.1103/PhysRevD.97.063531.

Large-scale structure phenomenology of viable Horndeski theories
Simone Peirone, Kazuya Koyama, Levon Pogosian, Marco Raveri, and Alessandra Silvestri, in *Phys. Rev. D 97, 043519, February 2018*.
doi.org/10.1103/PhysRevD.97.043519.

TASI Lectures on Moonshine
Summer School Lecture Notes 2018, Miranda C. N. Cheng and Vassilis Anagiannis.
arxiv.org/abs/1807.00723.

Observation of a Space-Time Crystal in a Superfluid Quantum Gas
J. Smits, L. Liao, H. T. C. Stoof, and P. van der Straten, in *Phys. Rev. Lett. 121, 185301, October 2018, Editor's suggestion.*
doi.org/10.1103/PhysRevLett.121.185301.





*The red-yellow lines show the **space-time crystal** at different times. The light beam illustrates how x-rays would be diffracted by the crystal. The sharp peaks on the projection screen give the experimental evidence that the structure is indeed a crystal in both space as well as time*

Tunable long-distance spin transport in a crystalline antiferromagnetic iron oxide
R. Lebrun, A. Ross, S. A. Bender, A. Qaiumzadeh, L. Baldrati, J. Cramer A. Brataas, R. A. Duine, and M. Kläui, in *Nature volume 561, pages 222–225 (2018).*
doi.org/10.1038/s41586-018-0490-7.

A new era in the quest for dark matter
Gianfranco Bertone and Tim M.P. Tait, in *Nature 562*, 51-56 (2018).
doi.org/10.1038/s41586-018-0542-z.

Perfect fluids
Jan de Boer, Jelle Hartong, Niels A. Obers, Watse Sybesma, and Stefan Vandoren, in *SciPost Phys. 5, 003 (2018).*
doi.org/10.21468/SciPostPhys.5.1.003.

Machine-learning-assisted correction of correlated qubit errors in a topological code
Paul Baireuther, Thomas E. O'Brien, Brian Tarasinski, and Carlo W. J. Beenakker, in *Quantum 2, 48 (2018).*
doi.org/10.22331/q-2018-01-29-48.
The year 2018 marked the breakthrough of machine learning in quantum physics. One of the very first applications of machine learning was to quantum error correction in a quantum computer, as described in this Quantum article.

Outreach activities

Many scientists of the Delta Institute for Theoretical Physics actively engage in knowledge dissemination through public lectures, master classes, radio and television interviews, popular books and articles. Delta ITP also provides financial support to outreach activities aimed at a wider audience. A selection of activities 2018.

Junior Physics Olympiad 2018, Amsterdam

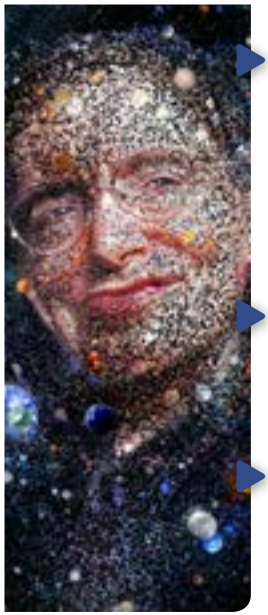
The Delta Institute for Theoretical Physics has initiated the Junior Physics Olympiad in 2014, a novel conception aimed at junior high school students. The Junior Physics Olympiad expands the already existing and highly successful Dutch Physics Olympiad for senior high school students, attracting over 3000 participants nation-wide. The Junior Olympiad consists of three rounds.

A total of 2700 participants took place in the 2018 first round, a major progress compared to the first years. Around 30 students were invited for the Finals in September 2018, organized by the University of Amsterdam. After a day full of tests, more tests, lectures and fun, the winner of the Junior Physics Olympiad 2018 was announced to be **Jochem van den Broek**, student at the Lorentz Casimir Lyceum in Eindhoven. Runners-up were Raf Buijsen (Het Stedelijk Gymnasium, Den Bosch) and in third place came Daniël Kunenborg (Utrechts Stedelijk Gymnasium, Utrecht).

The Junior Olympiad is developed by the Freudenthal Institute for Science and Mathematics Education in Utrecht.

Quantum Universe

Delta ITP is teaming up with the Quantum Universe, an online Dutch outreach platform initiated by Erik Verlinde. The website (**www.quantumuniverse.nl**) is aimed at the curious and ambitious high school students. **Marcel Vonk** (member of the Amsterdam string group, outreach expert, and science writer) is currently managing this major project together with a enthusiastic group of advanced Master and PhD students.
The scope of the website is already been extended to the broad spectrum of research done in the Delta Institute for Theoretical Physics, thus covering a wider variety of topics. Currently, the website is undergoing a heavily and long awaited transformation.



Stephen Hawking: a wonderful life in a universe filled with riddles

For theoretical physics worldwide 2018 was a special year because of the passing away of one of the greatest theoretical physicists of the 20th century: Stephen Hawking (8 January 1942 - 14 March 2018). Honouring his scientific legacy, the Netherlands Royal Academy of Arts and Sciences (KNAW) organised a wonderful symposium on 25 April 2018. The symposium, open to the general public, was heavily over-subscribed which reminds us of the amazing depth and creativity of Hawking's work, and his exceptional character. Speakers at the symposium were Thomas Hertog (KU Leuven), Jan de Boer (University of Amsterdam), Stefan Vandoren (Utrecht University) and Gideon Koekoek (Maastricht University).

On 15 March 2018 the Dutch Science Program **De Kennis van Nu** aired a 25 minute tribute to Stephen Hawking on national television, with appearances of Daniel Baumann (University of Amsterdam) and Daan Meerburg (DAMTP). They explained not only his work, but also how his personality inspired them, and will keep inspiring young physicists – and non-physicists as well – for generations to come.

The monthly **Science Café in De Balie**, Amsterdam, invited three theoretical physicists to ponder on Hawking's legacy and the future of Universe, on 14 May 2018. Manus Visser and Marcel Vonk (University of Amsterdam), and Klaas Landsman (RU Nijmegen) were interviewed by Martijn van Calmthout, science writer and journalist, in front of a live audience in a cozy atmosphere.

Black Holes – Captured in Space and Time

On 12 March 2018, mathematical physicist and science writer **Marcel Vonk** (UvA) presented his new popular science book Zwarte Gaten – Gevangen in Ruimte en Tijd (Black Holes – Captured in Space and Time) published by Amsterdam University Press for a full house in Spui25, Amsterdam. In his book, Marcel Vonk takes the lay reader on an exciting journey from the history of black holes to Hawking's discovery that black holes aren't entirely black but do emit a tiny bit of radiation; he ponders on the information paradox and the unexpected thermodynamic properties of the mysterious black objects. Recent theoretical brain-teasers are included as well: what can string theory add to our understanding of black holes, and does each black hole have a surrounding wall of fire, ready to roast up to embers everything that approaches it?

Femke en het zwarte gat (dat haar sok opvrat)

Two former PhD students in theoretical physics, Diego Cohen (UvA) and Watse Siebesma (UU) showed some of their other talents in a beautiful children's book about a young girl, Femke, who explores the black hole that devoured one of her socks. **The book** is written ánd illustrated by Diego and Watse. It's aimed at children between the age of 4 and 6. During the book presentation on 15 November 2018, astrophysicist Selma de Mink (UvA/API) gave a mini lecture on black holes tailored to this age group. Publication was made possible by the Utrecht Institute for Theoretical Physics.

A journey between infinitely small and infinitely big; TEDx talk by Gianfranco Bertone

Gianfranco Bertone, theoretical physicist and principle investigator at GRAPPA (UvA), was invited to give a 15 minute **TEDx talk at Lake Como**, Italy, in November 2018. He took the audience on an exiting journey alongside the four biggest mysteries in cosmology and particle physics: dark matter, dark energy, black holes and the big bang – and explained how multimessenger astronomy may help us to solve these riddles.

Bram Bet explains his PhD research on National Radio

On 3 March 2018 Bram Bet (UU) was a guest at the **NPO Radio 1 show dr Kelder en Co** hosted by Jort Kelder. He explained the nature of the PhD research he finished under supervision of Prof. René van Roij, and the applications of that research.

Cover of Bram Bet's dissertation 'Getting in Shape: Swimming with Stokes and Surfing with Brinkman', on the effect of shape on the motion of microscopic particles that perform a swimming motion or 'surf', driven by an external flow, through microscopic channels.

New Delta Research projects

Every year, the Delta Institute for Theoretical Physics intends to fund several PhD and postdoc positions, assigned to those research projects that best serve the general objectives of the Delta ITP initiative. Staff members from all three institutes can apply for such a research position. The projects should strengthen the Delta ITP cohesion, and will have to involve scientists from at least two of the three institutes.
In this annual review only the research projects that started in 2018 are mentioned. Granted projects from previous years can be found on **our website**. In 2018, one new Postdoc and two new PhD research projects started.

Postdoc project

Holography for Dirac nodal loops in ZrSiS - Henk Stoof (UU), Jan Zaanen (UL), Koenraad Schalm (UL) and Umut Gürsoy (UU).

PhD projects

Disorder: The multifractal bridge between strings and experiment - Vladimir Gritsev (UvA), Cristiane Morais Smith (UU), and Miranda Cheng (UvA). PhD student: Ward Vleeshouwers.
The microphysics of cosmic inflation, one feature at a time - Ana Achúcarro (UL), Jan Pieter van der Schaar (UvA). PhD student: Guadalupe Cañas Herrera.

Visitors 2018

The Delta Institute for Theoretical Physics runs an active visitor programma for senior researchers as well as PhD students. All Delta staff members are invited to send in proposals for medium or long-term visitors that would benefit the synergy and research programme of Delta ITP. Visitors from previous years can be found on **our website**.

Medium (2 - 6 weeks) and longterm visitors in 2018

Emil Yuzbashyan (Rutgers, USA) - **Mauro Valli** (INFN Rome) - **Maulik Parikh** (Phoenix, Arizona)
Adrian del Maestro (University of Vermont, Burlington (USA)) - **Chris Quigg**, Fermilab
Cesar Agon (Stony Brook University, USA) - **Alexander Becker**, University of Boston, USA
Sadra Jazayeri (Iran, Teheran) - **Benjamin Wallish** (Cambridge University, UK)
Isaac Perez Castillo (Mexico, Mexico City) - **Fabio Scardigli** (Politecnico of Milano, Italy)

Visiting PhD Students in 2018

Rodrigo Arouca de Albuquerque (Rio de Janeiro, Brazil), **Nicolas Kovensky** (La Plata, Argentina)

Grants

NWO Talent Scheme: Veni Vidi Vici

The Netherlands Organisation for Scientific Research (NWO) Talent Scheme provides three grants for talented, creative researchers who engage in innovative research. The funding enables applicants to do their own line of research. This boosts innovative research and promotes mobility within scientific research institutes. The Innovational Research Incentives Scheme comprises three grants geared to different stages in a researcher's scientific career: Veni, Vidi and Vici.

NWO Veni for Matteo Biagetti (University of Amsterdam)
Looking for cosmic fingerprints from billions of years ago.
Billions of years ago, the Universe expanded exponentially, giving rise to countless spinning particles. Matteo Biagetti will look for imprints of those primordial particles in today's astronomical observations, testing theories of cosmic expansion and opening a window to our early Universe.

NWO Vidi for Miranda Cheng (University of Amsterdam) - *Moonshine in String Theory*
String theory is a physical theory aiming at a uniform description of all laws of nature. The word moonshine refers to a mysterious relation between two different types of mathematical structures: special functions and finite groups. In this project, Miranda Cheng and fellow researchers will solve the puzzle of the origin of this relation by studying it in the context of string theory.

NWO Start-Up Grants

START-UP is intended for recently appointed associate, assistant or full professors in physics and chemistry. With a START-UP grant, these researchers can elaborate creative, speculative ideas within the focus areas of the Physics and Chemistry sector plan. The grant can be used to form and develop a research group by these new principle investigators.

Thomas Grimm (Utrecht University)
Thomas Grimm was awarded an NWO START-UP grant for his proposal on Quantum Black Holes. It was one of 11 projects awarded in the first round of this new NWO funding program (February 2018).

Joost de Graaf (Utrecht University)
In July 2018, Joost de Graaf was awarded a NWO START-UP grant for his proposal *The movement of micro-organisms in mucous*. With the grant, Joost de Graaf will develop numerical methods to understand how mucous influences the movement of microorganisms. These methods could lead to new medical insights. Mucous is vital for the protection of our airways, for example.

NWO Projectruimte Grants

The Physics Projectruimte is intended for proposals for innovative and risky fundamental research with a physics content, which are of high scientific quality and have a scientific, industrial or social urgency. Proposals can be submitted by professors and permanent scientific staff at the Dutch universities or at other research organisations that - at least in part - are funded by the Ministry of Education, Culture and Science.

Wouter Waalewijn (University of Amsterdam) - *Precise predictions at LHC*
Waalewijn's Projectruimte grant was awarded for his research on new methods needed to make precise predictions for the processes observed at the Large Hadron Collider in Geneva. The Large Hadron Collider is entering an era where precision measurements are the key to possible discoveries. Indications of new physics may lie hidden as faint signals that will be revealed as experimental uncertainties decrease, making it crucial to have the precise theoretical predictions to compare with. The researchers propose a new method to perform these calculations that will make them easier and therefore available for more processes.

Koenraad Schalmen and Jan Zaanen (Leiden University) - *From black holes to strange metals*
The so called 'strange metals' are materials that alleged to follow the bizarre laws of quantum mechanics even at everyday length scales. Schalm and Zaanen will focus on one aspect of strange metals' abnormal behaviour: the time they need to distribute heat throughout the entire material starting from one place. Remarkably enough, this solely depends on the temperature and Planck's constant. The researchers want to show that this is because strange metals indeed purely consist of quantum material. Subsequently, they draw a surprising parallel with black holes, which exhibit the same behaviour.

René van Roij (Utrecht University) - *Iontronics driven by peristaltic pumps and periodic potentials.*
Iontronics is the research field in which ions such as Na+ en Ca2+ dissolved in water or blood conduct electric currents. The researchers will theoretically predict how ion fluxes can be driven optimally through smart nano-channel geometries in order to make portable artificial kidneys, to desalinate seawater cheaply, and to harvest more blue energy from river- and seawater.

Vadim Cheianov (Leiden University) - *Slow as light, fast as a snail*
Sometimes the only way to quickly get where you need to go is to be really slow. Or so says the theory of adiabaticity - a concept behind certain strategies of quantum computational speedup. This project aims to get to the heart of this concept and lift the veil on how slow you have to be to be really fast.

NWO Physics Vrije Programma's

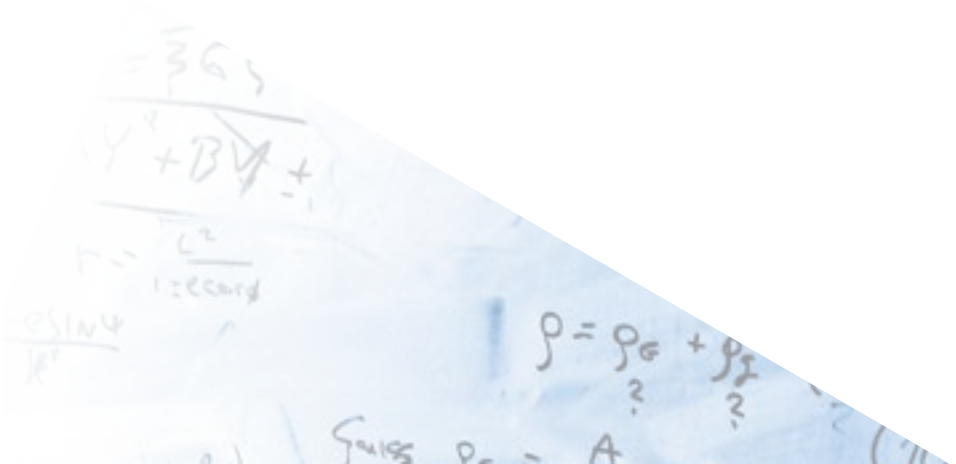
Physics Vrije Programma's are intended for top research with a convincing physics and/or applied physics objective. Besides scientific quality, the main characteristics are focus, critical mass and cohesion. Applications can be submitted by (consortia of) professors and group leaders (also on a tenure track).

Atomic Quantum Simulators 2.0 *-Taming Long-range Interactions*
Main applicant: Prof. F. Schreck (University of Amsterdam)
Collaborating institutions: University of Amsterdam, Radboud University, Utrecht University, Eindhoven University of Technology. With **Cristiane Morais Smith** (Utrecht University) et al.

Researchers in this programme will cool atoms, ions and molecules to a near-zero temperature, where quantum mechanics reigns. Using these particles like LEGO blocks, they will assemble artificial quantum materials in order to induce behaviours that go beyond currently used materials. The knowledge gained will contribute to both chemistry and materials science.

The Hidden Universe of Weakly Interacting Particles
Main applicant: Prof. Paul de Jong (University of Amsterdam)
Collaborating institutes: University of Amsterdam, Radboud University, Utrecht University, Nikhef and Leiden University. With **Alexey Boyarsky** (Leiden University) et al.

This programme will investigate the properties of the most elusive particles in our universe - neutrinos and dark matter - by means of the experiments KM3NeT, XENONnT and SHiP combined with theoretical modelling.



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