Niels Bohr International Academy

Annual Report 2015

The Niels Bohr International Academy

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From the Director

When the Niels Bohr International Academy (NBIA) started in 2007 we were literally three faculty members and around four post-docs. Things moved fast, and at the five-anniversary of the NBIA in 2012 we put together a five-year report that showed the remarkable scientific quality and breadth that had been achieved. Today, our level of activities are at a scale where we no longer fit into the building originally assigned to us. Slowly, office space in the main building of the Niels Bohr Institute on Blegdamsvej is now also becoming part of the NBIA. However, growth is not only in the number of scientist who work here, or who visit us. With limited (and fixed) institutional support, growth in numbers reflect the remarkable success young scientists at the NBIA have had with respect to securing science funding on the basis of individual achievements. Again, it is not on the large individual grants we should focus, but it is on the highest-quality science done at the NBIA that these grants reflect. This past year showed again the extraordinary situation: based on individual grant applications, the NBIA received three Starting Grants from the European Research Council, one 'large' Villum Young Investigator Grant, two EU Marie Curie individual fellowships and one EU COFUND 'MOBILEX' fellowship from the Danish Council for Independent Research in Natural Sciences.

In this first *annual* report you can read more details about the science we do and the events we organize (or help organize) throughout the year. The hard work and the many bright ideas will hopefully shine through. The excitement of science done at the forefront of our knowledge is what drives us every day, and telling others about it is always a great pleasure. For that reason we introduced a few years ago a series of popular lectures by young NBIA members. The series is organized with administrative help from the Danish 'Folkeuniversitet' and it has been a huge success, the first series of lectures (almost) entirely held in English at that institution. In 2015, due to overbooking, we expanded into two parallel series of popular lectures during a five-week period in the fall. It has really been heart-warming to see the historical Auditorium A on Blegdamsvej being filled up in evenings with an interested audience, often braving cold, rainy and windy weather.

The NBIA sees itself not only as theoretical physics institution with its own identity, but also as a service to the Niels Bohr Institute. This relationship permits us to keep contact with students, and we believe the Niels Bohr Institute likewise benefits enormously from our presence. This past year we were delighted to see that two NBIA members on temporary contracts received tenured positions at the Niels Bohr Institute while remaining at the NBIA, where they both have build up large research groups.

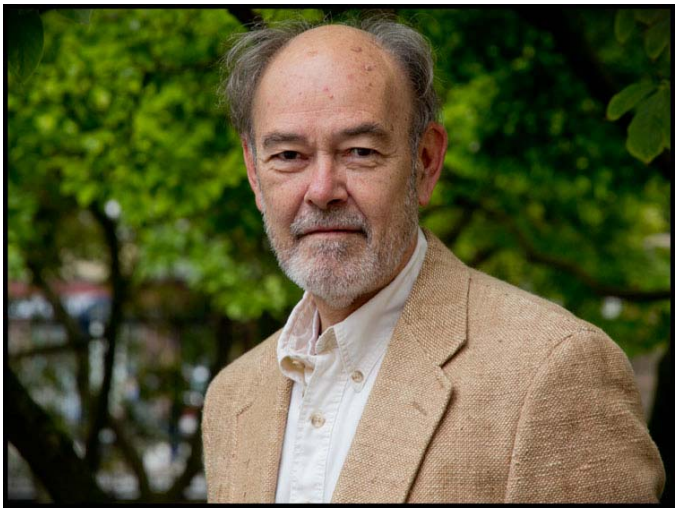
One of the most important events in 2015 was the founding of a new Director's Council for the NBIA. It is composed of prominent Danes who share our goal of building Europe's best institute of theoretical physics on the famous Blegdamsvej site of the historical Niels Bohr Institute. The first meeting was held in May 2015, with participation also of Dean of SCIENCE **John Renner Hansen** and the Head of the Niels Bohr Institute **Robert Feidenhans'l**. The support from this new Council is of immense importance to us. You can read much more about it in the following pages.

Institutionally, the NBIA has this year gratefully received renewed support from the **Ernst and Vibeke Husman Foundation** which will help us carry out our extended visitor program and

our support for workshops and PhD-schools. The **Knud Højgaard Foundation** has generously renewed their support so that from January 2016 we are hiring a new Knud Højgaard Assistant Professor for a five-year period, following a broad search. I look forward to giving you more details on that new hire in next year's report, but can already now reveal that with this new Knud Højgaard Assistant Professor the NBIA is moving into the exciting research area of neutrino astrophysics. Just as I am writing these lines, news ticks in that the NBIA has been granted important support from the **Simons Foundation** in New York. In addition, the NBIA gratefully acknowledges important support in 2015 from the **Danish Council for Independent Research in Natural Sciences**, the **Villum Foundation**, the **Lundbeck Foundation**, the **Oticon Foundation**, the **Direktør Ib Henriksen Foundation**, the **Carlsberg Foundation**, the **Danish National Research Foundation**, the **Nordea Foundation** and the **Danish National Bank**. The NBIA has also received generous support from **Raymond and Beverly Sackler**, New York.

Poul Henrik Damgaard
Dec. 2015

From the Board Chairman



As seen by the NBIA Board, 2015 has been a successful year on all fronts. The list of distinguished visitors and guests grows with each passing year. Auditorium A was filled for all nine of this year's NBIA colloquia on topics ranging from classical cryptography to the Chinese collider. An even dozen workshops and PhD schools gathered visitors and students from all over Europe to learn about topics as cold as the IceCube Collaboration on Antarctica and as hot as the prediction of storms on the Sun. Most importantly, the quality and productivity of our post-doctoral fellows continues to increase. In short, the NBIA is approaching its goal of becoming the premier center for theoretical physics in Europe and the first choice of potential postdoctoral fellows.

The Board recognizes that realization of this goal will require both increased public awareness of the NBIA and its accomplishments and a significant measure of independence from the economic uncertainties of competitive funding that have provided the bulk of NBIA resources. To date, NBIA outreach activities have been limited to a highly successful series of lectures under the auspices of the "Folkeuniversitet". These lectures, delivered by NBIA postdoctoral fellows and guests, provide listeners with an opportunity to learn about recent advances in physics and to meet the people who are making them. But greater efforts are required. To this end and at the explicit request of the NBIA Board, we have now formed the Director's Council. Composed of unquestioned leaders and opinion makers from the worlds of Danish business, public service and the arts, the Director's Council will play a central role in helping the NBIA to adapt best international practice in outreach and funding to a Danish context.

The task ahead of us is challenging and likely to be time consuming since it will require modifications of practices conventional in Denmark, but I am convinced that precedents can be changed. I note, for example, that the idea of a *genuine* endowed professorship was unknown in Denmark until the Villum Foundation created the Villum Kann Rasmussen Professorship currently occupied by the NBIA's Charles Marcus.

The first annual joint meeting of the NBIA Board and the Director's Council was held in August 2015. The atmosphere was one of collaboration and lively discussion leading to specific recommendations to the NBIA Director. I remain optimistic of success.

Andrew Jackson
Dec. 2015

From the Council Chairman

The Niels Bohr Institute has a special place in the hearts of many Danes. Even in Niels Bohr's younger years people were very much aware that something unusual was happening at "Bohr's Institute" on Blegdamsvej. Intellectual giants like Albert Einstein, Werner Heisenberg and Wolfgang Pauli were visiting. New ideas were being discussed, and stones were being overturned. Suddenly Copenhagen was "on the map". Niels Bohr was on his way to becoming an icon of Danish society. Since then, Danes take pride in the fact that something unusual and exceptional on a world scale can happen in this small country. I am sure that I speak on behalf of many Danes when I say that we really want to see the torch carried on so that the famous buildings on Blegdamsvej continue to be the intellectual home of the best theoretical physicists of today. The Niels Bohr International Academy (NBIA) has the right recipe to make this happen. This is why I agreed to be the first Chairman of NBIA's newly founded Director's Council.

I am delighted to say that we have been able to assemble a distinguished group of Danes to form the Director's Council. Its members bring with them expertise and important accomplishments in a broad variety of fields — *not* including physics — but they share an uncompromising commitment to excellence.

The Director's Council has met twice in the past year. A founding meeting was held in May, and in August we had an interesting joint meeting with the International Advisory Board. I was most impressed with the strong support and constructive suggestions from the eminent international scientists who serve on the International Advisory Board. High on our common agenda were strategies that will allow the NBIA to continue on its impressive path towards excellence in theoretical physics and ways to make its successes more widely known in Denmark. It is exciting to be able to help, and I am very much looking forward to seeing the developments in the coming years.

Lars Kann-Rasmussen
Dec. 2015

The NBIA in 2015

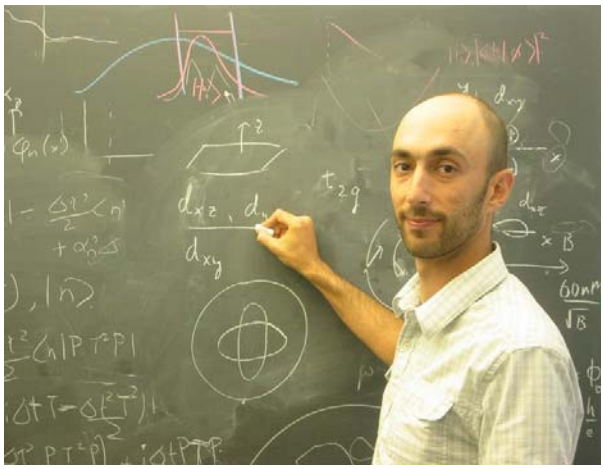
January is normally an intensely busy period at the NBIA: courses of the second quarter of the academic year are nearing the end, Students are studying hard in the NBIA lounge and in the library, and often pass by to ask questions. Papers that should have been written and sent out before Christmas are given final makeovers before submission. Days are short, but the work intensity is high; on weekends and in the long nights lights are on in many NBIA offices. That's how it feels in one of the control rooms of theoretical physics. But January 2015 was also the time of a few celebrations at the NBIA. **Oliver Gressel** and **Guido Festuccia** received prestigious ERC Starting Grants from the European Union, and **Michael Trott** was awarded a large Villum Young Investigator Grant. What used to be a dream about the research that could be done if the financial assistance were there had suddenly become reality, and the search for top-notch post-docs should begin. (Fortunately, that was a rather simple task: the NBIA had already received more than 800 applications).

Oliver Gressel's research focuses on an analysis of the physics of planetary disks. As the nurseries of planetary systems, protoplanetary discs are of key interest to planet formation theory. Their radiative, thermodynamic and dynamical properties critically define the environment for embedded solids: dust grains, pebbles, planetesimals, and protoplanetary cores. In short, the building blocks for planet formation. Oliver Gressel will employ massive supercomputers to model the dusty discs in which planets are believed to grow. This will allow astrophysicists to understand much better the environment in which planets from, and help interpret upcoming observations made, for example, with the ALMA telescope, a gigantic telescope array in Chile.

Guido Festuccia's research aims at shedding light on the dynamics of strongly coupled quantum systems. These are ubiquitous in Nature: they are, for instance, central to many phenomenons in condensed matter (e.g. non-Fermi liquids) and underpin also some of our understanding of nuclear forces. They are however notoriously difficult to study analytically. The research will focus in particular on supersymmetric field theories. Such systems are accessible to analytical studies even at strong coupling while displaying phenomena, like confinement, that occur in Nature. In addition, forthcoming experiments at the LHC have the potential to show if supersymmetry is realized at a more fundamental level in Nature. Insights on the fascinating dynamics of supersymmetric field theories at strong coupling will be obtained by analyzing their dependence on the geometry of space.

The research of Michael Trott is focused on studying with high precision the properties of the newly discovered Higgs boson. A Higgs-like boson was reported discovered by the Large Hadron Collider (LHC) experiments based at CERN in 2013, and Michael was fortunate enough to be at CERN during this discovery time. He has already significantly contributed to the development of the theoretical framework used to study Higgs data.

The exact nature and properties of the Higgs are essential to determine, as the Higgs boson is an unprecedented fundamental particle to discover. This is the first (apparently) fundamental boson ever discovered in nature. Further, it is believed that this particle is the key player in an intricate mechanism built into the fundamental interactions of Nature to generate the mass of the observed particles.



Michael Trott will utilize the resources of his Young Investigator Grant to build up a powerful research group aimed at further advancing the state of the art in analyzing Higgs data, as precision increases. The theoretical formalism used to study the Higgs will be continually developed so that any deviations in the properties of this particle can be consistently interpreted.

The European Research Council of the European Union has in general been good to the NBIA in 2015. As this report is being sent to the printers, we just learned that also **Mark Rudner** has received an ERC Starting Grant this year. Mark Rudner's research is centered around a wide range of interesting new phases of matter and quantum phenomena in condensed matter systems, building on some of the great discoveries of the last decade. In additional to unveiling new fundamental aspects of quantum many-body systems, some of the more exotic predicted phenomena may even hold the key to developing new robust platforms for quantum information processing. The challenge now is to find actual materials or physical systems where these exciting new phenomena may be realized. Motivated by this challenge, and inspired by the great strides achieved on the experimental side in recent years, Mark Rudner's seeks to understand what new robust quantum many-body phenomena may be accessible in driven quantum systems. The ERC grant will allow Mark Rudner to consolidate his existing research group and expand in new directions. In particular, Mark's group will explore new approaches for identifying and realizing topological phenomena in driven systems, obtaining along the way a broader and deeper understanding of quantum dynamics in non-equilibrium many-body systems.

Recognition for one's research comes in various ways. The most prestigious journal belonging to the American Physical Society, Physical Review Letters, introduced a few years ago one specially selected paper of each issue: the "Editor's Choice". In 2014 **Chris Pethick** had one paper (on neutron stars) that received this distinction, and in 2015 **Emil Bjerrum-Bohr**, together with collaborators from the IHES in Paris and University of Massachusetts, published a paper in Physical Review Letters that also was highlighted as "Editor's Choice". The paper concerns the use gravity as an effective field theory, a systematic

low-energy expansion of the otherwise unknown underlying quantum field theory of gravity. Through an effective field theory description and modern on-shell techniques for computation, they describe analytically the leading quantum effect to the bending of light caused by a heavy object like the Sun or a Schwarzschild black hole. While the effect is tiny, about (80 orders of magnitude smaller than the General relativity effects), it is shown that the quantum effects do make a difference in that the photon's motion can no longer be envisioned as being confined to a simple geodesic curve. The Letter's approach to computations of quantum gravity effects provides a simple path forward for quantum computations in gravity and sets a standard for how to investigate quantum effects in gravitational contexts.

Chris Pethick was in the news again when he was awarded the **Feenberg Medal** for 2015 based on his seminal work on ultracold atomic gases, liquid helium, and dense matter in neutron stars and stellar collapse. At first sight, these systems appear very different but, in fact, they display similar phenomena and, consequently, insights obtained for one system can be used to gain insight into others. The Medal commemorates Eugene Feenberg, who was a pioneer in nuclear physics and in the development of methods for calculating properties of nuclei and quantum liquids from microscopic theory. The official award ceremony took take place in August 2015 at the 18th International Conference on Recent Progress in Many-Body Theories.

Later in 2015, Oliver Gressel was awarded the **Johann Wempe Award** by the Leibniz-Institut für Astrophysik at Potsdam. This award is in honor of Johann Wempe (1906 - 1980), the last director of the former Astrophysical Observatory of Potsdam (AOP). The Leibniz-Institut für Astrophysik at Potsdam annually grants this award, first given in 2000, to an outstanding scientist, financed from funds left in the will of Johann Wempe. It consists of a stipend of €2,500 per month to facilitate a research visit to the AIP of up to six months. The recipient may be either a promising young scientist who has already made notable achievements or a senior scientist, in recognition of his or her life's work. The recipient is expected to enrich the scientific life of the institute through a series of lectures in their area of expertise.

Important developments also took place in terms of permanent staff positions. Since the NBIA was founded in 2007 all hires that had been made at the NBIA were of temporary nature. In the spring of 2015, **Martin Pessah** was appointed Professor WSR ('With Special Responsibilities') at the Niels Bohr Institute, the first of NBIA's junior scientists to gain tenure at the Niels Bohr Institute. Martin Pessah will continue his work at the NBIA, where he has created a new and dynamic group in theoretical astrophysics, thereby adding a new dimension to the research in astrophysics that is undertaken at Copenhagen University. Later in the spring, Emil Bjerrum-Bohr was appointed Associate Professor with tenure at the Niels Bohr Institute. Emil Bjerrum-Bohr will also remain at the NBIA, where he has built up a world-renowned group in the field of amplitude calculations for theoretical particle physics. Both Martin Pessah and Emil Bjerrum-Bohr previously held positions as **Knud Højgaard Assistant Professors**, thanks to a generous donation from the Knud Højgaard Foundation. In 2015 the Knud Højgaard Foundation renewed their support to the NBIA, thereby allowing the NBIA to hire one new Knud Højgaard Assistant Professor for the five-year period 2016-2021. Following a world-wide search, neutrino astrophysicist **Irene Tamborra**, presently

at the GRAPPA center for astroparticle physics in Amsterdam, will take up this position on January 1st. Irene Tamborra is a leading expert in neutrino astrophysics, an exciting topic that brings elementary particle physics together with astrophysics. Observation of neutrinos from astrophysical origins is a new and exciting way to learn both about neutrinos and their interactions (including mixings), and about explosive astrophysical events such as supernova explosions. Irene Tamborra will build up and lead a new research group at the NBIA with focus on these subjects.

Neutrino astrophysics is one example of the remarkable interplay between different fields in theoretical physics. Normally belonging to the realm of particle physics, neutrinos are highly elusive particles that nevertheless play crucial roles in fundamental processes such as radioactive decays. They are also seen indirectly in accelerator experiments such as those of the Large Hadron Collider at CERN in Geneva. Because they are so hard to detect, their importance in astrophysical contexts is only these years beginning to be explored. Many will be surprised to learn that more than 99% of the energy released in supernova explosions is carried away by neutrinos. Because they interact so feebly, such bursts of neutrinos can be measured on earth when supernovae explode in neighboring galaxies. At the NBIA, Chris Pethick has long played a leading role in understanding the physics of such processes, as well as in the physics of neutron stars. Now, with the appointment of Irene Tamborra, this topic is given a new boost.

In just a handful of years, the field of theoretical astrophysics has seen a dramatic development at the NBIA fueled by young international talent. The team assembled by Martin Pessah is building up to become a leading European group in astrophysical fluid dynamics, strategically positioning itself to produce breakthroughs in diverse areas of theoretical astrophysical encompassing the intricate processes leading to planet formation in protoplanetary disks (Oliver Gressel), fundamental physics in hot accretion flows onto black holes (new NBIA Associate Professor **Tobias Heinemann**), as well as transport processes in the dilute, magnetized plasma permeating the intergalactic medium (Martin Pessah). In collaboration with the computational astrophysics group at the Niels Bohr Institute, the NBIA theoretical astrophysics group recently acquired some of the largest computer resources dedicated to astrophysics in Scandinavia. The stimulating academic environment of the Niels Bohr International Academy, coupled to these powerful resources, allows this group to work at the international forefront addressing the complex dynamical processes that shape the Universe as we observe it.

In 2015 this group has developed a new way to characterize magnetohydrodynamic turbulence in accretion disks with potential implications for the development of astrophysical disk models (**Gareth Murphy**, Martin Pessah). **Colin McNally** has developed the theoretical framework to study photophoresis in a dilute, optically think medium in order to investigate whether it can aid the levitation of highly porous silicate dust grains in protoplanetary disks. A new framework has been developed that generalizes the standard shearing box that has been a workhorse for investigating astrophysical disk dynamics in local settings for over two decades (Colin McNally, Martin Pessah). The group has also studied ways to characterize the mean-field dynamo coefficients that describe the long-term evolution of large-scale magnetic fields in disks (Oliver Gressel, Martin Pessah). This theme will be boosted with the recent hire of **Farrukh Nauman**. The group's analysis provides a more coherent picture of how several instabilities can dominate the disk dynamics depending on the cooling time used in the model for thermal relaxation (**Gopakumar Mohandas**, Martin Pessah). With the aim of interpreting revolutionary astronomical observations of molecular emission in forming solar systems, the group is also developing world-leading spectral line radiation transfer tools and applying them to simulation data (**Christian Brinch**, Oliver Gressel). Work is also ongoing to combine fast methods for ionization chemistry and grain charging with first-of-their-kind fluid simulations to establish the relevance of magnetic fields for the dynamic state and structure of the planet-forming disks around young stars and the moon-forming disks around young planets (**Yuri Fujii**, Oliver Gressel). The group has also been active in developing new tools to understand the dynamics of low density astrophysical plasmas, where it is necessary to go beyond the MHD approximation (**Jacob Trier Frederiksen** and **Thomas Berlok**, Tobias Heinemann).

The astrophysics group has also been heavily involved in teaching and outreach activities in 2015. Martin Pessah developed a new MSc and PhD course in Theoretical Astrophysics at the NBI. This fundamental course provides an overview of the most important astrophysical processes that shape the evolution, and observational properties, of astrophysical systems, from planets to stars, and from supermassive black holes to entire galaxies. Courses similar to this exist in the top astrophysics programs in USA but have not been offered at NBI until recently. This course is now one of the mandatory courses for astrophysics students at NBI, including many students that will continue their careers teaching in elementary schools and high schools.

Andrew Jackson has worked in close collaboration with **Pavel Naselsky, Assaf Ben-David,** and **Sebastian von Hausegger** to develop new techniques for the statistical analysis of data related to Cosmic Microwave Background (CMB) radiation. The aim is to use more sophisticated statistical tools to remove the contamination of foreground phenomena in order to reveal genuine CMB effects. This problem is particularly challenging in the analysis of CMB polarization data in the hope of finding evidence of primordial gravitational waves in the so-called B-modes.

While some NBIA scientists measure neutrino collisions in the IceCube detector at the South Pole, others look to the skies close to the North Pole. This past year Pavel Naselsky received a grant from the **Villum Foundation** that allowed him to set up a so-called Deep Space observa-

tory in Greenland together with an American team led by Philip Lubin from the University of California at Santa Barbara. The project aims at observing for the first time the polarized B-modes of the CMB sky, or to put new stringent upper limits on such modes. The site in Greenland was chosen for the purity of the air and the low background in the required frequency domains. With this brand-new experiment that will begin to take data in 2016, the NBIA now has research projects in both Greenland and on South Pole! One of the first goals of the Deep Space project is to map out carefully the noise (background) that will contaminate the hoped-for B-mode signal. Once this background is completely understood, the Deep Space observatory will start searching for the B-mode signal of primordial gravitational waves. We can hopefully report more on this exciting experiment in next year's annual report.

Subir Sarkar, who leads his own astroparticle physics group at the NBIA through funding from the **Danish National Research Foundation** to his Niels Bohr Professorship, forms the link to cosmology. Subir Sarkar is responsible for the blossoming of the new field of astroparticle physics at the NBIA and in 2015 he brought in Visiting Professors **Roya Mohayaee** and **Jacques Colin**, who will be staying with us until next August. In the past year, the work of Subir Sarkar and his group has focused on three overall themes: (1) Does dark energy exist? (2) Testing primordial inflation, and (3) Probing dark matter.

The `standard' model of cosmology is founded on the basis that the expansion rate of the universe is accelerating at present --- as was inferred originally from the Hubble diagram of Type Ia supernovae (rewarded with the Nobel Prize 2011 and the Fundamental Physics Prize 2015, among others). There exists now a much bigger database of supernovae so one can perform rigorous statistical tests to check whether these `standardisable candles' indeed indicate cosmic acceleration. Taking account of the empirical procedure by which corrections are made to their absolute magnitudes to allow for the varying shape of the light curve and extinction by dust, Subir Sarkar, **Alberto Gufanti** and **Jeppe Trøst Nielsen** have shown that the data are still quite consistent with a *constant* rate of expansion. The usual interpretation of the acceleration is that it is caused by the `Cosmological Constant' term in Einstein's equations of general relativity. Therefore the observation that the data do not in fact require the universe to be accelerating opens up interesting possibilities as to how the deceleration of gravity may be otherwise countered, e.g. by the `back reaction' in approximating the observed inho-

mogeneous universe as a perfectly homogenous Friedman-Robertson-Walker cosmology, or by the `bulk viscosity' possibly induced during the formation of structure, which causes a departure from the usual ideal gas approximation to describe the matter content of the universe.

The theoretical particle physics group continued its expansion into more phenomenological directions through the hire of new NBIA Assistant Professor **William Shepherd**, who is a world expert on dark matter scenarios in particle physics and in particular particle physics collider contexts. William Shepherd received a MOBILEX Fellowship from the Danish Council for Independent Research and he was joined by new NBIA post-doc **Yun Jiang**, who works in close collaboration with Michael Trott. In the past year, Michael Trott, in collaboration with PhD-students **Christine Hartmann** and **Laure Berthier,** has started the program to systematically explore what has already been dubbed the Standard Model Effective Theory: the systematic extension of the Standard Model of particle physics with higher-dimensional operators that encapsulate new physics at higher energy scales. One first paper on the decay of the Higgs particle to two photons written by Michael Trott and Christine Hartmann made it into Physical Review Letters this past fall. Michael Trott's team is turning into the leading group in a consistent analysis of incoming data from the Large Hadron Collider (LHC) at CERN in terms of effective field theory and corresponding constraints on unexplored physics at larger energy scales.

What can be generically called the 'amplitude group' at the NBIA works on the forefront of more theoretical developments, rephrasing relativistic quantum field theory in manners that allow for more and more complex computations relevant for processes studied at particle physics colliders. In the past year, collaborations among **Christian Baadsgaard**, Emil Bjerrum-Bohr, **Jacob Bourjaily, Simon Caron-Huot** and **Poul Henrik Damgaard** together with NBIA Visiting Professor **Bo Feng** revealed new avenues for calculating amplitudes based on a new formalism that goes under the name of 'scattering equations' and, more generally, using what the group dubbed a **Q-cut** formulation of loop amplitudes. Work in that direction is still underway, and it will be interesting to see new results in 2016. Jacob Bourjaily has also continued his fundamental work in the new direction of local integrand representations of multi-loop amplitudes together with **Nima Arkani-Hamed** (IAS, Princeton) and **Jaroslav Trinka** (Caltech).

Tantalizing hints of a new particle with a mass more than five times that of the Higgs boson were reported from CERN at the end of 2015. Michael Trott and William Shepherd, together with NBIA Visiting Professor **James Cline** provided an in-depth analysis of the experimental and theoretical constraints on such a potentially new state very quickly after the CERN data were released in December 2015. A new scalar particle at that mass resembling the Higgs particle could have profound implications on our understanding of why there is almost no antimatter in the universe through the mechanism of so-called electroweak baryogenesis. This was explored by Poul Henrik Damgaard together with former NBIA scientists **Donal O'Connell, Anders Tranberg** and PhD-student **Anders Haarr** in

a paper that also shows how this fits into the program of effective field theory.

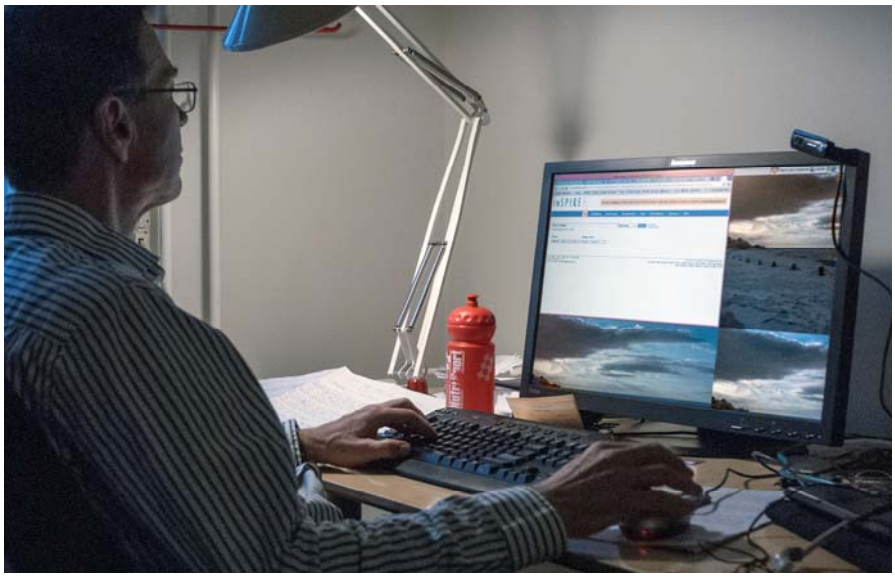
The particle physics group at the NBIA also pursues more formal paths such as the approach to quantum field theory that explores maps to higher-dimensional gravitational theories, generalizations of what generically has become known the AdS/CFT correspondence. NBIA scientist **Cynthia Keeler** has in particular pursued this in the non-relativistic contexts known as Lifshitz space-times. New NBIA post-doc **David McGady** has derived a new correspondence between a certain limit of Yang-Mills theory and a two-dimensional conformal field theory.

In 2015 the NBIA started a new line of research in quantum information theory which contributes to the growing local activity, and is helping to place the University of Copenhagen as one of the top institutions in Europe for quantum information sciences. The core of the NBIA quantum information group consists of **Michael Kastoryano** and **Ben Brown**, who collaborate very closely with the groups of **Matthias Christandl**, **Jan-Philip Solovej** and **Bergfinnur Durhuus** at the Department of Mathematics department, Mark Rudner in NBIA's condensed matter theory group, and the QDev center lead by **Charles Marcus** as well as NBI's QUANTOP center lead by **Eugene Polzik**. The quantum information community unites around a weekly common "quantum lunch seminar" with both internal and external speakers, and regular journal clubs -- the current one in collaboration with the QDev superconducting circuits group from the lab headed by Charles Marcus. Hence the activity is highly interdisciplinary and collaborative following the spirit of the NBIA. The group's research spans a wide variety of research topics ranging from (i) topological quantum memories and fault tolerance, (ii) quantum simulations, and (iii) the mathematical theory of quantum spin systems. The theory of quantum fault tolerance broadly aims to find and analyze many-body quantum systems that can naturally host protected quantum degrees of freedom into which quantum information is encoded and manipulated. One of the research highlights of 2015 was a paper published in a Nature journal as well as a number of preprints on related topics. The gorup is presently organizing a high-profile international conference on this topic at Benasque, profiling the NBIA as on of the

major players in this field.

The group plans to expand next year with two shared post-docs between the NBIA and the department of Mathematics: **Albert Werner** coming from the FU Berlin on an outgoing Humboldt grant, and **Claire Levoyant** coming from Microsoft Station Q in Santa Barbara.

The condensed matter theory group at NBIA has been active on many fronts in 2015, including in the field of topology and dynamics in driven, dissipative, and self-organizing systems, spintronics, plasmonics, and semiconducting and superconducting quantum devices. These works have ranged from the abstract, *e.g.,* developing new a conceptual framework for characterizing topology in periodically driven systems (a joint work by PhD student **Frederik Nathan** and Mark Rudner, to be published as an invited article in a special issue of New Journal of Physics), all the way to direct collaborations with experimentalists --see below for examples. In addition to enjoying many fruitful internal collaborations, the group has benefited from collaborations with external partners across Europe and the US. Over the past year the group has explored many questions in novel topological systems. In collaboration with friends at Caltech and the Technion, Mark Rudner co-authored an in-depth theoretical study of many-body dynamics that exposed powerful new means for potentially controlling the steady states of open, driven topological systems. A collaboration with experimentalists in Jena and at the Technion yielded the first experimental observation of a topological dynamical transition in a non-Hermitian quantum system, finally confirming a long-standing prediction of Mark's from 2009. This work is published in Physical Review Letters. Meanwhile a collaboration between Mark Rudner and QDev scientists **Karsten Flensberg**, and **Michael Schecter** shed new light on self-organized topological phases in hybrid systems, earning publication in Physical Review Letters this year. In the area of spintronics, NBIA post-doc **Kjetil Hals** has led the way. In a joint work with Mark Rudner and Karsten Flensberg, Kjetil explored damping dynamics in so-called helimagnetic systems where the magnetic coupling is mediated by an interacting one-dimensional electron gas. This work offers a clear set of predictions that can be used to help resolve an ongoing debate about recent experimental findings in quantum wires. It also bears connections to Michael Schecter's work on self-organized systems in one dimension, and has sparked a new ongoing collaboration. Additionally, in collaboration with **Arne Brataas** in Trondheim, Kjetil Hals has developed a general framework for understanding the reciprocal processes of so-called charge pumping by spin-motive forces and current-driven magnetization dynamics. Over the past year, the condensed matter theory group has also investigated phenomena relevant for a variety of semiconducting and superconducting quantum devices. This includes works on decoherence in spin qubits (joint work with **Ed Barnes** at Virginia Tech and experimentalists at the Center for Quantum Devices), dynamical nuclear polarization in quantum Hall systems (joint work with **Bernd Rosenow** in Leipzig and experimentalists at ETH Zurich), and transport in topological superconductor/normal metal junctions (**Jeroen Danon** in collaboration with Karsten Flensberg and local theory and experiment Masters/PhD students).



At a more political level, the most important development for the NBIA in the past year was surely the founding of a new Director's Council. Having met already twice (once jointly with the NBIA's International Scientific Advisory Board), this new Board is already providing important advice and help to the NBIA. Members of this Director's Council are **Connie Hedegaard, Niels Due Jensen Per Magid, Bjørn Nørgaard, Lars Kann-Rasmussen** and **Michael Rasmussen**. With innovative leaders of industry, the arts, and European politics, the Director's Council is representative of the best of Denmark and an impressive supplement to the International Scientific Advisory Board. The goals of the Director's Council are to work with the NBIA to improve the visibility of the NBIA in Denmark and to help us attain a greater degree of financial stability. At the founding meeting in May 2015, Lars Kann-Rasmussen was elected Chairman of the Council, and Per Magid was elected vice-Chairman.

The International Science Advisory Board, currently consisting of Andrew Jackson (Chairman), **David Gross**, Charles Marcus, **Itamar Procaccia, Herbert Spohn, Paul Steinhardt** and **Frank Wilczek,** monitors the science policy issues and provides very valuable advice and support. Both the International Science Advisory Board and the Director's Council point towards directions where the NBIA could strengthen its programs and consolidate activities. At an exciting meeting in August 2015, the two boards met for the first time and exchanged views.

Let us end with a few words about our program of workshops, PhD-schools and conferences. In the past year the NBIA sponsored and co-sponsored twelve such activities. There were four one-week intense PhD-schools: the **Nordic Winter School on Cosmology and Particle Physics**, a **PhD School on Protoplanetary Disks and Planet Formation**, a **PhD School on Holography: Entangled, Applied and Generalized**, the **Fifth NBIA School on ESS Science**, as well as a **Master Class on Quantum mathematics**. Of topical meetings, the NBIA supported a workshop on **"Measuring B-Mode Polarization from Greenland"**, an **International Symposium in High Energy Physics**, **"MHJ60: Excursions in Complexity", 'Current Themes in High Energy Physics and Cosmology"**, the **IceCube Collaboration Meeting 2015** and **"Solar Storm Early Forecasting".** Of particular interest was an 'experimental' meeting in 2015, the **NBIA-Oxford Colloquium,** where the NBIA invited prominent members of the Rudolf Peierls Centre for Theoretical Physics at Oxford University to visit the NBIA for a three-day meeting with talks in widely separated areas within theoretical physics. The idea of this meeting was to counter the trend towards narrow specialization and revive the tradition of scientific meetings at Blegdamsvej with a broad range of topics. With a mixture of talks by local NBIA scientists and the invited speakers from Oxford, this provided a highly stimulating atmosphere.

Many of these meetings were only possible due to massive support from other sources. During these meetings the halls of the NBIA were loud and noisy, scientific ideas were exchanged, and there was often a crowd in the NBIA lounge discussing until very late in the evenings. The assertion that a top institute in theoretical physics needs to have a top-line espresso machine in order to function properly seems to be true!

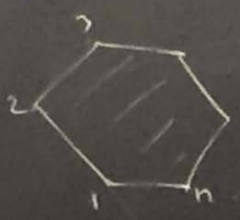
NBIA Colloquia and Talks

The NBIA organizes 3-4 NBIA Colloquia every semester. These are broad talks aimed at non-experts, but at a level from PhD-students and up. Topics are not limited to physics, but can cover any subject under the sun that is of interest to NBIA scientists. In the past we have had talks on such varied topics as ancient DNA, the geological history of the earth, the science of textile archeology, the theory of paintings from a science perspective, and many other fascinating topics. This past year NBIA Colloquia covered topics from classical cryptography, through the search for exoplanets to the theory of how to stack blocks with maximum overhang.

A more informal series of talks are given on Friday afternoons. Known as 'N-Talks', this is the opportunity for NBIA scientists to explain their fellow Academy members what their current research is about – in very simple terms! The rule is simple: 15 minutes at most, slides only (exceptions are tolerated), and totally simple. This is more difficult than one could imagine, but it is a very useful exercise for the speaker and a rewarding experience for the audience.

Being part of the existing research groups at the Niels Bohr Institute, all scientists at the NBIA also participate in (and several help organize) the regular seminar programs on more narrowly defined subjects, aimed at experts. Not many days pass by without an opportunity to participate in one of these seminars.

Tree Amplituhedron



Z_a^I, $a = 1, \dots, n$
$I = 1, \dots, 3$

$Y_I = c_1 Z_1^I + \dots + c_n Z_n^I$

$c_a > 0$

$(c_1, \dots, c_n)$
$1 \times n$ matrix

$1 < a_2 < a_3$

Public Outreach

Since 2011 the NBIA has organized a n annual series of public lectures on physics in collaboration with the Danish Open University 'Folkeuniversitetet'. The idea was from the start to let the public benefit from the presence of young and enthusiastic scientists at the NBIA, each of them speaking about a topic very close to their actual on-going research, but at a level appropriate for an audience with no background in science. By design, these lectures will then cover a wide range of topics in modern theoretical physics, giving a glimpse of the questions, ideas and approaches that are now at the scientific forefront. This formula turned out to be a success, and although the subjects covered are at the forefront of present-day research, the attendance is increasing. All lectures take place at the historical Auditorium A and for the first time we had to introduce two parallel series of talks in 2015 in order to accommodate everybody who had signed up. Noticing that several who signed up came back year after year, the NBIA has introduced a **Friends of the NBIA** circle of interested and supportive laymen who also receive the biannual Newsletter. As it develops and grows, the plan is to offer special opportunities for this group of people also beyond what they sign up for through the Open University.

Outreach is not limited to this series of lectures. Scientists at the NBIA who speak Danish are often called upon for interviews in radio or TV, and some write in newspapers and Danish popular science journals on a regular basis. Likewise, popular talks are often given outside of the Copenhagen area, at public libraries or through local cultural organizations.

Finally, the NBIA is lucky to have **Janet Rafner** visiting for a year on a Fulbright Fellowship. Janet Rafner graduated from the University of Virginia last year with a major in physics and a minor in studio art. Janet is working on ways to visualize physics through artwork. We will have much more to say about this project in next year's annual report!

NBIA Faculty

N. Emil J. Bjerrum-Bohr

N. Emil J. Bjerrum-Bohr is a Lundbeck Foundation Junior Group Leader and Associate Professor at the NBIA. Emil is Danish, and completed his Ph.D. in Copenhagen in 2004. He did his first postdoc in Swansea 2004-2006, concentrating his research on investigating on-shell amplitudes for gauge theories and quantum gravity. Emil's next postdoc was in Princeton, New Jersey from 2006-2009, where he was a member of the School of Natural Sciences at the Institute for Advanced Study.

Emil moved to Copenhagen in 2009 for a Knud Højgaard Assistant Professorship at the Niels Bohr International Academy.He was awarded a FNU STENO grant in 2009 and has been running his amplitude group CAMP as Lundbeck Foundation Junior Group Leader since 2011.

Emil's current research focuses on amplitudes in QCD, Yang-Mills and quantum gravity theories. Amplitude physics plays a vital role forming fruitful interdisciplinary interplay between the fields of high-energy phenomenology, experiment and high-energy theory.

Matthias Christandl

Matthias Christandl is a Professor at the Department of Mathematical Sciences at the University of Copenhagen.

Matthias' research is in the area of Quantum Information Theory. It is his aim to improve our understanding of the ultimate limits of computation and communication given by quantum theory. Concrete research results include a proposal for a perfect quantum wire and a new method for the detection of entanglement.

Matthias Christandl received his PhD from the University of Cambridge in 2006. He then became a Thomas Nevile Research Fellow at Magdalene College Cambridge. In 2008, he joined the faculty of the University of Munich as a Juniorprofessor; since 2010 he has been assistant professor at ETH Zurich. He moved to the University of Copenhagen in April 2014.

Per Rex Christensen

Per Rex Christensen did his undergraduate and graduate studies in experimental nuclear physics at the Niels Bohr Institute, University of Copenhagen, and became Mag. Scient. in 1960. He has since then been staff member at the Niels Bohr Institute, first as Amanuensis, then as Associate Professor and eventually, after 2006, as Professor Emeritus.

In 1970, he received the Ph.D. degree in nuclear physics (Lic. Scient.) from the University of Copenhagen. He was Post-Doc 1965-1966 and Research fellow 1974-1975 at California Institute of Technology and Visiting associate at ESO, La Silla, Chile in the autumn 1983.

Per Rex Christensen was Director at the Niels Bohr Institute 1989-1992 and Adm. Director at the Theoretical Astrophysics Center 1994- 2003. He was member of the Danish National Committee for Astronomy 1985-2006, member of the Astronomy Board under the Danish Natural Science Research Council and chairman of the DK-Planck consortium 1998-2006 and Planck Scientist since 2002.

His current research is focused on the Cosmic Microwave Background (CMB) in connection with the ESA Planck satellite CMB observation and on the preparation of the upcoming Deep Space project in Greenland to measure the B-mode polarization in relation the Inflation.

Poul Henrik Damgaard

Poul Henrik Damgaard did his undergraduate studies at the University of Poul Henrik Damgaard did his undergraduate studies at the University of Copenhagen and then went to Cornell University, where he received his PhD in 1982. He has held post-doctoral positions at Nordita, CERN, and the Niels Bohr Institute, and has for a period of six years been Scientific Associate at the Theory Group of CERN.

In 1995 he took up a position as Senior Lecturer at Uppsala University and that same year moved to the Niels Bohr Institute on a similar position. He has been Professor of Theoretical Physics since 2010, and Director of Niels Bohr International Academy since its beginning in 2007.

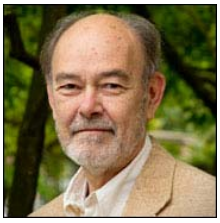
His current research interests include modern techniques for amplitude computations, non-perturbative studies of a highly supersymmetric theory as formulated on a space-time lattice, and constraints on so-called electroweak baryogenesis from the Large Hadron Collider (LHC).

Bergfinnur Durhuus

Bergfinnur Durhuus did his undergraduate studies at the University of Copenhagen. Funded by a university scholarship he spent 1978-79 at Institut des Hautes Études Scientifiques in Paris. In 1980-82 he held a postdoc position at NORDITA and from 1982-1984 a senior scholarship at the NBI. In 1984 he became Assistant Professor at the Department of Mathematisc at University of Copenhagen, in !988 Associate Professor, and in 2008 Professor of Mathematical Physics.

His current research interests include discretized models of quantum gravity and strings, non-commutative field theory, random graphs and related problems in statistical mechanics.

Andrew Jackson



Andrew D. Jackson is Professor and Board Chair at the NBIA. Born in New Jersey, he was educated at Princeton University and received his PhD in experimental nuclear physics. After almost three decades at the State University of New York at Stony Brook as professor of Theoretical Physics, Andrew joined the Niels Bohr Institute in 1996.

He is a Fellow of the American Physical Society and the American Association for the Advancement of Science and is also a member of the Royal Danish Academy of Sciences and Letters.

His current interests include the biophysics of the action potential, the study of cold atomic gases, and various topics in the history of science.

Zohar Komargodski

Zohar Komargodski did his undergraduate studies at Tel-Aviv University in Israel and he then pursued his doctoral studies at the Weizmann Institute in Rehovot, Israel. After completing his graduate studies in the field of high-energy physics, Zohar Komargodski took up a postdoctoral position at the Institute for Advanced Study, Princeton, New Jersey. After three years at Princeton, Zohar Komargodski returned to the Weizmann Institute as an Assistant Professor and was recently promoted to an Associate Professor.

The current research interests of Zohar Komargodski include non-perturbative methods in Many -Body Quantum systems and especially in Quantum Field Theory. This research program is very

closely related to the problem of Quantum Gravity, in which Zohar Komargodski is also interested.

Benny Lautrup

Benny Elley Lautrup did his undergraduate studies at the Niels Bohr Institute (under the University of Copenhagen), and continued to the now obsolete mag. scient. degree (roughly corresponding to the present Danish phd) which he finished in 1965. After two years at Nordita, he was in 1967 awarded a two-year post-doc position in the theory group of Brookhaven National Laboratory (US). Afterwards he spent three years in the theory group at CERN, followed by half year at Nordita, and one-and-a half years at Institut des Hautes Etudes Scientifiques. In 1974 he returned to the Niels Bohr Institute as a lecturer and later professor in theoretical high-energy physics until his retirement in 2009.

In 2004 he published a 600 page textbook on "Physics of Continuous Matter " which in 2011 came out in a second edition. Otherwise his recent interests are the double-slit experiments with single wave-driven particles and their non-relation to quantum mechanics.

Charles Marcus

Charles Marcus was raised in Sonoma, California, USA, and was an undergraduate at Stanford University (1980-84). He received his Ph.D. at Harvard in 1990 and was an IBM postdoc at Harvard 1990-92. He was on the faculty in Physics at Stanford University from 1992-2000 and Harvard University from 2000 to 2011. In 2012, Marcus was appointed Villum Kann Rasmussen Professor at the Niels Bohr Institute and serves as the director of the Center for Quantum Devices, a Center of Excellence of the Danish National Research Foundation, and director of Microsoft Station Q – Copenhagen. He is an affiliate of the Niels Bohr International Academy.

Marcus's research interests involves fabrication and low-temperature measurement of quantum coherent electronics in semiconductors and superconductors, including nanowires, quantum dots, quantum Hall systems, and Josephson devices. Current activities include the realization of spin qubits for quantum information processing and topological quantum information schemes based Majorana modes in nanowires and 5/2 fractional quantum Hall systems.

Ben Mottelson

Ben Mottelson was born in Chicago, Illinois, the son of Georgia (Blum) and Goodman Mottelson, an engineer. He graduated from Lyons Township High School in LaGrange, Illinois. He received a Bachelor's degree from Purdue University in 1947, and a Ph.D. in nuclear physics from Harvard University in 1950.

He moved to Institute for Theoretical Physics (later the Niels Bohr Institute) in Copenhagen on the Sheldon Traveling Fellowship from Harvard, and remained in Denmark. In 1953 he was appointed staff member in CERN's Theoretical Study Group, which was based in Copenhagen, a position he held until he became professor at the newly formed Nordic Institute for Theoretical Physics (Nordita) in 1957. In 1971 he became a naturalized Danish citizen. He received the Nobel prize in 1975.

Pavel Nasselski

Pavel Naselsky did his undergraduate studies at the Southern Federal University of Russia and then he received his PhD in 1979 at Tartu University (Estonia). In 1989 he got Doctor Habitability degree at Moscow State University, Russia, working in collaboration with world famous Yakov Zeldovich theo-

retical astrophysics group at the Moscow University and the Space Research Institute. His collaborator for more than 30 years is Professor Igor Novikov.

In 2000 Pavel Naselsky took up a position as Associate Professor at Theoretical Astrophysics Center (Copenhagen, Denmark) and at 2003 he was appointed as Senior Lecturer at the Niels Bohr Institute . He has been Professor of Theoretical Physics since 2015, and Head of the Theoretical Particle Physics and Cosmology department of Niels Bohr Institute.

His current research interests include modern cosmology, theory of the primordial black holes formation, physics of the Dark Energy and the Dark Matter, physics of the CMB etc. Since 2000 Pavel Naselsky is working on the Planck project and from 2004 he is a Planck scientists. During last 5 years Pavel has published more than 140 papers devoted to the CMB data analysis from Planck mission.

Åke Nordlund

Åke Nordlund is a professor in theoretical and computational astrophysics, working on research topics related to star formation, the solar system, and the Sun. He did his undergraduate studies at Uppsala University, continuing with a 1976 PhD at the University of Stockholm. He came to Copenhagen as a Nordita Fellow in 1976 and became an associate professor at the University of Copenhagen in 1980. He has been a guest scientist at NCAR and JILA in Boulder, Colorado for three years, and is a frequent participant in the thematic research programs at KITP/UCSB in Santa Barbara. In 2008, he and his research group joined the Niels Bohr International Academy, to which they remain closely connected, in particular through collaboration with Martin Pessah and his group. In 2009 ÅN became a staff member at the newly funded Centre for Star and Planet Formation (STARPLAN), now in its second funding period (2014-2019).

His research interests span over a number of topics in the general area of computational astrophysics, including turbulence and MHD-turbulence, radiative transfer and diagnostics, modeling of charged particle acceleration and other particle dynamic effects. He is or has been a user at most of the supercomputer centers in the world, and is currently an active user and code developer at NASA/Ames and NCSA/Urbana, with particular interest in the use of hardware acceleration and design of software for the forthcoming exa-scale computing era.

Igor Novikov

Igor Novikov did his undergraduate and graduate studies at Moscow State University, Moscow.
He received his PhD at the same University in 1962. He has held the research positions at the Institue of Applied Mathematics, Mosow; Space Research Institute, Moscow; Lebedev Physical Institute, Astrospace Centre, Moscow.
He has been the Professor of Astrophysics at the Mocow Pedagogical University and Professor of Astrophysics at the Mocow State University .
In 1991 he took a position as a Professor of Astrophysics at the University of Copenhagen, Niels Bohr Institute. He has for a period 1994-2005 been director of Theoretical Astrophysics Centre, Copenhagen.
In 2006 he took a position as deputy director of Astrospace Centre, Lebedev Physical Institute, Russian Academy of Sciences, Moscow.
Igor Novikov is a member of Danish Academy of Siciences and Letters since 1996 and a member of Russian Academy of Sciences since 2000. Now he is Emeritus Professor of Niels Bohr International Academy, Copenhagen.

His current research interests include: Physics of the Cosmic Microwave Background, Physics of Black Holes and Hipotetical Wormholes, Physics of Gravitational Waves and investigation of astrophysial processes using cosmic spacecrafts.

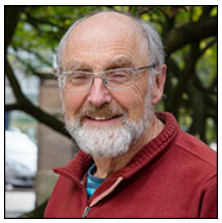
Martin Pessah

Martin Pessah was born and raised in Buenos Aires and obtained his first degree in Astronomy in 2000 from the University of La Plata, Argentina. He received his PhD in Theoretical Astrophysics from the University of Arizona in 2007. He was later a member at the School of Natural Sciences at the Institute for Advanced Study in Princeton for a period of three years.

In 2010, Martin moved to Copenhagen as a Knud Højgaard Assistant Professor at the Niels Bohr International Academy. In 2012, he started to build a new group in Theoretical Astrophysics at the Niels Bohr Institute, after receiving grants from the Villum Foundation and the European Research Council. He became Associate Professor in 2013 and Professor MSO in 2015 and is now leading an active, young group working at the forefront of theoretical and computational astrophysics.

His research interests span a broad range of subjects in plasma astrophysics, astrophysical fluid dynamics and magnetohydrodynamics.
These include fundamental aspects of accretion physics in young starts and black holes, the interstellar medium, and galaxy clusters.

Christopher Pethick



Chris Pethick is Professor at the NBIA. He did his undergraduate and graduate studies at the University of Oxford, and received his D. Phil degree in 1965. After a period as a postdoc at the University of Illinois, he joined the teaching faculty there, becoming full professor in 1973. In that year he also became a professor at Nordita. In 2008 he received the Lars Onsager Prize of the American Physical Society for his work on quantum liquids and cold atomic gases, and in 2011 the Society's Hans Bethe Prize for his work in nuclear physics and astrophysics.

His research focuses on condensed matter in the laboratory and in the cosmos. Current interests include the crusts of neutron stars, neutrino processes in dense matter, ultracold atomic gases, and dilute solutions of 3He in liquid 4He, a topic of importance for a planned experiment to place an improved bound on the electric dipole moment of the neutron.

Subir Sarkar

Subir Sarkar was educated in India, obtaining his BSc & Msc degrees at the Indian Institute of Technology, Kharagpur. He did both experimental & theoretical work in cosmic ray astrophysics at the Tata Institute of Fundamental Research, Bombay, where he was appointed to a staff position and awarded a PhD (1982). Subsequently he held visiting positions at Oxford Astrophysics, SISSA Trieste, CERN Geneva and Rutherford Laboratory Chilton, having switched to the field of astro-particle physics.

He returned to Oxford in 1990 and has been there since in various capacities, having been appointed Lecturer in 1998, and Professor in 2006. He became an Associate of the Discovery Center at NBI and developed close ties to the NBIA. Having been awarded a Niels Bohr Professorship 2013-18, he is now dividing his time between Copenhagen and Oxford.

His research interests are at the interface between fundamental physics and astrophysics/ cosmology. He also participates in experiments such as the IceCube Neutrino Observatory at the South Pole and the forthcming Cherenkov Teescope Array.

Jan Philip Solovej

Jan Philip Solovej did his undergraduate studies at the University of Copenhagen and his Phd in mathematics at Princeton University in 1989. He was then a postdoc at Univerity of Michigan, University of Toronto, and IAS Princeton before taking up an assistant professorship at Princeton University 1991-1995.

In 1995 he became a research professor at Århus University and in 1997 he became a full professor at the mathematics department of the University of Copenhagen.

He works in mathematical physics and in particular quantum physics. His current research interests include systems such as atoms, molecules, and gases of fermions, and bosons. His research addresses issues such as stability of matter, superconductivity and -fluidity, and quantum information theory.

Anders Tranberg

Anders Tranberg is Professor of Physics at the University of Stavanger, and Adjunct Associate Professor at the NBI and NBIA.
Anders is Danish and did his Masters studies at the NBI, before taking his PhD at the University of Amsterdam in 2004. His postdoc trajectory then led him to the Universities of Sussex and Cambridge in the UK (2004-7), the Universities of Oulu and Helsinki (2007-10), and back to the NBI on a personal Carlsberg Fellowship. Throughout, his field of research has been quantum and classical field theory in the context of the early Universe, numerical simulations of out-of-equlibrium systems, topological and non-topological solitons and most notably Baryogenesis in extension of the Standard Model.

In 2012, Anders was awarded a Villum Young Investigator Grant, and shortly after (January 2013) was appointed to a permanent professorship in Stavanger. Through the Villum grant, University funding and an EU/Marie Curie grant, his group now includes four postdocs and two graduate students, working on lepto-/baryogenesis and quantum field theory in Cosmology. One of these postdocs is currently located at the NBIA, where Anders also supervises a Masters project.


NIELS BOHR


INSTITUTET
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Junior Faculty

Jacob Bourjaily

Jacob Bourjaily is a new Assistant Professor at the NBIA, moving to Copenhagen in the fall. Jacob completed his Ph.D. at Princeton University in 2011, writing a thesis on scattering amplitudes in quantum field theory under the supervision of Nima Arkani-Hamed at the Institute for Advanced Study. Jacob continued this research while a Junior Fellow in the Harvard Society of Fellows at Harvard University from 2011-2104 before taking up his current position at the NBIA.

The primary focus of Bourjaily's research has been working toward an emerging reformulation of quantum field theory. He has contributed many research articles on the subject, including the discovery of a recursive description of scattering amplitudes to all orders of perturbation theory. For this work, Jacob was awarded a MOBILEX grant from the Danish Council for Independent Research in September.

Christian Brinch

Christian Brinch joined the NBIA as assistant professor in August. Brinch received his Ph.D. in astronomy from Leiden University in 2008. After two postdoctoral appointments at the university of Bonn and at Leiden university, he moved to the Niels Bohr Institute in 2011 to take up another postdoc position.

Brinch's research is mainly focussed on understanding the formation and evolution of young stellar objects and Protoplanetary disks from a phenomenological point of view. Dealing both with observations in sub-millimeter wavelengths as well as with numerical simulations of star formation, Brinch's main contribution has been the development of a unique molecular excitation and radiative transfer code which is used to post-process simulations in order to make direct comparison between models and observations. Brinch is currently working on extending this framework to models of planet formation in order to make predictions about, and potentially be able to detect, embedded protoplanets during their formation.

Simon Caron-Huot

Simon Caron-Huot is an Associate Professor at the NBIA. Simon hails from Canada and completed his Ph.D. in 2009 at McGill University, Montréal. He did his first postdoc as a member of the School of Natural Sciences at the Institute for Advanced Study in Princeton, New Jersey, starting in 2009, where he devoted his research to on-shell scattering amplitudes in gauge theories. Simon moved to Copenhagen in 2012 for an Assistant Professorship at the Niels Bohr International Academy, meanwhile retaining his affiliation with the IAS which he visited frequently until 2014.

Simon was awarded a FNU grant which supported his amplitude work during 2012-2014.

Amplitudes provide a critical connection between the fields of high-energy theory and experiment. Simon's current research focuses on developing new tools for calculating them most efficiently and uncovering new structures present in them.

Guido Festuccia

Guido Festuccia is an Assistant Professor at the NBIA since August 2013. Originally from Italy he studied in Pisa before obtaining his Ph.D at the Massachusetts Institute of Technology. He held a postdoctoral position at the University of California Santa Cruz up to 2010 and was then a member of the School of Natural Sciences at the Institute for Advanced Study in Princeton.

He was awarded a Mobilex grant from the DFF in 2013 and just obtained an ERC Starting Grant from the European Union.
Guido's research, centered on the study of the dynamics of Quantum Field Theories, has ranged from the analysis of the structure and phenomenology of supersymmetric field theories to the application of Gauge/String duality to understand the physics of spacelike singularities. Recently he has explored the interplay between geometry and supersymmetry, establishing new techniques to study quantum field theory at strong coupling.

Jacob Trier Frederiksen

L. Jacob Trier Frederiksen is an associate professor at the Niels Bohr Institute, and an associate of NBIA within theoretical astrophysics. Jacob is danish, and completed his ph.d. from Institute for Astronomi at Stockholm University in Sweden medio 2008 within computational plasma physics. He has been employed as a postdoc at NBI since then, first in a postdoc in the group for astrophysics and planetary sciences, focusing on high-energy astrophysics of gamma-ray bursts and relativistic astrophysical plasmas. The second postdoc term concentrated on the Sun-Earth plasma coupling, through an FP7 EU collaborative project to cross-scale couple computational plasma models, in preparation for a fully integrated space weather forecasting framework.

Presently, Jacob is the danish national coordinator for the EU COST Action MP1208, to strengthen networking, research and public awareness regarding fusion technology research and development in Europe.

His present research focuses on advanced computational plasma physics modeling of tenuous hot plasmas — such as are relevant to the Galactic Intra-Cluster Medium and for cosmic distance propagation effects of gamma rays. He still continues collaboration on GRBs and relativistic plasma physics with groups in the US and Europe. Further, he is involved in computational modeling of extreme high-power, high-intensity pulsed laser-plasma interaction, with the objective to support construction of a laser-plasma wakefield accelerator at the Ecole Polytechnique, France.

Oliver Gressel

Oliver Gressel is an Assistant Professor at the NBIA. Oliver is German and joined the Niels Bohr Institute in 2013. He received his Ph.D from Potsdam University in 2009, and has worked as a postdoc at the University of London 2009-2011. Next, in 2012, Oliver assumed a Nordic Fellowship at Nordita, Stockholm to work in the field of mean-field magnetohydrodynamics and dynamo theory.

He was awarded an FNU Mobilex grant in 2013 to study accretion disk turbulence. He also received a prestigious ERC Starting Grant in 2014, which will allow him to build his own small research group in the near future.

Oliver's current research at the NBIA is centered around astrophysical turbulence and MHD, with special emphasis on dynamo theory. Applications included the modelling of the turbulent interstellar medium, the large-scale galactic dynamo, and magnetic turbulence in protoplanetary accretion discs, including its influence on the formation of planets.

Alberto Guffanti

Alberto Guffanti is Assistant Professor at the NBIA and the Discovery Center. Alberto is Italian, and obtained his Ph.D. from the Università degli Studi di Parma in 2004. Before coming to Copenhagen he hold post-doctoral positions at the DESY laboratory in Zeuthen (2003-2005) and the University of Edinburgh (2005-2007) and an Hochschulassistent position at the Albert-Ludwigs-Universität in Freiburg (2007-2011).

Alberto moved to Copenhagen in June 2011to join the Discovery Center and the Niels Bohr International Academy.

During his carreer Alberto has worked on a wide vairety of topics connected to particle physics phenomenology at colliders, including QCD resummation, higher order computations and Parton Distribution Functions. He is now involved in a number of projects that are crucial for the interpretation of data coming from experiments at the Large Hadron Collider at CERN.

Tobias Heinemann

Tobias Heinemann joins the NBIA as an Associate Professor after postdoctoral experiences at IAS, Berkeley and KITP. His research interests span a wide spectrum of problems in astrophysical fluid dynamics, dynamo theory and plasma astrophysics.

Michael Kastoryano

Michael Kastoryano joined the NBIA in September 2014 as a Carlsberg Postdoctoral fellow, and with a Villum Young Investigator startup grant. Michael earned his MsS in Physics at Yale University in 2008, and his PhD-degree in Quantum Information Theory at the Niels Bohr Institute in 2011, and has since held an Alexander von Humboldt post-doctoral appointment at the Dahlem Center at the Freie University Berlin. His arrival at the NBIA coincides with an upswing in activity in theoretical quantum information sciences at the university of Copenhagen, following the appointments of Mark Rudner (NBI) and Matthias Christandl (Math). Michael will be building a quantum information group at the NBIA as part of a larger operation to make Copenhagen a pole of excellence in this dynamic field of research. Michael Kastoryano works mainly on quantum information motivated questions in many body physics. Recently his focus has shifted towards topologically ordered systems and topological computation.

D. Jason Koskinen

D. Jason Koskinen is an Assistant Professor and local group leader for the IceCube Neutrino Observatory. From 2009-2013 he was a postdoc at the Pennsylvania State University, with a brief trip to the South Pole for IceCube calibration studies. His focus is on neutrino oscillations, further physics beyond the Standard Model, and detector extensions to IceCube to probe fundamental properties of particle physics.

Mark Rudner

Mark Rudner is an Associate Professor at the NBIA. Born and raised in California, Mark moved eastward after his Bachelor's studies at Caltech to study for a PhD in Condensed Matter Theory at MIT. After his PhD on "Classical and Quantum Control in Nanosystems" in 2008, Mark spent three years as a postdoc at Harvard. In 2012 Mark continued eastward, landing in Copenhagen to take charge of the Condensed Matter Theory group at NBIA.

Currently Mark's group is enjoying the generous support of the Villum Foundation through the Young Investigator Award Program, and he is further supported by a Marie Curie International Incoming Fellowship from the European Union.

Mark's research spans a broad range of topics in quantum dynamics and many-body physics. Current topics of interest include coherence and control in solid state qubits, nonlinear dynamics of many-body spin systems, topology and dynamics in strongly driven systems, and semiclassical dynamics of electrons in topological materials. The condensed matter theory group at NBIA maintains strong links with the Center for Quantum Devices, with a healthy interplay between theory and experiment.

William Shepherd

William Shepherd is a new Assistant Professor at the NBIA, beginning in May 2015. William completed his Ph.D. at UC Irvine in 2011, working with Professor Tim Tait. He continued his research as a postdoctoral scholar at UC Santa Cruz before taking up his current position at the NBIA.

Shepherd's research focuses on ensuring that full advantage is taken of all the data available to probe new fundamental physics. He has worked on integrating the data of low-energy probes into the expectations for the LHC, and has particularly focused on the physics of dark matter, developing a dictionary of possible interactions for comparison of experiments ranging from direct detection of dark matter scattering in a mine to telescopes searching for evidence of its annihilations and the LHC attempting to produce new dark matter particles. His research has recently been funded by a MOBILEX grant from the Danish Council for Independent Research, to officially begin in January 2016.

Michael Trott

Michael Trott is the leader of the EFT phenomenology group and an Associate Professor at the NBIA. Michael is Canadian, and completed his Ph.D. at the University of Toronto in 2005. Michael has held research appointments at UC San Diego (2005-2008), Perimeter Institute (2008-20011) and CERN (20011-2014) before joining NBIA in the fall of 2014. Michael has broad and continuing research interests in the areas of Higgs physics, Beyond the Standard Model physics, collider phenomenology, Flavour physics and Neutrinos, as well as precision Standard Model calculations and even Cosmology. In pursuing research projects into all of these areas, the common unifying tool used is Effective Field Theory.

Michael was awarded a Villum Young Investigator award in 2015 and currently has a junior research group with two Ph.D students, and two postdocs are expected to arrive in the fall of 2016 to join the group.

Currently the EFT research group is most focused on the systematic development of the Standard Model Effective Field Theory and interpreting the data expected out of the Large Hadron collider in Run II, which starts in 2015.

Postdoctoral Fellows

Matteo Barnabé

Matteo Barnabè is a postdoc at NBIA and at the Dark Cosmology Centre.
He completed his PhD at the Kapteyn Institute (Univ. of Groningen, NL) and worked as a postdoctoral fellow at Stanford University before coming to the Niels Bohr Institute in 2012.

The main goal of Matteo's research is to achieve a deeper understanding of the formation and evolution processes of massive galaxies. His focus is on unveiling the mass and dynamical structure and the dark matter content of massive elliptical galaxies beyond the local Universe by combining all the available constraints from gravitational lensing and stellar kinematics.

Assaf Ben-David

Assaf Ben-David is a postdoc at the NBIA. He was born in Israel, and has completed his Ph.D. at Tel-Aviv University. Assaf arrived at the NBIA in 2013 as part of the newly formed astro-particle and cosmology group. He is interested in cosmology, and studies the cosmic microwave background radiation and other data in connection to models of the early Universe.

Benjamin Brown

Ben Brown is a postdoc at the NBIA in the Quantum Information group of Michael Kastoryano. Ben received his Ph.D. from Imperial College London in 2014, and arrived at NBIA at the beginning of 2015 after completing a one year fellowship in the Controlled Quantum Dynamics Theory Group at Imperial College. Ben's research interests include quantum error correction, and the application of topologically ordered phases for realising scalable quantum computation.

Jeroen Danon

Jeroen Danon is a postdoc at the NBIA. Jeroen graduated in 2009 from the Delft University of Technology (The Netherlands), and after doing a postdoc at the Dahlem Center for Complex Quantum Systems of the Freie Universität Berlin (Germany) he came to the NBIA in October 2012.

Jeroen works as a theoretical physicist in the fields of quantum transport and mesoscopic condensed matter physics. His main research interests concern the quantum dynamics of nanoscale solid state systems, mostly focusing on topics related to quantum information applications. He likes to work on problems closely related to actual experiments, such as experiments involving spin qubits or Majorana bound states, and much of his research is in very close collaboration with experimentalists.

Tristan Dennen

Tristan Dennen is a postdoc at the NBIA and Discovery Center on a FNU grant from the Danish National Research Foundation. He completed his PhD at the University of California, Los Angeles before coming to the Niels Bohr Institute in 2012.

Tristan's research interests are in particle scattering in the Standard Model and quantum gravity theories. His focus is on analytical calculation of scattering amplitudes, used both in the study of the ultraviolet properties of supergravity theories and in phenomenological studies of the Standard Model.

Sami Dib

Sami Dib is a postdoc and Marie Curie Intra European Fellow at the NBIA. Sami is French, having completed his M.Sc. at Liege University (Belgium) and his Ph.D. at the Max-Planck Institute for Astronomy and the University of Heidelberg (Germany). He previously worked in Morelia at the Universidad Nacional Autonoma

de Mexico, the Korea Astronomy and Space Science Institute in Daejeon, the Astrophysics Division of the French Atomic Energy Agency in Saclay, and at Imperial College London.

Sami arrived at the NBIA in spring 2014 in the theoretical astrophysics group, and he is also a member of STARPLAN at the National Geology Museum of Denmark.

Sami's Research is multifacted, and he is currently working on a variety of problems pertaining to star formation on small and large scales. Central among these is the origin and universality of the mass distribution of stars in clusters and in Galaxies. His current research portfolio includes, among others, the study of the stability of protostellar disks and the formation of binary systems, the nature and origin of dust in external galaxies, and the development of sophisticated statistical models that are used to analyse complex astrophysical observations.

Yuri Fujii

Yuri Fujii is a postdoc at the NBIA (and StarPlan). She completed her PhD at Nagoya University, Japan in March 2015 (and did a short term postdoc at Tokyo Tech before coming to the Niels Bohr Institute in July).

Her research interest is planet and moon formation, especially dynamics of protoplanetary and circumplanetary disks which are the birthplaces of planets and moons. She performs non-ideal MHD simulations of those disks with time-dependent ionization chemistry.

Kjetil Hals

Kjetil M. D. Hals is a postdoc at the NBIA. He is Norwegian and received both his Master degree (2007) and PhD degree (2011) in theoretical physics at NTNU, Trondheim, Norway, with Professor Arne Brataas as a supervisor.
Kjetil has previously worked as a researcher at Christian Michelsen Research in Bergen and as a postdoc at NTNU, before joining NBIA in 2014.
His main research area is Spintronics and his research is currently focused on helical spin textures formed in one-dimensional (1D) interacting electron systems. These 1D magnets represent a completely new quantum state of matter and are currently attracting considerably interest because they have been proposed as a basis for creating topological superconductors, with potential use for quantum computation.

Matti Herranen

Matti Herranen is a postdoc at the NBIA since October 2012. Matti did his PhD at the University of Jyvaskyla in Finland followed by a postdoc at the RWTH Aachen University in Germany before joining NBIA.

Matti's research interests are focused on particle physics and cosmology, including baryogenesis, leptogenesis and inflationary cosmology, as well as quantum field theory in extreme conditions such as high temperature and curved spacetime.

Yun Jiang

Yun Jiang is joining the NBIA as a postdoctoral fellow and also a member of Discovery Center. He obtained his Ph.D. degree at U.C. Davis in 2015 with the highest honor Outstanding Academic Achievement Award. He was the 2013 LHC Theory Initiative Graduate Fellow and the winner of the 2014 National Award for Outstanding Chinese Students Studying Abroad. Prior to his Ph.D., he earned his M.Sc. degree at National University of Singapore in 2011 and B.S. degree at Zhejiang University in China.

The focus of his research is New Physics beyond the Standard Model, including Higgs physics and dark matter. He is interested in phenomenology and model building. His past work concen-

trated on the LHC implications of various Higgs models both within and outside the framework of supersymmetry or extra dimensions. He is now expanding his research area from particle physics to cosmology, particularly on the baryogenesis and inflation of the early universe.

Ervand Kandelaki

Ervand Kandelaki is a postdoc in theoretical condensed matter physics at the NBIA. He completed his PhD at the Ruhr University Bochum, Germany, before coming to the Niels Bohr Institute in 2015.

Ervand's current research focus lies in non-equilibrium quantum physics, especially with regard to the impact of interactions on many-body effects and topological properties. He is interested in studying gapped phases in periodically driven systems going beyond the one-particle picture and looking for genuine many-body phenomena.

Cynthia Keeler

Cynthia Keeler is a postdoc at NBI. After obtaining her PhD from University of California at Berkeley in 2008, she held postdoctoral positions at Harvard University (2008-2011) and University of Michigan (2011-2014).
She arrived at NBI in Fall 2014, and will become a Marie Curie Fellow in fall 2015.
Cynthia's research is in the area of high energy theoretical physics, focusing on dualities between gravitational systems and strongly coupled field theories. She studies both novel forms of dualities which may allow applications to non-relativistic regimes, and novel calculation techniques to study the underpinnings of all gauge-gravity dualities.

Changyong Liu

Changyong Liu is a visiting scholar at the NBIA supported by China Scholarship Council and Northwest A&F University. He completed his PhD at the Institute of Theoretical Physics, Chinese Academy of Sciences and work at the Northwest A&F University. Changyong's research interests are in scattering amplitude in quantum field theory and string theory.

David McGady

David McGady is a postdoc at the NBIA and Discovery Center. He completed his PhD at Princeton University before coming to the Niels Bohr Institute in 2015.

David's research interests are spread across high energy physics and quantum field theory. Currently, he is actively focused on analytic structures in scattering processes in quantum field theories, and elucidating both the fundamental cause of, and the consequences derived from, a recently discovered symmetry of partition functions under reflection of temperatures (first observed in four-dimensional gauge-theories).

Colin McNally

Colin McNally is a postdoc and Marie Curie International Incoming Fellow at the NBIA. Colin is Canadian, having completed an M.Sc. at McMaster University (Hamilton, Ontario, Canada) and his Ph.D. at Columbia University and the American Museum of Natural History (New York, USA).

Colin arrived at the NBIA in 2012 in the theoretical astrophysics group, first as a NBIA Fellow before becoming a Marie Curie Fellow in 2013.

Currently, Colin's research centers around the structure of and magnetic energy dissipation mechanisms in protoplanetary accretion disks, with applications in the early history of solar systems. This physics is central to both the formation of extrasolar planets, and long-standing problems in the study of meteorites in our own solar system.

Shunji Matsuura

Shunji Matsuura is a postdoc at the NBIA and QDev. He belonged to Yukawa Institute for Theoretical Physics, Kyoto University, before coming to Niels Bohr Institute in 2015.

Shunji's research interests are in theoretical condensed matter physics and high energy physics.

His focus includes 1) error correction in quantum annealing and 2) quantum entanglement in topological phases and gauge/gravity duality.

Gareth Murphy

Gareth Murphy is a postdoc at the NBIA. Gareth is Irish, having completed a Ph.D. at Trinity College, Dublin and the Dublin Institute for Advanced Studies (DIAS). He has been a postdoc at the Institut de Planétologie et d'Astrophysique de Grenoble and DIAS.

Gareth arrived at the NBIA in 2012 in the theoretical astrophysics group, as an NBIA Fellow.

Currently, Gareth's research focuses on probing the physical processes linking accretion and ejection in astrophysical disks. He is also interested in energetic collisionless shock waves in supernova remnants and gamma ray bursts.

Farrukh Nauman

Farrukh Nauman works as a postdoc at the NBIA in the theoretical astrophysics group led by Martin Pessah. Before joining the NBIA, he finished his PhD at the University of Rochester in 2015.

Farrukh's research focuses on turbulence in astrophysical fluids and plasmas with a particular emphasis on understanding the origin, survival and influence of large scale magnetic fields in accretion disks. This involves both theoretical and computational work.

Hiroki Ohta

Hiroki Ohta is a postdoc at the NBIA and Center for Models of life. He completed his Ph.D. at the University of Tokyo in 2011, and studied as a postdoc at YITP in Kyoto University and LPTMS in Université Paris-Sud before coming to the Niels Bohr Institute in 2013.

Hiroki's research interests are in statistical physics and its application to biology. His focus is, in particular, on developing analytical approaches for collective phenomena in stochastic processes on graphs, combined with random graph theories.

Michael Schecter

Michael Schecter is a postdoc at the Center for Quantum Devices and Niels Bohr International Academy. Mike is originally from Michigan (U.S.), having completed a B.Sc. at the Michigan State University (East Lansing, MI) and a Ph.D. at the University of Minnesota (Minneapolis, MN).

Mike arrived at QDev/NBIA in the Fall of 2014 in the theoretical condensed matter group.

Currently, Mike's research involves understanding the low-temperature magnetic structure of atoms placed on a metallic or superconducting substrate. The intriguing interplay between the magnetic and electronic properties of such systems may lead to important applications in future quantum information processing techniques or spintronic devices.

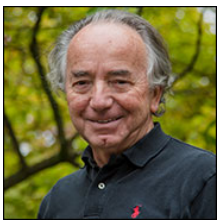
Visiting Professors

James Cline

James Cline is Professor at McGill University in Canada. He received his PhD from Caltech in 1988 and held post-doctoral positions at Ohio State University, McGill University and University of Minnesota before joining faculty at McGill in 1995. He has since had extended research visits at CERN, Nordita, Perimeter Institute and Lawrence Berkeley Lab.

James Cline is leading expert in the overlap between particle physics and cosmology. While visiting the NBIA he has worked intensely on new results from the Large Hadron Collider at CERN, often in collaboration with Michael Trott and others at the NBIA.

Jacques Colin



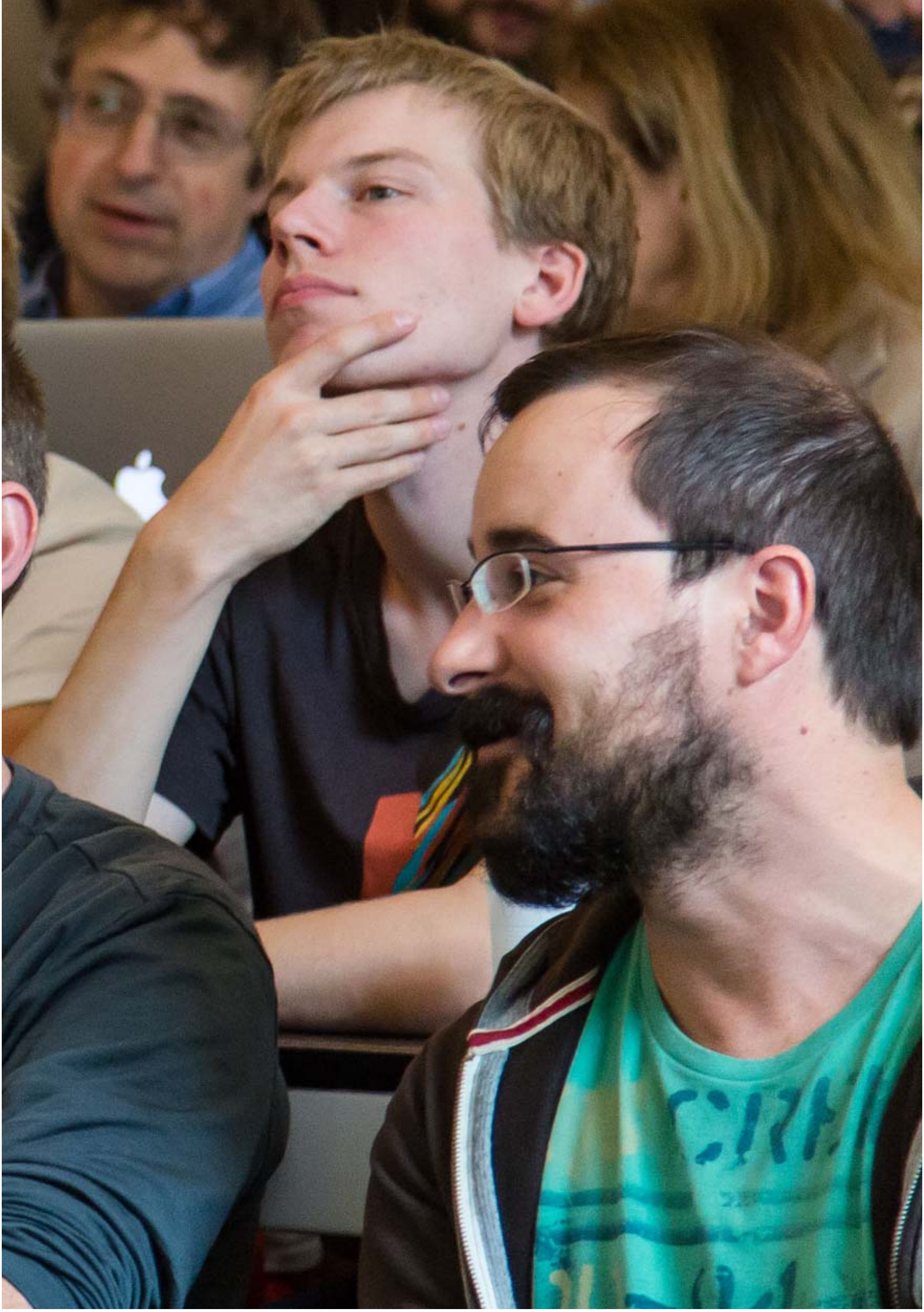
Jacques Gerard Colin is Deputy Director of the Institute of Astrophysics of Paris (IAP). He received his PhD from Pierre and Marie Curie University, has been Director of the Astronomy and Astrophysics Laboratory of Bordeaux from 1987-1999 and has been General Director of the Nice Observatory 1999-2009. He currently works on the large-scale structure of the university and extragalactic astrophysics.

Roya Mohayaee

Roya Mohayaee is Charge de Recherche CNRS at University of Paris VI.
She received her PhD in 1995 from Imperial College and held post-doctoral appointments at ICTP in Trieste, University of Rome and University of Cardiff before joining faculty at University of Paris.
Roya Mohayaee started out in theoretical particle physics, but has since switched to theoretical cosmology and large-scale astrophysics, working, in particular, on the understanding of dark matter and large-scale anisotropies in the universe.

Kelvin Richards

Kelvin John Richards is Professor at the University of Hawaii and holds also a position with the International Pacific Research Center in Hawaii. He received his PhD from the University of Southampton in 1978 and then received a Royal Society Ernest Cook Trust Fellowship at the University of Cambridge. He was Lecturer and later reader at the University of Southampton until become Professor at the University of Hawaii in 2022. Kelvin Richards works on mathematical modelling of large-scale oceanographic structures.



PhD Students

Thomas Berlok

Thomas began his studies at the University of Copenhagen in 2008 where he initially specialised in quantum optics and cold atoms. He joined the Theoretical Astrophysics group at NBIA during the spring of 2013 and completed his Master's degree under the supervision of Martin Pessah.
Thomas has continued working with Martin Pessah on understanding the influence of Helium on the dynamics of the intracluster medium of galaxy clusters and has recently begun working with Martin Pessah, Troels Haugbølle (NBI) and Tobias Heinemann (KITP) on simulations of collisionless plasmas.

Laure Berthier

Initially studying Engineering at the Institut d'Optique in France, Laure went to the University of Cambridge where she completed a Masters in Applied Mathematics and Theoretical Physics. She started her phD at the Niels Bohr Institute last October and is now working on Standard Model Effective Field Theory with Michael Trott.

Amel Durakovic

Amel undertook his postgraduate studies in theoretical physics at Imperial College London. He completed these writing a dissertation under the supervision of Professor Michael Duff on division algebras and supergravity. Amel now works with Professor Subir Sarkar studying aspects of cosmological inflation and the reconstruction of primordial power spectra from observations.

Christine Hartmann

Christine completed her Master's degree at the University of Copenhagen after having spent also 18 months at the University of California, Santa Barbara. There, she began her Master's Thesis in neutrino physics under the supervision of KITP Professor Anthony Zee, finishing it at the NBIA with Poul Henrik Damgaard as advisor.

She currently works with Richard Ball (Edinburgh) and Poul Henrik Damgaard on constraining anomalous dimensions from conformal symmetry and with Michael Trott on Standard Model Effective Field Theory.

Meera Machado

Meera acquired her Master's degree at the University of Sao Paulo, Brazil, under the supervision of Prof. Dr. Frederique Grassi. The thesis title was "*Event-by-event Hydrodynamics for LHC*". She currently works with Poul Henrik Damgaard, Kim Splittorff and Ante Bilandzic (TUM) in a PhD project titled *"The Little Bang of High-Energy Heavy-Ion Collisions"*, whose aim is to analyse the anisotropic flow of heavy-ion collisions by the use of statistical tools employed in the analysis of cosmological data from the early Universe, the Cosmic Microwave Background (CMB).

Gopakumar Mohandas

After graduating with an M.Sc. in Physics at the Chennai Mathematical Institute in India, Gopakumar joined the Theoretical Astrophysics group at the NBIA in the fall of 2013. He currently works, with his principal supervisor Dr. Martin Pessah, on analysing the stability and dynamics of accretion disks using magnetohydrodynamic theory. He will also be working with Dr. Oliver Gressel on studying the evolution of magnetic fields and associated dynamo processes in accretion disks.

Jeppe Trøst Nielsen

Jeppe began, and is still trying to finish, his studies at the Niels Bohr Institute. He is currently working with Alberto Guffanti and Subir Sarkar, looking for ways to disentangle assumptions from data, to get a clear view of the universe.

Mads Søgaard

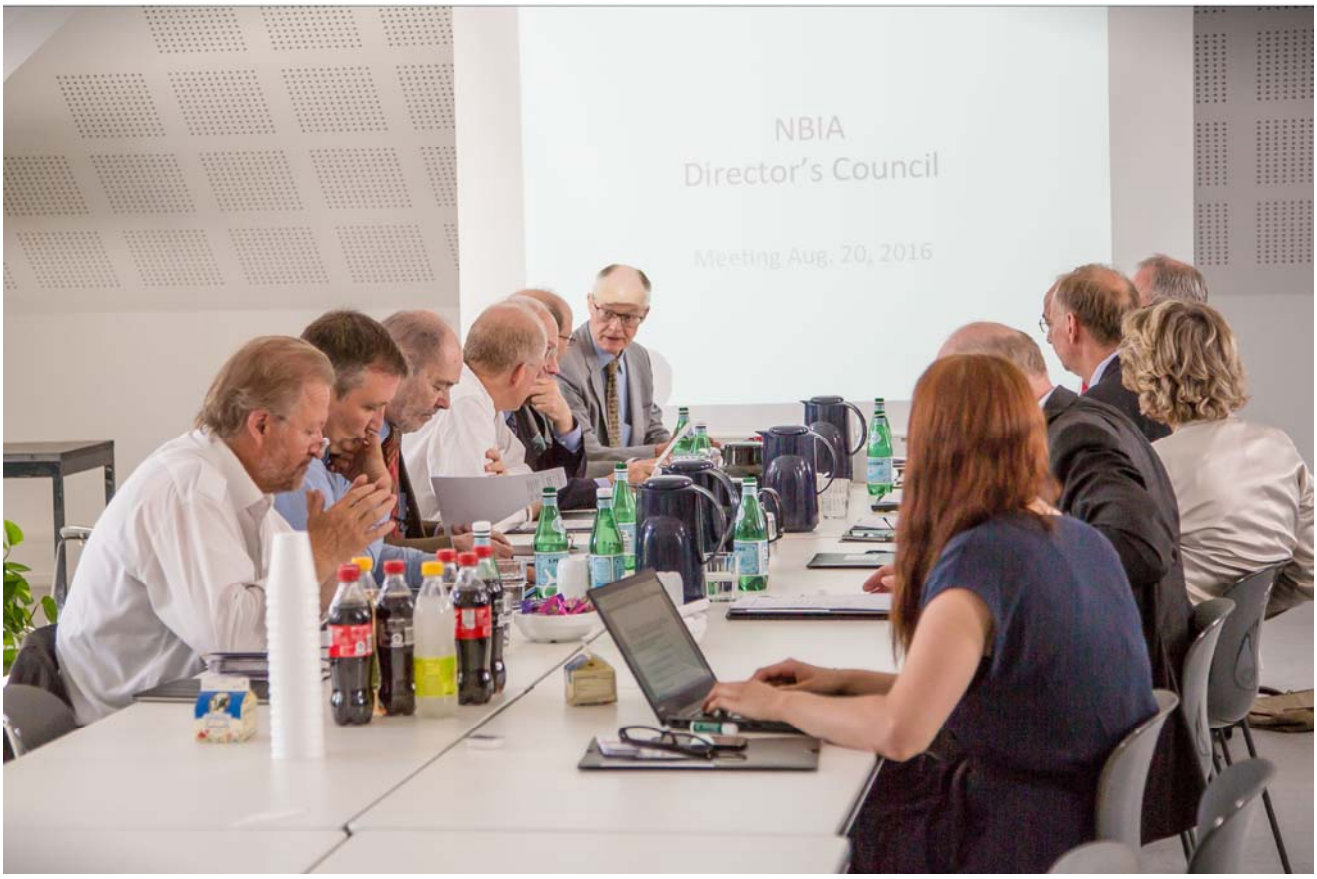
Mads completed his master's degree at NBIA with Poul Henrik Damgaard and Emil Bjerrum-Bohr as advisors. In his master's thesis, he began to work on mathematical aspects of quantum field theory scattering amplitudes.

He currently works with David Kosower (CEA Saclay), Kasper Larsen and Yang Zhang (ETH Zurich) on unitarity methods to calculate two-loop amplitudes, needed for precision physics at the LHC.

MSc Students

Erik Alexander Andersen	Particle Physics
Emil Andre	Particle Physics
Anine Borger	Condensed Matter
Mikkel Bjørn	Particle Physics
Carsten Fritzner Frøstrup	Particle Physics
Gitte Clausen	Particle Physics
Dennis Hansen	Particle Physics
Asta Heinesen	Astroparticle Physics
Rasmus Peter Larsen	Particle Physics
Aslak Sindbjerg Poulsen	Plasma Physics
Anders Schreiber	Particle Physics

Administrative staff



Anette Studsgård

Anette Studsgård did her Master of Arts in Cognitive Science at Lund University and has been employed at the NBIA since August 2014. As an administrative coordinator, Anette is responsible for workshop organization, visa applications secretarial work, budget allocation, etc. You can always contact Anette if you have any questions concerning your employment or stay in Denmark.

Kaare Møller

Kaare Møller is the grant finance officer responsible for the grants received by the researchers at the Niels Bohr International Academy.

Visitors 2015

Kris Gorski
13.12.2015—15.12.2015

Syksy Räsänen
08.12.2015—14.12.2015

Paolo Benincasa
07.12.2015—11.12.2015

Jon Gudmundsson
02.12.2015—06.12.2015

Ludovic Planté
30.11.2015—11.12.2015

Ilaria Brivio
29.11.2015—02.12.2015

Benjamin Basso
25.11.2015—27.11.2015

Nima Arkani-Hamed
17.11.2015—21.11.2015

Belen Gavela
12.11.2015—15.11.2015

Giampiero Passarino
12.11.2015—14.11.2015

Gianluca Gregori
01.11.2015—03.11.2015

Sonia El Hedri
28.10.2015—07.11.2015

Ludovic Planté
27.10.2015—03.11.2015

Irene Tamborra
19.10.2015—23.10.2015

Katherine Freese
01.10.2015—04.10.2015

Jonathan Cornell
01.10.2015—31.12.2015

Philipp Mertsch
25.09.2015—30.09.2015

Kimmo Kainulainen
22.09.2015—24.09.2015

Subodh Patil
13.09.2015—19.09.2015

Jeremie Choquette
10.09.2015—24.10.2015

Jacques Colin
01.09.2015—31.08.2016

Roya Mohayaee
01.09.2015—31.08.2016

Joaquín Santos Blasco
31.08.2015—01.12.2015

Janet Rafner
26.08.2015—30.06.2016

Paul Hunt
23.08.2015—29.08.2015

Alexander Karlberg
18.08.2015—29.08.2015

Pablo Benitez-Llambay
08.08.2015—15.08.2015

Ken-Ishi Nishikawa
03.08.2015—08.08.2015

Jim Cline
01.08.2015—31.12.2015

Bo Feng
27.07.2015—27.08.2015

Diego Torres
27.07.2015—29.07.2015

Simon Foreman
25.07.2015—31.07.2015

Jack Lissauer
25.07.2015—08.08.2015

Tobias Heinemann
15.07.2015—23.07.2015

Alexander Lande
13.07.2015—10.08.2015

Arindam Chatterjee
05.07.2015—11.07.2015

Steve Flammia
02.07.2015—08.07.2015

Nyantara Gupta (Raman)
01.07.2015—31.07.2015

Isaac Kim
29.06.2015—11.07.2015

Tanmay Vachaspati
27.06.2015—30.06.2015

Sacha Davidson
24.06.2015—26.06.2015

David McGady
07.06.2015—13.06.2015

Yun Jiang
16.06.2015—23.06.2015

Graham Farmelo
03.06.2015—09.06.2015

Changyong Liu
01.06.2015—31.05.2016

Congkao Wen
30.05.2015—03.06.2015

Fabrizio Caola
28.05.2015—29.05.2015

Tobias Heinemann
19.05.2015—29.05.2015

Daniel Nagaj
11.05.2015—13.05.2015

Barry Simon
04.05.2015—07.05.2015

Turlough Downes
29.04.2015—01.05.2015

Henriette Elvang
23.04.2015—26.04.2015

Daniel Litim
22.04.2015—24.04.2015

Simon Badger
22.04.2015—24.04.2015

Yuri Fujii
20.04.2015—28.04.2015

Ervand Kandelaki
09.04.2015—10.04.2015

Raul Garcia-Patron
09.04.2015—14.04.2015

Thomas Quella
09.04.2015—10.04.2015

Irene Tamborra
09.04.2015—10.04.2015

William Shepherd
09.04.2015—11.04.2015

Andrej Kosmrlj
09.04.2015—11.04.2015

Davide Forcella
08.04.2015—09.04.2015

Christoph Pfrommer
08.04.2015—09.04.2015

Roberto Auzzi
07.04.2015—11.04.2015

Roman Rafikov (Princeton)
07.04.2015—07.04.2015

Alexander Karlberg (Oxford)
28.03.2015—18.04.2015

Peter Landrock (Cryptomathic)
20.03.2015—20.03.2015

Georgios Kavuolakis (Crete)
26.02.2015—26.03.2015

Maxim Pospelov (Victoria)
11.02.2015—18.02.2015

Tom Douglas (Leeds)
04.02.2015—06.02.2015

Ben Pecjak (Durham)
26.01.2015—29.01.2015

Natalie Dzyurkevich (IRA)
20.01.2015—23.01.2015

Mario Flock (CEA)
20.01.2015—23.01.2015

Katherine Freese (Michigan)
20.01.2015—20.01.2015

Eric Laenen (Amsterdam)
16.01.2015—16.01.2015

Tilman Plehn (Heidelberg)
16.01.2015—16.01.2015

Aksel Stenholm (Aarhus)
15.01.2015—15.01.2015

Damiano Caprioli (Princeton)
14.01.2015—16.01.2015

José Ignacio Latorre (Barcelona)
13.01.2015—15.01.2015

Lorenzo Sironi (Harvard)
08.01.2015—09.01.2015

Sunny Vagnozzi (Melbourne)
05.01.2015—15.09.2015

Alessandro Romito (Berlin)
05.01.2015—06.01.2015

Tobias Heinemann (USA)
07.01.2015—24.01.2015

Yanli Jia (Hawaii)
01.01.2015—30.06.2016

Kelvin Richards (Hawaii)
01.01.2015—30.06.2015

Publications 2015

1. Soam A., Maheswar G., Chang Won Lee, Sami Dib, Bhatt H C, Motohide Tamura, Gwanjeong Kim: *Magnetic field structure around cores with very low luminosity objects*, A&A 573, A34 (2015)
2. IceCube collaboration (S. Sarkar, J. Koskinen, J. Adams): *IceCube-Gen2: A Vision for the Future of Neutrino Astronomy in Antarctica*, Preprint
3. IceCube collaboration (S. Sarkar, J. Koskinen, J. Adams): *Search for Prompt Neutrino Emission from Gamma-Ray Bursts with IceCube*, Astrophysical Journal 805 L5
4. David Kraljic, Subir Sarkar: *How rare is the Bullet Cluster (in a ΛCDM universe)?*, JCAP 04 (2015) 050
5. Planck Collaboration (I. Novikov): *Planck intermediate results. XXXIV. The magnetic field structure in the Rosette Nebula*, A&A
6. Jeroen Danon, Karsten Flensberg: *Interaction effects on proximity-induced superconductivity in semiconducting nanowires*, Phys. Rev. B Accepted
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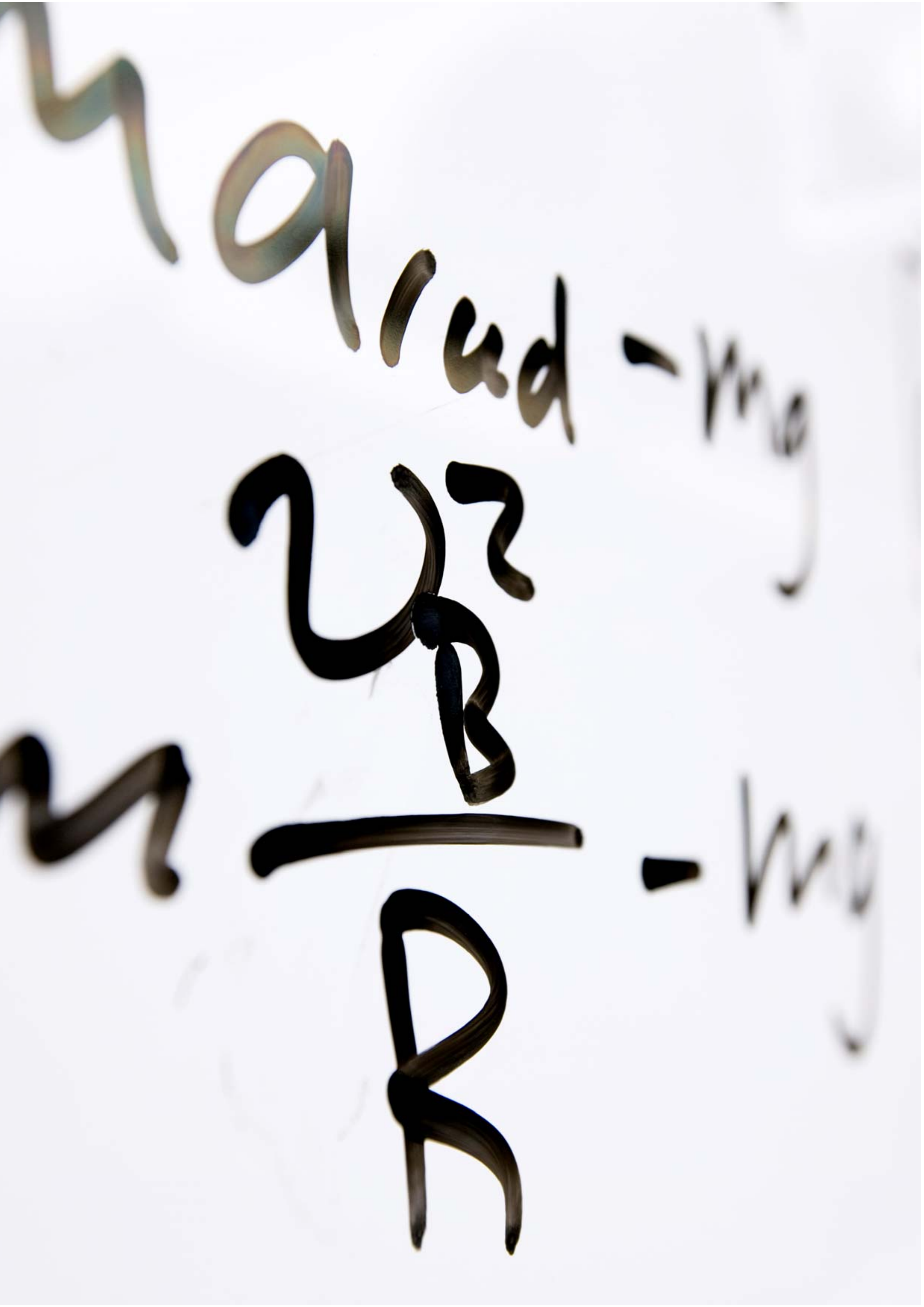
- IceCube Collaboration Meeting 2015 (October 10-17)
- Current Themes in High Energy Physics and Cosmology (August 17–21)
- PhD School on Protoplanetary Disks and Planet Formation (August 3-7)
- MHJ60: Excursions in Complexity (June 4-5)
- Master Class on Quantum Mathematics (May 26-29)
- International Symposium on High Energy Physics (May 4-6)
- NBIA-Oxford Colloquium (April 13–15)
- Measuring B-mode Polarization from Greenland (Febuary 2–4)
- Nordic Winter School on Cosmology and Particle Physics 2015 (January 2-7)

NBIA Colloquia

- 20.11.2015 | Nima Arkani-Hamed
- 02.10.2015 | Katherine Freese (University of Michigan and NORDITA, Stockholm): *Inflationary Cosmology in Light of Cosmic Microwave Background Data*
- 25.09.2015 | Mikkel Thorup (Department of Computer Science, KU): *What is the Maximum Overhang for a Stack of n Blocks?*
- 31.07.2015 | Jack Lissauer (NASA Ames): *Kepler's Multiple Planet Systems*
- 19.06.2015 | Antti-Pekka Jauho (DTU Nanotech): *Nanostructuring graphene: moving from ideas to practical applications*
- 07.05.2015 | Barry Simon (Caltech): *Singular Eigenvalue Perturbation Theory*
- 20.03.2015 | Peter Landrock (Cryptomathic): *Classical Cryptography*
- 20.02.2015 | Kelvin Richards (University of Hawaii): *Turbulence in the Natural Environment*
- 06.02.2015 | Martin Bizzarro (StarPlan, Natural History Museum of Denmark): *Mass transport regimes in the solar protoplanetary disk - insights from meteorites and their components*



$ma_{rad} - mg$
$m\frac{v_B^2}{R} - mg$