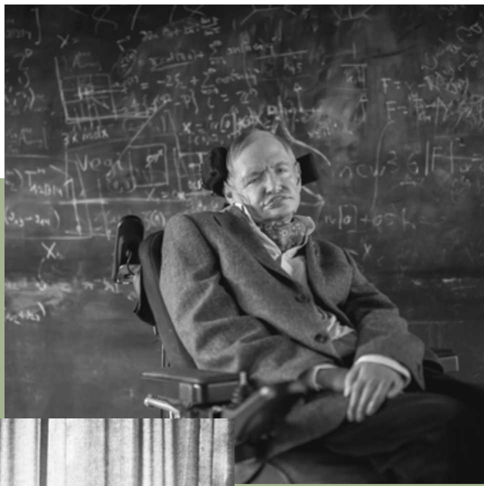

2016

Annual Report

The Niels Bohr International Academy

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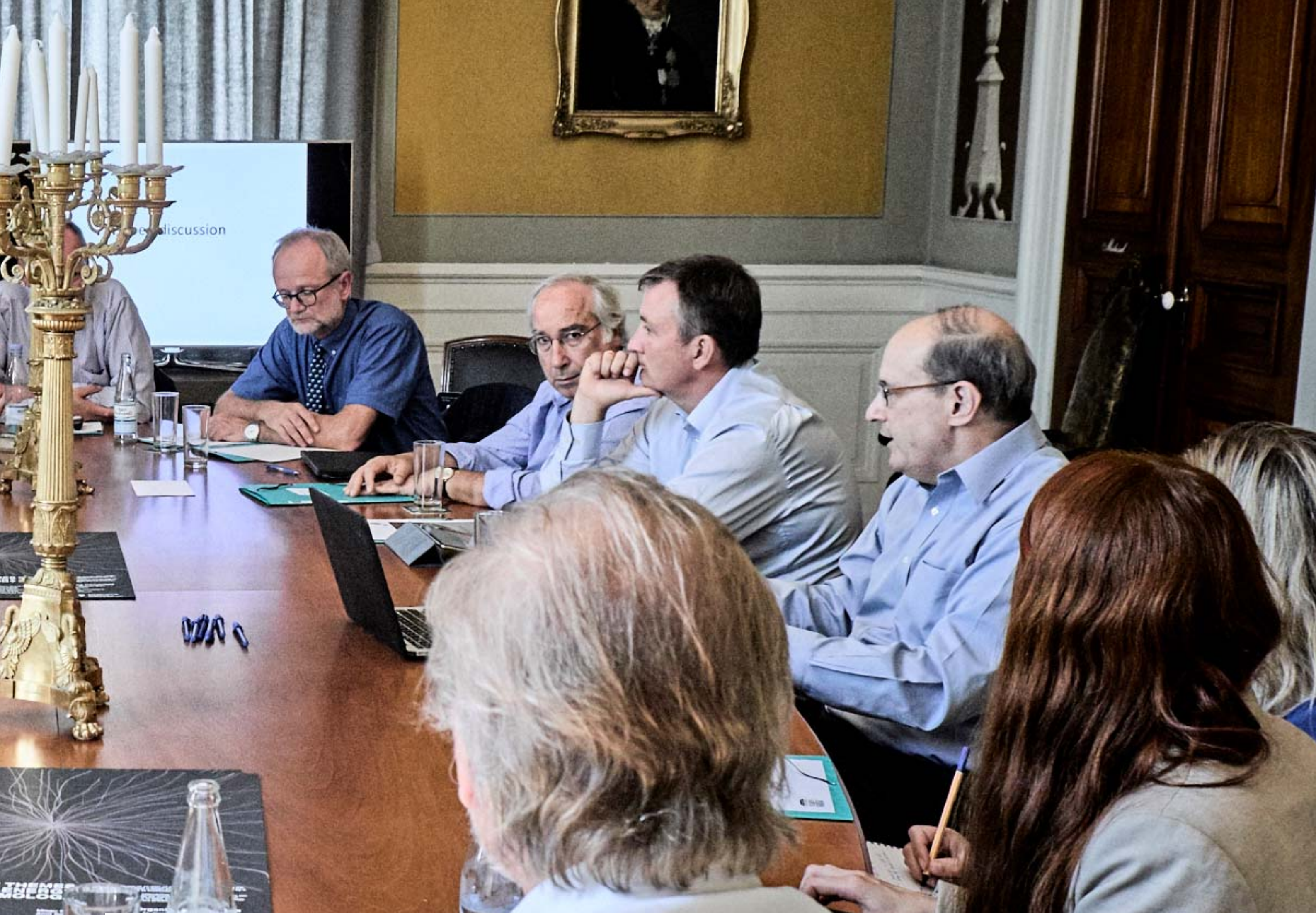

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From the Director

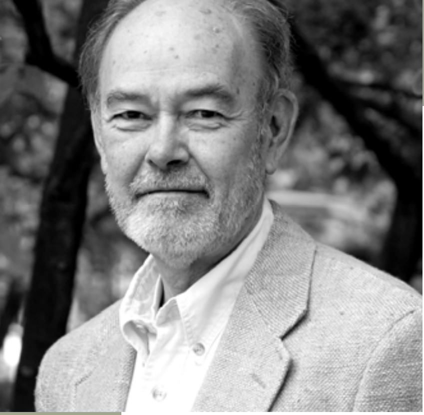
In this report of the activities of the Niels Bohr International Academy (NBIA) during 2016 you can read a bit about the science that we do, how we disseminate our work to the public, and how we steer our way through avenues for science funding. Fortunately, things are going well! The list of extremely well-qualified applicants for our post-doctoral positions continues to grow, our junior faculty continues to be remarkably successful in obtaining science funding on a very competitive basis, and work is now underway towards establishing a more stable funding situation for the NBIA. If we succeed in this, short-term fluctuations in research funding can be evened out, and a completely new strategy towards high-profiled hires can be established. But this still lies ahead of us, and in this report we restrict ourselves to some of the highlights of the year 2016.

Based on a generous grant from the **Simon Foundation** in New York, the NBIA launched a new series of *Simons Programs* in 2016. Over a three-year period we can offer six prestigious Simons Visiting Professorships to outstanding scientists who can visit the NBIA on sabbaticals, roughly one new Simons Visiting Professor per semester. The first Simons Program started in the fall of 2016, and first Simons Visiting Professor was eminent cosmologist Viatcheslav ‘Slava’ Mukhanov, Professor of Physics and Head of the Astroparticle Physics and Cosmology Group at the Department of Physics at the Ludwig Maxmilian University of Munich. Best known for his theory of how the Universe can have evolved from an initial quantum fluctuation, Slava Mukhanov helped co-organize one of the most spectacular scientific meetings at the NBIA, the ‘Current Themes in High Energy Physics and Cosmology’ of August 2016. Surely, in the public eye it was the arrival of Stephen Hawking that caught most of the attention. Visiting Copenhagen for only the second time in his life, Stephen Hawking volunteered to give a public lecture at the concert hall of Danish National Radio. With an interest from the public that has only been surpassed by rock stars, the tickets for this public lecture were sold out in 19 minutes and the waiting list exceeded 10,000. With most important support from the **Carlsberg Foundation**, the visit by Stephen Hawking went extremely well. A last-minute arrangement with numerous cinemas across Denmark, allowed an audience of several thousands more to enjoy the lecture, live streamed from the concert hall.

Because of the participation of Stephen Hawking, the scientific meeting itself had been partly shifted to the lecture room of the Royal Danish Academy of Sciences and Letters. A highlight of the meeting was the settling of a wager regarding the possible discovery of so-called supersymmetry at the Large Hadron Collider at CERN in Geneva. The wager was signed long ago, and the winning side should have been decided already in 2010. Due to unforeseen delays of the Large Hadron Collider, the winning side had graciously extended the bet, - and still to no avail for the losing side! Supersymmetry does not seem to appear in this generation of experiments. Institute for Advanced Study scientists Nima Arkani-Hamed, a long-time friend of the NBIA and one of the scientists who had bet that supersymmetry would be found by 2016 flew in to concede defeat and hand over an expensive bottle of brandy to the winning side. The event was much publicized in international science blogs and also became quite a big issue in the Danish press. Hopefully, such reporting that brings the excitement of science to the public will help build up for support for science in a longer perspective.

On the science funding side, 2016 was again a good year for the NBIA. Assistant Professor Jacob Bourjaily received a Villum Young Investigator Grant from the **Villum Foundation**. NBIA post-doc David McGady and Associate Professor Emil Bjerrum-Bohr received Distinguished Postdoctoral and Distinguished Associate Professor Fellowships from the **Carlsberg Foundation**. Knud Højgaard Associate Professor Irene Tamborra was awarded a Mercator Fellowship from the **German Research Foundation** (DFG) as part of her participation in the Collaborative Research Center "Neutrinos and Dark Matter in Astro- and Particle Physics" in Germany. Finally, NBIA post-doc Pablo Benitez-Llambay received a two-year Marie Curie Fellowship from the **European Union**.

Poul Henrik Damgaard
2016



From the Board Chairman

Director Poul Henrik Damgaard has provided a thorough description of the many "external" successes that the NBIA has enjoyed during the past year. The visibility of the NBIA has increased on all levels. Local institutes and university administrations tend to focus on the number and magnitude of external funding and overhead. As in past years, members of the NBIA have been remarkably successful in obtaining external support for their research programs. On a somewhat larger scale, the NBIA's success in attracting distinguished senior guests as well as some of the world's brightest young scientists has been noted with approval by the broader scientific community. The extraordinarily large number and high quality of applicants for post-doctoral positions at the NBIA provides a clear indication that the coming generation regards Copenhagen as the right place to do theoretical physics. Inevitably, the most successful "event" of the last year was Stephen Hawking's visit. It captured the attention and emotions of the Danish press and public with unprecedented intensity. The roar that answered Stephen's famous question of "Can you hear me?" was literally heard all over Denmark. In spite of their evident importance, such external indicators do not have much to say about the internal successes of the NBIA in creating a working environment that supports and encourages scientific achievement.

Research at the Niels Bohr Institute is thematically organized. The NBIA is the sole exception. From its inception in 2007, the NBIA has had a mandate to support a broad spectrum of activities in theoretical physics. Our assumption has been that talented scientists will thrive in the company of others of similar ability independent of their specific areas of interest, and our appointment strategy has been shaped accordingly. It is not so difficult to begin a new venture with an open and supportive atmosphere. At the start, senior staff members naturally play a dominant role, and the "pioneer spirit" of a shared adventure is easy to communicate. After 10 years of existence, however, the NBIA has grown so that there are now many more post-doctoral fellows and post-graduate students than permanent faculty. In addition, success in attracting significant external funding for individual research programs has created smaller thematic groups within the larger NBIA. It is not obvious that an initial policy of open doors, open minds and open inquiry can survive such growth.

In spite of the challenges of rapid growth, I am pleased to be able to report that the scientific atmosphere at the NBIA remains open and optimistic. Good physical facilities and an active program of talks — both formal and informal — are important. But it is even more important that the expanded permanent staff of the NBIA remains committed to its original mission and spirit. And I would like to believe that an unusually active emeritus staff also has a significant role to play. Young scientists benefit from our experience; we thrive on their enthusiasm and imagination. Best of all, the desire to participate in maintaining a warm and open atmosphere seems to be infectious!

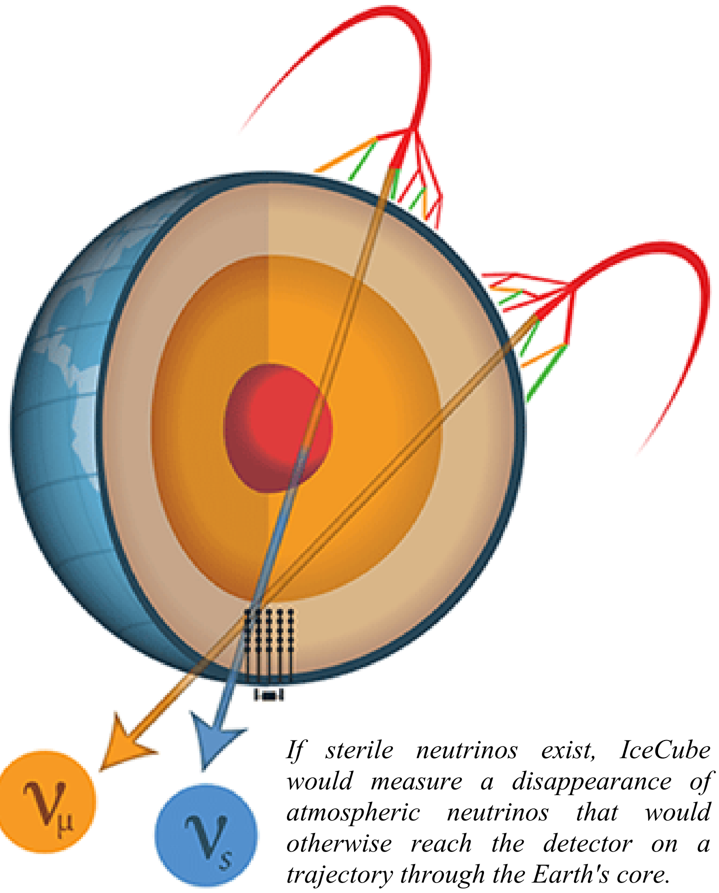
In short, the NBIA seems to be entering maturity without losing its initial idealism and enthusiasm. The future looks bright.

Andrew Jackson
2016

Astroparticle Physics

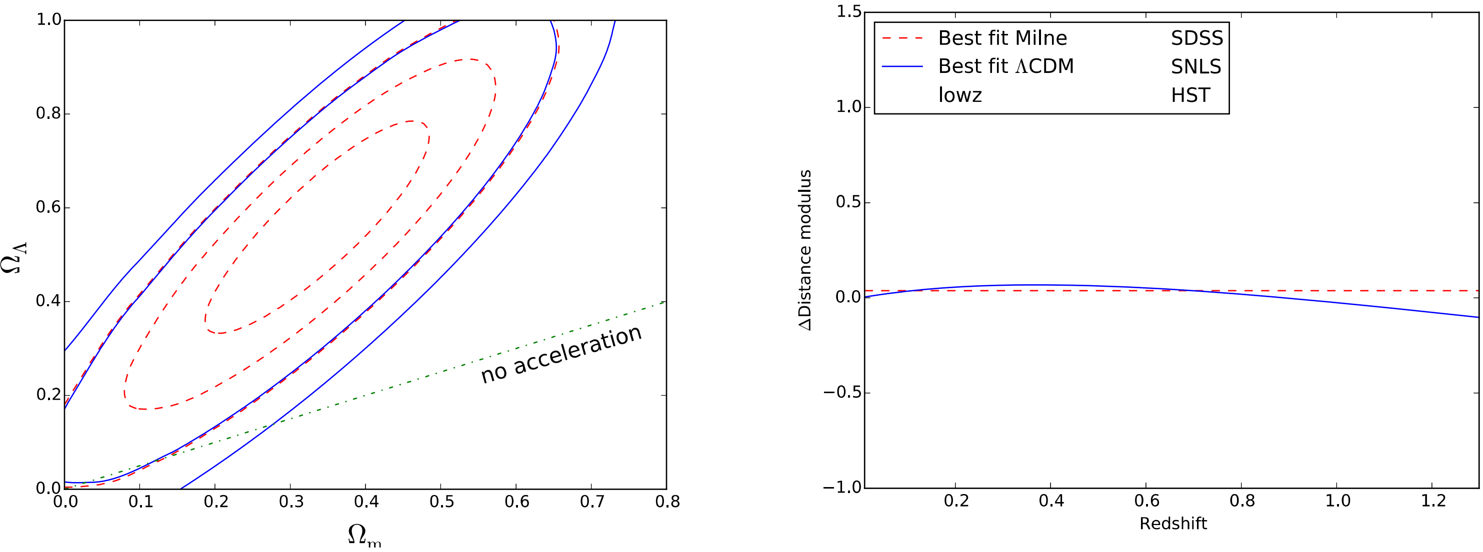
The activities in astroparticle physics have ranged over several fronts – cosmic rays and high energy neutrinos, cosmology and the cosmic microwave background, dark matter, *etc* – the unifying theme being new phenomena beyond the standard models of particle physics and cosmology.

The highlight of 2016 was our demonstration with the *IceCube* detector at the South Pole that a sterile neutrino with mass of around 1 eV does not in fact exist. Such a particle had been hinted at by several previous laboratory experiments and had attracted huge interest because it would provide important clues to the mechanism for neutrino mass generation and contribute to the dark matter of the universe. IceCube has an *unique* sensitivity towards such particles because they should be produced resonantly through matter–enhanced quantum oscillations of ordinary muon-type neutrinos as they travel through the Earth. So from the South Pole we looked for *disappearance* of muon neutrinos produced by cosmic ray interactions in the Earth's atmosphere above the *North* Pole – but found that they are in fact present in the expected number. Our result demonstrates the power of a *non*-accelerator experiment, using a natural particle 'beam' to settle an important issue in fundamental physics.



If sterile neutrinos exist, IceCube would measure a disappearance of atmospheric neutrinos that would otherwise reach the detector on a trajectory through the Earth's core.

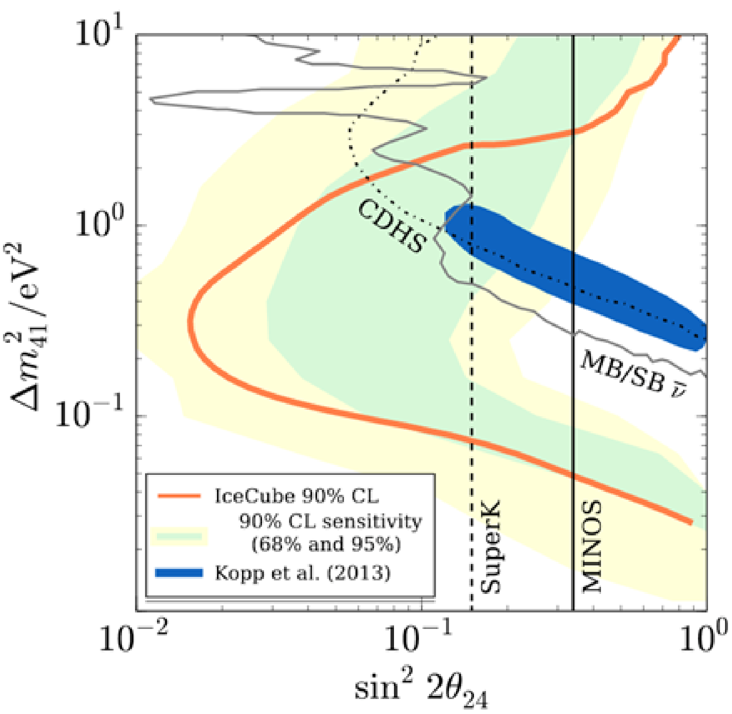
On the cosmological front, we confirmed our previous finding that there are traces of the nearby old supernova remnant Loop I in the sky maps of the cosmic microwave background made by NASA's WMAP and ESA's Planck satellite, i.e. that 'foreground cleaning' by standard methods such as 'Internal Linear Combination' is not entirely successful. This has important implications for the searches being carried out to detect primordial gravitational waves from the inflationary era via their 'B-mode' polarisation signal as this can be mimicked by the radiation presumably from magnetised dust grains in the shell of such a supernova remnant. Another major result in cosmology was our demonstration that the evidence for cosmic acceleration from the Hubble diagram of Type Ia supernovae is in fact marginal (less than 3 standard deviations) when the latest data set of 740 supernovae is analysed using the Maximum Likelihood Estimator.



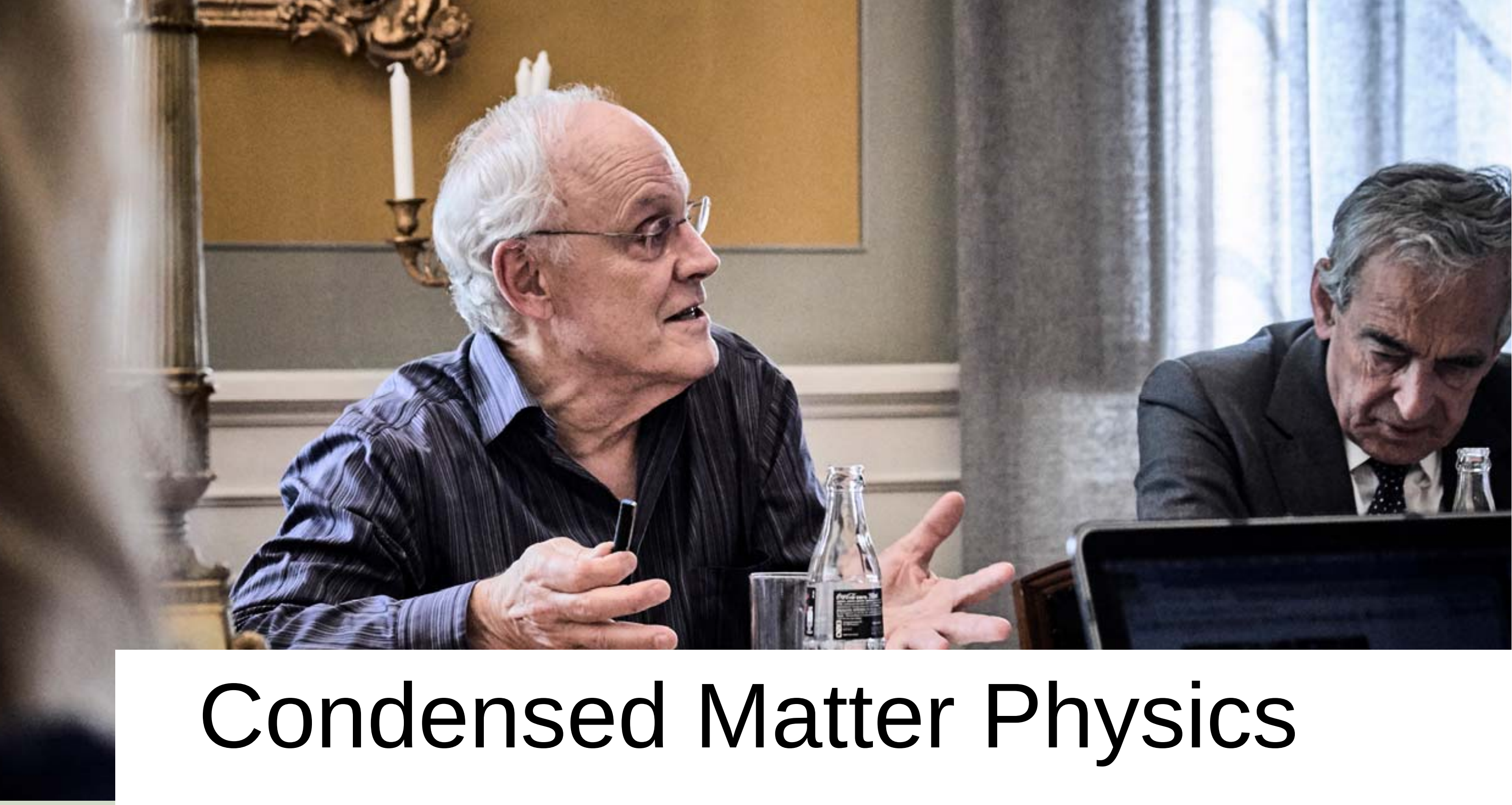
Left panel: *Contour plot of the profile likelihood in the* W_m - W_L *plane showing that the 3*s *contour (outermost dashed red line) is consistent with expansion at a constant rate ('Milne universe').* ***Right panel***: *This can be visually assessed from the residuals of the Hubble diagram for Type Ia supernovae with respect to the Milne model, compared to the expectation for an accelerating universe (LCDM model).*

This raises the question of whether the 'dark energy' presumed to be responsible for cosmic acceleration does in fact exists.

Concerning dark matter we showed that the observed separation between a galaxy falling into the core of the galaxy cluster Abell 3827 and its dark matter halo (as inferred from gravitational lensing), *if* interpreted as due to dark matter self-interactions, implies a rather large value for the cross-section (~10^4 times larger than claimed earlier). If this is true there should also be a separation between the dark matter and galaxies in colliding clusters of galaxies like 1E 0657-56 (The 'Bullet Cluster') which may soon be observable. Astronomers are excited by this possibility and are undertaking searches for such systems – especially as such a large cross-section would immediately rule out most of the particle candidates discussed for dark matter e.g. supersymmetric neutralinos, sterile neutrinos or axions.



Results from the IceCube search. The 90% (orange solid line) CL contour is shown with bands containing 68% (green) and 95% (yellow) of the 90% contours in simulated pseudo-experiments, respectively. These are overlaid on 90% CL exclusions from previous experiments, and the MiniBooNE/LSND 90% CL allowed region.



Condensed Matter Physics

The condensed matter theory group at NBIA continues to grow, exploring a range of topics at the forefront of the field. In 2016, Ajit Balram joined us as a postdoc, and Michele Burrello joined as an Assistant Professor. Ajit came to us from Penn State, where he gained extensive expertise in the quantum Hall effect. Michele has a background in field theory, cold atoms, and topological systems, bringing many opportunities for the group to expand in new directions and also to form links with the high energy theory community at NBIA. Below we summarize some of the group's research highlights from 2016.

Novel collective phenomena: The study of collective phenomena -- emergent behaviors of many-body systems which often exhibit intriguing characteristics fundamentally unlike those of the system's microscopic constituents -- is one of the cornerstones of condensed matter physics. At NBIA we seek to characterize the novel types of collective phenomena that may emerge in exotic materials such as topological or hybrid systems. In 2016 we had two key results in these areas. First, Mark Rudner and his collaborator Justin Song (NTU, Singapore) studied the effect of the novel kinematics of electrons in two-dimensional topological systems, namely the "anomalous velocity," on collective modes of the interacting electronic fluid (Song and Rudner, PNAS 2016). They found a new type of chiral plasmonic mode that propagates along the edges of such systems, in the absence of an applied magnetic field. In addition to being of fundamental interest, such modes may also find practical applications as mediators of strong, on-chip, magnetic field free optical non-reciprocity. Inspired by rapidly advancing capabilities for growing or assembling high-quality layered hybrid systems, for example combining superconductors with ferromagnets, postdocs Kjetil Hals and Mike Schecter, along with Mark Rudner, explored the novel topological excitations that may emerge in such systems. They found, in particular, that the topological modes of the individual subsystems (vortices in the superconductor and Skyrmions in the magnet) tend to bind, forming a new type of composite topological excitation that they dubbed the "Skyrmion Vortex Pair" (Hals, Schecter, and Rudner, PRL 2016). These composite objects propagate as a single unit, and may for example provide new means for manipulating vortices and Skyrmions through their mutual coupling.

Topological phenomena in non-equilibrium systems: Topological phenomena comprise a class of particularly robust collective phenomena, in which physical observables take on precisely quantized values that are insensitive to microscopic details of the system (such as sample size, shape, chemical composition, etc.). Going outside the standard paradigm of topological phenomena in equilibrium systems, our group is investigating topological phenomena in driven and dissipative systems, which are inherently far from equilibrium. In a joint effort with collaborators at Caltech, the Technion, and the Weizmann Institute, we uncovered a new phenomenon of topological, non-adiabatic quantized charge pumping that

occurs in disordered, periodically-driven systems (Titum, Berg, Rudner, Refael, and Lindner, Phys. Rev. X 2016). This work, and a subsequent work led forward by PhD student Frederik Nathan (under review), provided new insight into the interplay of disorder and topology in periodically-driven systems.

Spinformation: Quantum spin, which can take one of two possible values upon measurement, is a natural carrier of quantum (or classical) information. We have a long-standing effort in studying spin dynamics in various types of semiconducting quantum devices. These efforts often involve close collaborations with experimentalists both locally, in the Center for Quantum Devices (QDev), and externally with our international partners. In 2016, together with QDev experimentalists and collaborator Ed Barnes (Virginia Tech), we published a theoretical paper describing how noise from the nuclear spin environment of an electronic spin qubit destroys the fragile quantum information stored in the electronic spin (Barnes et al., PRB 2016). The methodology developed for this paper has been used to help analyze experimental data of the QDev spin qubit team. Moreover, in a collaboration with Bernd Rosenow (Leipzig) and Klaus Ensslin's experimental team at ETH Zurich, we developed a mechanism to explain mysterious self-oscillations observed in the Ensslin group's dc transport measurements on fractional quantum Hall systems (Hennel et al., Phys. Rev. Lett. 2016). The nonlinear oscillations arise from an intriguing interplay between coupled dynamics of the electron and nuclear spins, and the energetics of domain formation in the quantum Hall ferromagnet system. By developing a deeper understanding of this mechanism, we hope to develop new tools for pattering of nuclear fields on small spatial scales, which can in turn provide new handles for controlling exotic electronic states.

Theoretical Astrophysics

During 2016 the NBIA astrophysics group has tackled a number of problems related to protoplanetary disks with a very wide perspective, ranging from fundamental theoretical aspects, and state-of-the-art simulations to observations that help constrain gas and dust dynamics surrounding young stellar objects and their associated protoplanetary disks.

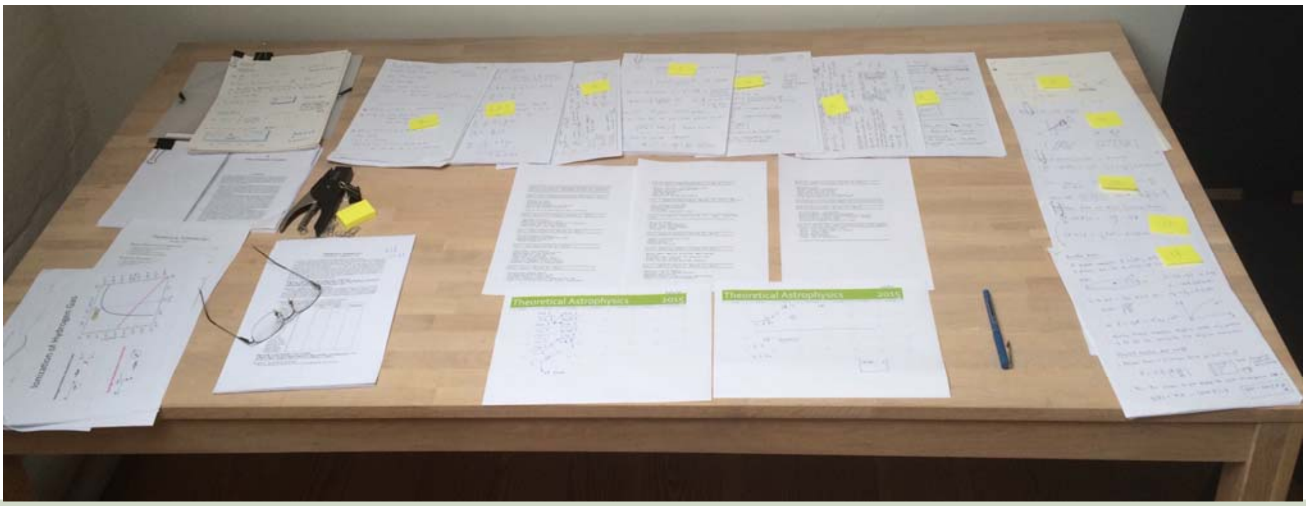
We have developed a comprehensive multi-fluid framework to study dust dynamics in protoplanetary disks, including gas-dust interaction via drag forces. This development is crucial to obtain the mutual distribution of gas and dust, providing more physically realistic environments to investigate, for example, the formation and survival of vortices, as well as the interactions between the disk and the forming planets, which can lead to the opening of gaps and planet migration. Modeling disk-planet interactions is also critical for understanding the distribution of near-resonant Kepler systems. We have developed a possible mechanism to explain the origin of the 2/1 and 3/2 (near)-resonant population of close-in exoplanets by planetary migration. Further work on this subject involves long-term and large-scale hydrodynamical simulations with the numerical codes that we are developing.

The low temperatures and relatively high densities in protoplanetary disks imply that the gas is only partially ionized and thus the standard approach involving ideal magnetohydrodynamics needs to be relaxed in order to incorporate non-ideal effects. We have been deploying the first simulations including the Hall effect along with ambipolar diffusion and Ohmic resistivity. We are among a handful of world-leading teams capable of producing global models of protoplanetary disks that can account for the impact of stellar irradiation heating on the complex non-equilibrium ionization chemistry. We are working on coupling these numerical codes with a sophisticated software pipeline for post-processing in order to include the effects of chemistry, molecular excitation, and radiative transfer. Taken in concert, our work is a crucial step forward for interpreting observations of thermal dust emission in the sub-mm band using state-of the art telescope arrays, such as the Atcama Large Millimiter Array (ALMA), in order to better understand the processes that lead to planet formation and evolution in protoplanetary disks.

A natural stage in this process is characterized by the formation of circumplanetary disks in which satellites (exoplanetary moons) may form. We have also modeled weakly accreting circumplanetary disks and studied the configurations of satellite systems formed in these disks. Investigating the fate of these moons demands a detailed understanding of the formation and evolution of the circumplanetary disks. With this goal in mind, we are setting up global simulations of protoplanetary disks with an embedded planet that make it possible to measure the mass infall rate onto the circumplanetary disk. In order to do this, we implemented a scheme to calculate non-equilibrium ionization chemistry into a global MHD

code because the ionization degree that determines non-ideal effects in magnetohydrodynamics may not be in a steady state in low-density regions, such as gaps carved by a planet. On more observational grounds, we obtained exciting results about the nature of the source IRS43, a binary system with three, mutually misaligned disks. Keplerian motion was detected on scales ranging from a few up to a thousand astronomical units. This work revealed several novel features, including a warp in the circumbinary disk, outflows from each of the two circumstellar disks, and possibly a central cavity. We are currently working on a detailed model of this extraordinary system.

During 2016 there have also been a number of developments on several fundamental aspects of accretion disks and the intergalactic medium. We conducted a comprehensive local study of the magnetorotational instability when subjected to the combined influence of all the non-ideal diffusive effects believed to be present in a protoplanetary disk. This has enabled us to determine the basic characteristics of the transport stresses that are expected to lead to angular momentum transport and accretion towards the star when the Hall effects dominates the local disk dynamics. Group members have also explored rotating and non-rotating magnetized shear turbulence in the context of shear-periodic numerical simulations. These investigations show that, contrary to previous conception, turbulence can sustain in non-rotating magnetized shear flows. It was also found that turbulence in rotating Keplerian flows can sustain even at low magnetic Pradtl numbers, i.e., for regimes where the fluid viscosity is much lower than the magnetic resistivity. On another front, we have continued the development of a new hybrid code which solves the Vlasov equations for ions and treats the electrons as a massless fluid. Using this code we will be able to describe plasma phenomena from first principles with applications to black hole accretion disks and the weakly collisional intracluster medium. We also solidified our models for mixing of the helium content in the intracluster medium of galaxy clusters. These models contribute to the interpretation of the X-ray observations. During the year we also began a collaboration with Eliot Quataert at Berkeley to understand how microscale plasma instabilities could modify the behaviour of the large scale dynamics of the intracluster medium.



Neutrino Astrophysics

In 2016 the neutrino astrophysics group has worked on a range of topics in neutrino astrophysics in order to further advance our understanding of the role of neutrinos in astrophysical sites and improve the neutrino detection chances in upcoming telescopes.

We have been investigating the role of fast neutrino conversions occurring in neutrino-dense environments, such as core-collapse supernovae. Those flavor conversions are exclusively driven by the neutrino-neutrino interaction and may induce flavor equilibration within scales of 10 cm in the neutrino decoupling region, hence affecting the supernova explosion. The understanding of this phenomenon is currently very preliminary. We presented a novel approach to study fast conversions: A dispersion relation for the frequency and wave number of disturbances in the flavor field. This approach completely changes the way we have previously looked at flavor oscillations in dense media and stresses the importance of the neutrino angular distributions in triggering fast conversions. This research line has been further pushed forward by an explorative study on the characterization of the neutrino angular distributions from a set of hydrodynamic simulations of supernova progenitors.

For the first time, we have investigated whether fast conversions could occur in compact binary mergers. Given the mounting evidence of compact mergers as sites where elements heavier than iron may form, it is important to understand the exact distribution of neutrinos of different flavors and its feedback on the nucleosynthetic outcome. In this pilot study we found that fast conversions are even more likely to occur in compact mergers than in supernovae, given the disk geometry and the naturally neutron-rich environment. We are currently exploring whether neutrino conversions could affect the synthesis of new elements in mergers. The optical and near-infrared emission and the detection chances of radioactively powered electromagnetic transients occurring in the aftermath of compact binary mergers ('macronovae') has also been studied.

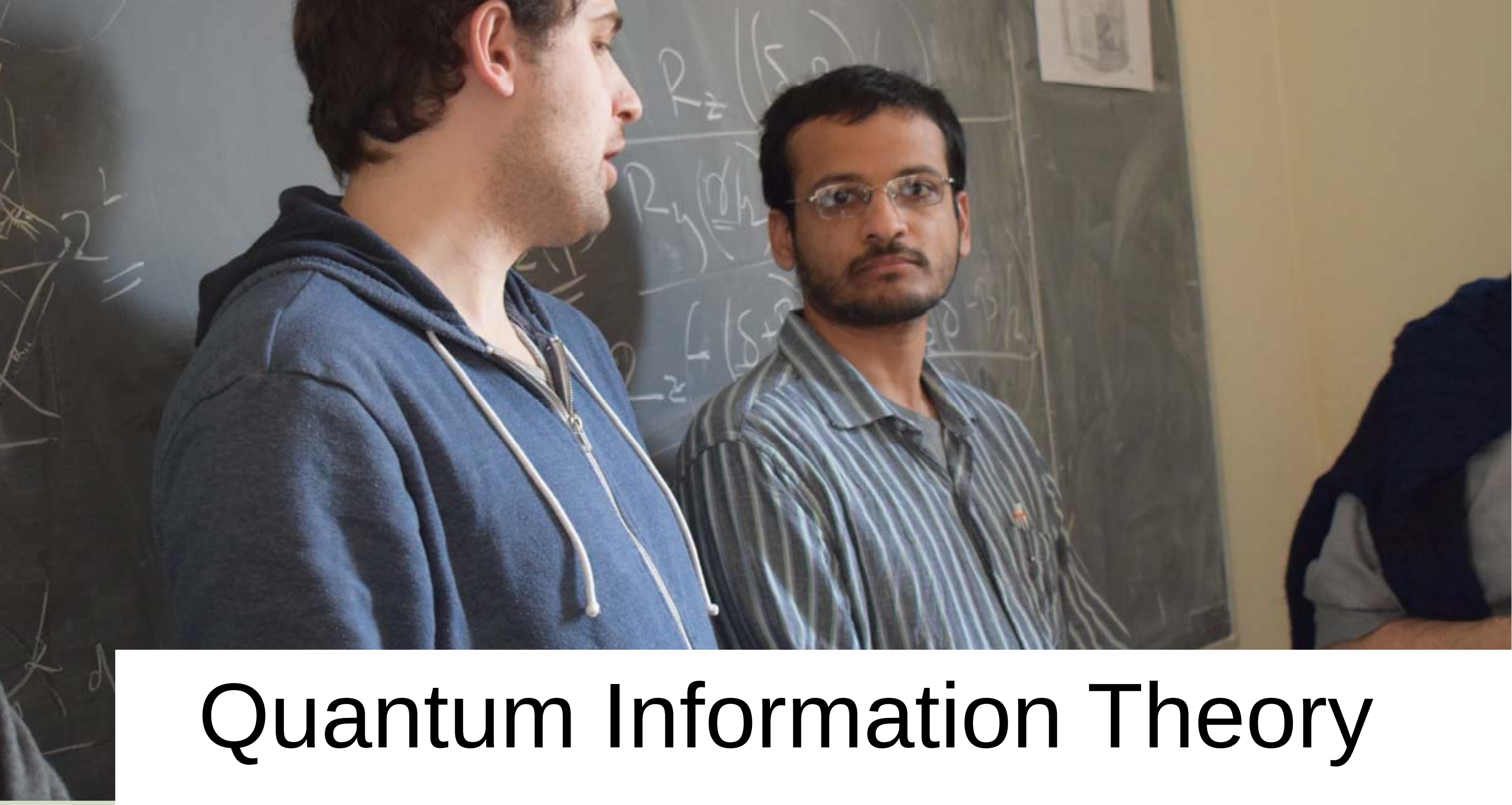
Besides ordinary neutrino detectors sensitive to neutrinos from the next galactic supernova burst, we proposed to use dual-phase xenon dark matter detectors as neutrino telescopes. Such detectors exploit the neutrino-nucleus elastic scattering and are flavor-insensitive. As a consequence, they will be able to provide unique information on the supernova burst without uncertainties related to the oscillation physics.

On the high-energy neutrino astrophysics front, we have explored the possibility to study the supernova-

gamma-ray-burst connection by using high-energy neutrinos. We found that the sparse sample of high-energy neutrino data currently available implies that no more than 10% of all supernovae can generate jets. Such bounds will become tighter as the neutrino data sample increases.

We then further focused on exploring possible methods to improve the source characterization of the neutrino events observed by the IceCube telescope. To that purpose, we developed the first one-point fluctuation analysis of the high-energy neutrino sky . This statistical method will be especially powerful for the current low-statistics sample of high-energy neutrino data. The one-point fluctuation analysis method puts stringent limits on the astrophysical sources of high-energy neutrinos detectable by the IceCube telescope , e.g. blazars and star-forming galaxies.

Up to now, dedicated searches looking for neutrino point sources have only placed upper limits. In order to pinpoint the classes of neutrino sources that we could detect with IceCube and its extension IceCube-Gen2, we suggested to exploit the matter anisotropies of the local universe as from the 2MASS Redshift Survey. In fact, by correlating the matter anisotropies with the observed clusters of neutrino events, we could probe a region of the parameter space larger than the one constrained by the upper limits on the non -detection of neutrino point sources.



Quantum Information Theory

This year the quantum information group at the NBIA has worked on a number of topics in quantum information and many body theory. The main areas of focus have been (i) tensor network states and models of holography, (ii) quantum error correction and fault tolerance, and (iii) studies of randomness generation.

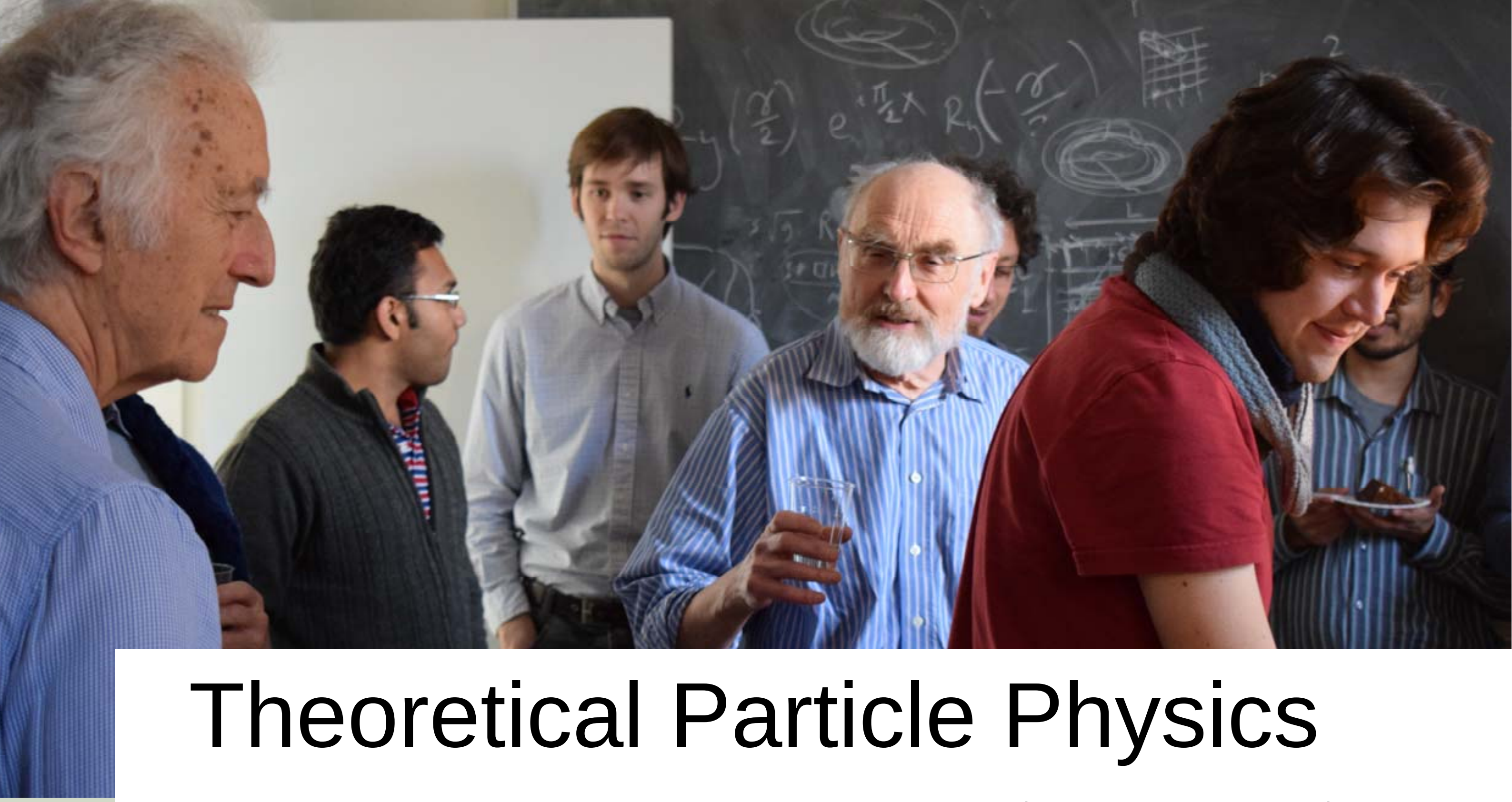
(i) The principle of Holography loosely prescribes that there is a correspondence between the physics in the bulk of a system and the 'holographic' image at the boundary. In the context of high energy physics this correspondence manifests itself in the form of the celebrated AdS/CFT correspondence, while in condensed matter systems, it takes the form of a bulk-boundary correspondence of topological order. In a series of projects, we have explored the holographic correspondence using the tools of tensor networks. In particular, we describe a one dimensional (critical) CFT by a MERA network. We show that the MERA network naturally defines an encoding circuit for an approximate error correcting code, thus providing the first derivation of the celebrated correspondence between error correction and AdS/CFT

In the context on solid state physics, we have completed an important proof on the intrinsic structure of 2D tensor networks (PEPS), that can be traced all the way back to the original AKLT and FCS papers before the birth of quantum information. The proof connects the locality properties of boundary states to the gap of the bulk Hamiltonians. It provides a crucial step to proving the gap of 2D PEPS from bulk static properties, and could lead to improved simulation techniques. This new result will form the basis of a large part of our future research.

(ii) We have worked on a number of projects in fault tolerance research including a new protocol for performing fault tolerant gates in the Toric code by braiding corners and fault lines. These braiding operations can be seen as a spin analogue of Majorana braiding, hence connecting two apparently unrelated notions of topology. We have also introduced a new framework for approximate quantum error correction which allows for making robust statements of error preservation, and for expressing the actual limits of information storage in many body systems.

(iii) We have produced three projects connected to randomness generation. In the first, we introduce a

framework describing the mixing properties of continuous-time unitary evolutions reflecting a Brownian motion on the unitary group. The induced stochastic time evolution is shown to converge to a unitary design. In a second project we show that a controlled classical source of randomness can efficiently generate a quantum unitary design, and give rigorous bonds on its mixing time. We use sophisticated tools from the theory of open system. The final project involved the topological classification of one-dimensional symmetric quantum walks.

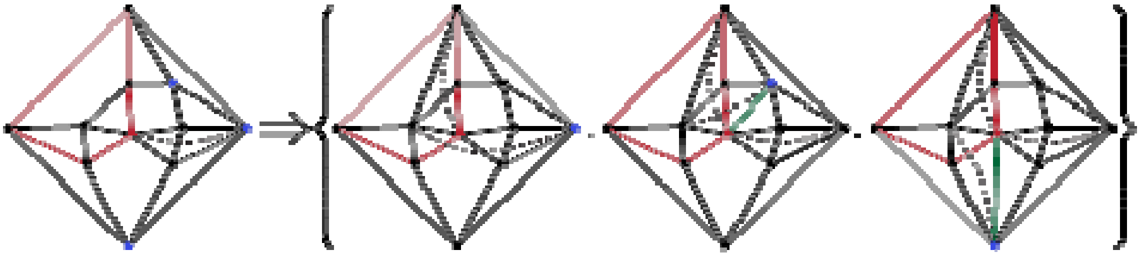


Theoretical Particle Physics

Theoretical particle physics at the NBIA in 2016 was quite strongly influenced by the start-up of the Large Hadron Collider at CERN at an almost doubled energy compared to the first run. The new run at the LHC contains an unprecedented amount of data on the interactions of the fundamental particles around what is known as the electroweak scale. While excitement ran high regarding an excess of measured events (in a di-photon search at around 750 GeV), in the beginning of the year 2016 this excess has in fact (as it often happens in these scenarios) disappeared again. The passing of this excess was not surprising considering the results members of the NBIA group had published earlier.

With the so-called Standard Model of particle physics being confirmed to higher and higher precision at the Large Hadron Collider, it is crucial to have a clear strategy for how to move beyond the Standard Model. Knowing that deviations will occur eventually (dubbed 'new physics'), and seeing so far not the slightest evidence for new particles in the spectrum at accessible energies, there exists a well-understood framework for how to augment the Standard Model of particle physics with the (tiny) effects of new physics at yet higher energies. This is known as Effective Field Theory. Its particular implementation in beyond-Standard-Model constructions of particle physics is vigorously being pursued by NBIA scientist Michael Trott and members of his research group, which is supported by a Villum Young Investigator Grant. The ambitious aim is to develop a fully consistent Effective Field Theory interpretation of new data from the Large Hadron Collider (and, for consistency, also checks with other collider data). The task is daunting in that a very large 'basis' of possible extensions of the Standard Model needs to be consistently included, much beyond what particle theorists are used to from the Standard Model alone. This modern approach to high-energy physics is gaining importance in the particle physics community and in the fall of 2016 the NBIA hosted a workshop on “Higgs Effective Field Theories 2016”. In this continually growing field the theoretical efforts is expected to dominate the analysis of the large data set that has just begun to flow in from the experiments.

Another group at the NBIA takes one step back, and attacks the very foundations of the Standard Model and the way one uses it to compute observable quantities. These modern approaches to computation of scattering amplitudes and cross-sections in quantum field theory have turned over tables and made previously impossible calculations doable. The field has been rapidly evolving recently, and 2016 has been no exception with many contributions from members of the NBIA, including Poul Henrik Damgaard, Emil Bjerrum-Bohr and Jacob Bourjaily. An entirely new formalism computes scattering amplitudes of the Standard Model by means of solving a set of algebraic equations, known as the Scattering Equations. While simple in principle, it turns out to be very challenging in practice to find all the solutions. During 2016 the group at the NBIA discovered a set of simple 'integration rules' that allows one to circumvent finding the solutions explicitly, instead providing a straightforward algorithm the provides the final answer for the scattering amplitude. Working together with long-term associate of the NBIA Bo Feng from Zheji-



New representations of Yang-Mills amplitudes that manifest duality between color and kinematics have been discovered by the subgroup focusing on scattering amplitudes. This research has also led to the discovery of a new set of string-like dual models for general scalar quantum field theories as seen here.

ang University in China, new explicit representations of Yang-Mills amplitudes that manifest duality between color and kinematics were discovered.

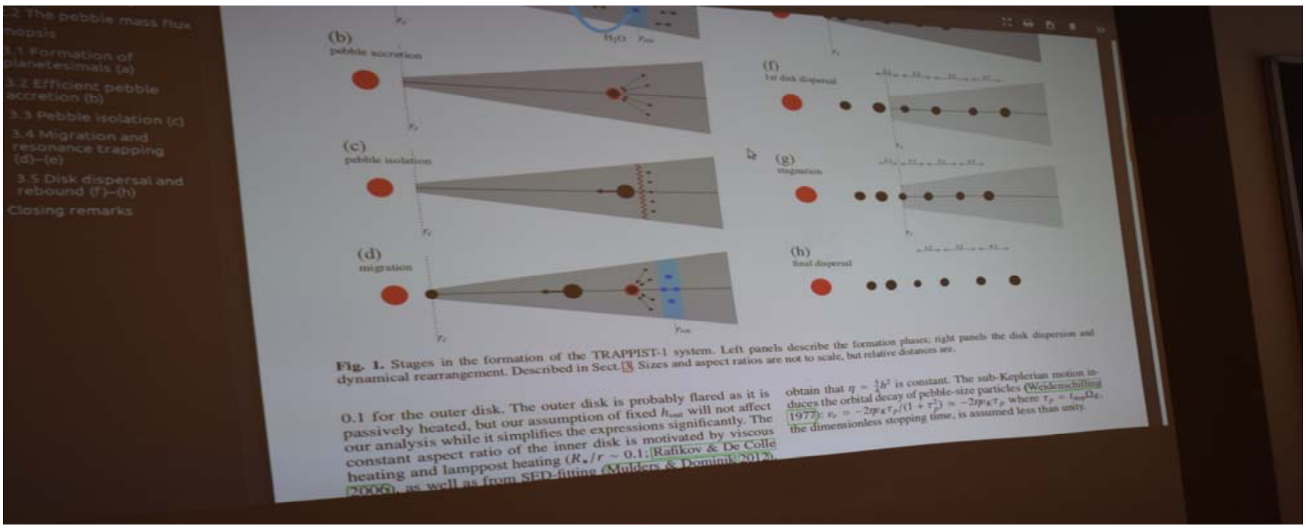
At the very beginning of 2016, NBIA member Jacob Bourjaily set a new record for the computation of the full integrand of the highest-order perturbative scattering amplitude in four dimensions—for two-to-two scattering, where the integrand was computed through eight loops. By the middle of the summer, however, the record was shattered again by the discovery of powerful new methods—allowing the integrand of this amplitude to be computed through ten loops! Another advance in our understanding of scattering amplitudes was the complete classification of strictly observable functions (to all orders) for two-to -four processes beyond the planar limit. This result was obtained through the link between such functional building blocks and Grassmannian geometry as described in the book "Grassmannian Geometry of Scattering Amplitudes", written by a group involving NBIA member Jacob Bourjaily and published in 2016 by Cambridge University Press. As the year drew to a close, it became known that Jacob Bourjaily was awarded a Villum Young Investigator Grant. This will help strengthen the status of the NBIA as a leader in the development of new methods for the computation of scattering amplitudes.

NBIA Seminars 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 the history of the theory ofgravitational waves, through strategies to meet the future energy needs to a talk by Sir Roger Penrose on topics from his new book. .

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. The subsequent refreshments in the NBIA Lounge often continue directly with the social activities (in town) known as NBIA Social Nights.

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.



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.

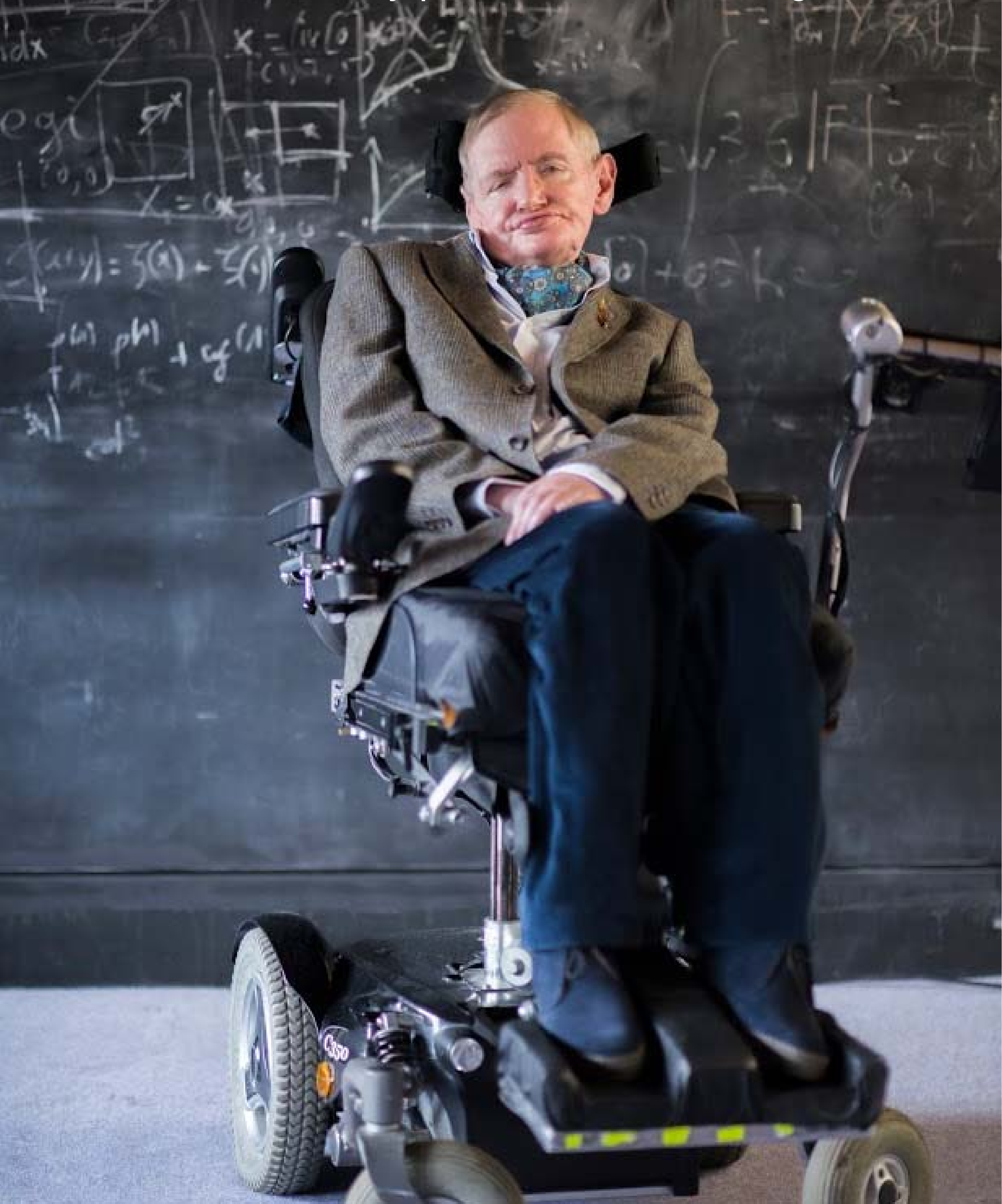
This past year a highlight was the visit of Stephen Hawking to the NBIA, and the public lecture the NBIA arranged together with the Carlsberg Foundation at the Concert Hall of the Danish National Radio. Live streamed to numerous movie theaters in Denmark, this was public outreach at a most extraordinary level. In connection with the Simons Program arranged around Simons Visiting Professor Slava Mukhanov the NBIA also experimented with upload of NBIA lectures to YouTube which so far have around 8,000 views. The special live streaming of the settling of the famous "bet on supersymmetry" in August 2016 also drew on the order of 10,000 views.


Matter bounce
Anamorphic

Steven Hawking

World-famous physicists visits NBIA and

delivers extraordinary public lecture reaching thousands



Stephen Hawking's public talk took place at the concert hall of the Danish National Broadcasting Corporation in July 2017. All 1800 seats were sold within 20 minutes!. Due to the overwhelming interest, the talk was also live-streamed to 27 cinemas all over Denmark, reaching more than 8000 people. This extremely successful event was made possible by the generous support of the Simons and Carlsberg Foundations.

NBIA Faculty

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 was postdoc in Swansea 2004-2006, concentrating his research on amplitudes for gauge theories and quantum gravity. He was a Member at the Institute for Advanced Study in Princeton 2006-09. Emil was appointed Knud Højgaard Assistant Professor at the NBIA in 2010, at the same time being awarded a Steno grant from the Danish Science Research Council. He was appointed Associate Professor in 2016. Emil's current research focuses on amplitudes in Yang-Mills theory and quantum gravity.

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 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 and 2010-14 he was assistant professor at ETH Zurich. He moved to the University of Copenhagen in April 2014.

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 supersymmetric theories on a space-time lattice, and constraints on so-called electroweak baryogenesis from the Large Hadron Collider (LHC).

Andrew 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.

Charles Marcus 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 StationQ – Copenhagen. He is an affiliate of the Niels Bohr International Academy. Marcus' 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 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 Naselsky did his undergraduate studies at the Southern Federal University of Russia and received his PhD in 1979 at Tartu University. In 1989 he got Doctor Habilitation at Moscow State University, Russia, working with theoretical astrophysics group of Zeldovich. In 2000 Pavel Naselsky took up a position as Associate Professor at the Theoretical Astrophysics Center (Copenhagen, Denmark) and at 2003 he was appointed as Lecturer at the Niels Bohr Institute . He has been Professor of Theoretical Physics since 2015, and group leader of the Theoretical Particle Physics and Cosmology group at the Niels Bohr Institute. His current research interests include modern cosmology, theory of the primordial black holes formation, physics of dark energy and dark matter, physics of the CMB etc. Since 2000 Pavel Naselsky has been working on the Planck project.

Martin Pessah 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 a Member at the Institute for Advanced Study in Princeton 2007-10. In 2010, Martin moved to Copenhagen as a Knud Højgaard Assistant Professor at the NBIA. In 2012, he started to build a new group in Theoretical Astrophysics 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, including fundamental aspects of accretion physics in young starts and black holes, the interstellar medium, and galaxy clusters.

Christopher Pethick is Professor at NBIA. He did his undergraduate and graduate studies at 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 neutron stars (especially the properties of their solid crusts), neutrino processes in dense matter, and ultracold atomic gases.

Subir Sarkar obtained his BSc & Msc degrees at the Indian Institute of Technology, Kharagpur. He did both experimental and 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, SISSA Trieste, CERN Geneva and Rutherford Laboratory Chilton, having switched to the field of astroparticle 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. 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 forthcoming Cherenkov Telescope Array.

Jan Philip Solovej did his undergraduate studies in Copenhagen and his Phd in mathematics at Princeton University in 1989. He was then a postdoc at University 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 Aarhus 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

NBIA Faculty

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.

Irene Tamborra is Knud Højgaard Associate Professor at the NBIA since 2016. Irene completed her Ph.D. at the University of Bari in 2011. Irene has held research appointments at the Max Planck for Physics in Munich, as Alexander von Humboldt Fellow, and at GRAPPA Center in Amsterdam. Irene's research activity is in the area of theoretical astroparticle physics, with focus on neutrino astrophysics and cosmology. Irene is interested in exploring the role of weakly interacting particles, such as active and sterile neutrinos, in astrophysical environments. She also aims at unveiling what can be learnt from the observation of neutrinos from the most extreme but yet mysterious astrophysical transients occurring in our Universe, such as core-collapse supernovae, neutron star mergers and gamma-ray bursts. Thanks to generous support from the Villum Foundation, Irene leads a research group at the NBIA with focus on these subjects.

Junior Faculty

Jacob Bourjaily has been Assistant Professor at the NBIA since 2014. 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 2011-2104 before taking up his current position at the NBIA. The primary focus of Jacob Bourjaily's research has been working toward an emerging reformulation of quantum field theory. He has contributed in numerous ways to 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.

Christian Brinch joined the NBIA as Assistant Professor in August 2016. 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. Brinch's research is focused on understanding the formation and evolution of young stellar objects and protoplanetary disks. Dealing both with observations in sub-millimeter wavelengths and 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 to models of planet formation in order to make predictions about, and potentially be able to detect, embedded protoplanets during their formation.

Michele Burrello joined the NBIA as Assistant Professor in 2016. Michele's main research interest is the study of topological phases of matter, their engineering and the possibility they offer for quantum computation. He works on different quantum many-body systems, ranging from ultracold atoms to topological superconductors. Despite their different nature, the aim is to search for the common structures which are at the core of their behavior.

Simon Caron-Huot 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 MOBILEX grant which supported his 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. Simon left NBIA in August 2016 to take up a faculty position at McGill University.

Jacob Trier Frederiksen completed his Ph.D. from Institute for Astronomy at Stockholm University in Sweden in 2008. He has been at the Niels Bohr Institute since then, first as a postdoc in the group for astrophysics and planetary sciences, focusing on high-energy astrophysics of gamma-ray bursts and relativistic astrophysical plasmas, later concentrating on the Sun-Earth plasma coupling, through an EU collaborative project. Jacob was research associate professor at the NBIA until switching in mid-2016 to work in a private company.

Oliver Gressel joined NBIA as an Assistant Professor 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 held a Nordic Fellowship at Nordita in Stockholm to work on mean-field magnetohydrodynamics and dynamo theory. He was awarded a MOBILEX grant in 2013 to study accretion disk turbulence. He received an ERC Starting Grant in 2014, which has allowed him to build his own research group at the NBIA. Oliver's current research is centered around astrophysical turbulence and magnetohydrodynamics, 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.

Tobias Heinemann joined the NBIA as an Associate Professor after postdoctoral appointments at the IAS in Princeton, at the University of California at Berkeley and KITP, University of California, Santa Barbara. His research interests span a wide spectrum of problems in astrophysical fluid dynamics, dynamo theory and plasma astrophysics.

Michael Kastoryano joined the NBIA in September 2014 as a Carlsberg Postdoctoral fellow, and with a Villum Young Investigator 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 coincided with an upswing in activity in theoretical quantum information sciences at the university of Copenhagen. Michael has been 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. He works mainly on quantum information motivated questions in many body physics. Recently his focus has shifted towards topologically ordered systems and topological computation.

Cynthia Keeler is an assistant professor at the NBIA. After obtaining her PhD from the University of California at Berkeley in 2008, she held postdoctoral positions at Harvard University (2008-2011) and University of Michigan (2011-2014). She arrived in Copenhagen in the fall of 2014, and received a Marie Curie Fellowship from the EU in 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.

Junior Faculty

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. Jason's research on neutrino mixing and neutrino probes of the universe is graciously supported by a Villum Young Investigator award.

Philipp Mertsch was appointed Assistant Professor at the NBIA in 2016. He has broad interest in high-energy astrophysics. Most recently, he has been working on modelling Galactic diffuse emission with applications to searches for dark matter and B-modes from inflation.

Subodh Patil joined the NBIA in the fall of 2016 as an Assistant Professor after post-doctoral stints at the University of Geneva (2015-16), CERN (2012-15, as Marie Curie Intra-European Fellow from 2012-14), CPHT Ecole Polytechnique (2009-12), and the Humboldt University of Berlin (2007-9), having obtained his Ph.D from McGill university in 2007. He works on broadly defined themes in early universe cosmology, gravity and related aspects of beyond the standard model and string phenomenology.

Mark Rudner is an Associate Professor at the NBIA. Mark received his PhD in Condensed Matter Theory from MIT in 2008. After his PhD, Mark spent three years as a postdoc at Harvard. In 2012 Mark landed in Copenhagen to take charge of the Condensed Matter Theory group at the NBIA. Currently Mark's group is enjoying the generous support of the Villum Foundation through the Young Investigator Award Program. He and his group is further supported by a Marie Curie International Incoming Fellowship and an ERC Starting Grant from the EU. 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 joined the NBIA as Assistant Professor in 2015. William completed his Ph.D. at UC Irvine in 2011, working with Professor Tim Tait. He continued his research as a postdoc at UC Santa Cruz before taking up his current position at the NBIA. William'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 been funded by a MOBILEX grant from the Danish Council for Independent Research.

Michael Trott is leading the particle physics phenomenology group and is an Associate Professor at the NBIA. Michael completed his Ph.D. at the University of Toronto in 2005 and later 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.

Postdoctoral Fellows

Ajit Coimbatore Balram's research interests are in field of theoretical condensed matter with an emphasis on the physics of the fractional quantum Hall effect and topological insulators.

Pablo Benítez-Llambay received his PhD in Astronomy from the Universidad Nacional de Córdoba, Argentina in December 2015 and joined the NBIA as a postdoc in the Theoretical Astrophysics group in July 2016. Pablo's research focuses on studying the processes that determine the large-scale dynamics of planetary embryos as they interact with the protoplanetary disk in which they form. In December 2016 Pablo obtained a Marie Curie Fellowship that will allow him to explore the impact of more detailed physics on planet migration processes, with the potential to produce a leap forward in our understanding of how planetary orbits evolve. Pablo's goal is not only to produce better models to understand exoplanets observations but also to improve current formation models of our own Solar System.

Ilaria Brivio carried out undergraduate studies at the University of Padua and obtained her PhD in 2016 from the Universidad Autónoma de Madrid. Ilaria's research mostly focuses on the use of Effective Field Theories to study the phenomenology of electroweak interactions and the properties of the Higgs boson. Her interests are quite broad and related to all the main open questions of particle physics, from the nature of Higgs boson to neutrinos, flavor and Dark Matter. A relevant component of her research is the development of new ideas and theoretical tools to improve the interpretation and understanding of experimental data.

Benjamin Brown works 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 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. Jeroen left NBIA in February 2016 to take up a faculty position at Trondheim University.

Peter Denton received his PhD from Vanderbilt University and spent a year at Fermilab. His work includes high energy cosmic ray and neutrino anisotropies, astrophysical neutrino production, and lower energy neutrino oscillation studies both in the context of the standard model and beyond. He is also interested in new ways to look for new physics at high energies at the LHC and in cosmic ray interactions.

Sami Dib is a 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. His current research portfolio includes, among others, the study of the stability of protostellar disks and the formation

Postdoctoral Fellows

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 completed her PhD at Nagoya University, Japan in March 2015 and moved to Tokyo Tech as a postdoc before coming to the Niels Bohr Institute in July 2015. Her research interest is dynamics of protoplanetary and circumplanetary disks that are the birthplaces of planets and moons. She performs non-ideal MHD simulations of those disks with time-dependent ionization chemistry. She also works on modeling of circumplanetary disks and satellite formation.

Kjetil Hals received both his MSc (2007) and PhD degree (2011) in theoretical physics at NTNU, Trondheim, Norway. 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.

Xiaoyuan Huang has worked on dark matter indirect detection and high energy gamma-ray astrophysics using Fermi-LAT data. He is also interested in particle acceleration and multimessenger Astrophysics.

Yun Jiang 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 now expanding his research area from particle physics to cosmology, particularly on the baryogenesis and inflation of the early universe.

Ervand Kandelaki completed his PhD at Ruhr-University Bochum before joining the NBIA in 2015. Ervand's research interests include various areas of condensed matter physics. Currently, his focus lies in non-equilibrium quantum physics, especially with regard to the impact of interactions on many-body effects and topological properties. He is aiming at understanding gapped phases in periodically driven systems going beyond the one-particle picture and looking for genuine many-body phenomena.

Angelo Lucia works in the Quantum Information group of Michael Kastoryano, and at QMATH in the Department of Mathematical Sciences. He did his Master studies in University of Pisa, and completed his PhD in Mathematics in July 2016 at the Universidad Complutense de Madrid, Spain. Angelo's research interest lies in the interactions between quantum information theory and many-body quantum physics. He has worked on open dissipative dynamics, area laws, and he is now focusing on tensor network states.

David McGady 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 in elucidating both the fundamental cause of, and the consequences derived from, a recently discovered symmetry of partition functions under reflection of temperatures.

Colin McNally completed an M.Sc. at McMaster University and his Ph.D. at Columbia University and the American Museum of Natural History. Colin arrived at the NBIA in 2012 in the theoretical astrophysics group, first as an NBIA Fellow before becoming a Marie Curie Fellow in 2013. 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 belonged to Yukawa Institute for Theoretical Physics, Kyoto University, before coming to NBIA in 2015. Shunji's research interests are in theoretical condensed matter physics and high energy physics. His current focus includes 1) error correction in quantum annealing and 2) quantum entanglement in topological phases and gauge/gravity duality.

Gareth Murphy 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. 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 works in the theoretical astrophysics group led by Martin Pessah. He obtained 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.

Mohamed Rameez received his PhD from the University of Geneva in 2016, working on Dark Matter indirect detection and point source searches with the IceCube detector. While at NBIA, he ia expanding iinto a better understanding of Cosmology and local universe anisotropies.

Michael Schecter is a postdoc at the Center for Quantum Devices and Niels Bohr International Academy. Mike completed a B.Sc. at Michigan State University and a Ph.D. at the University of Minnesota. Mike arrived at QDev/NBIA in the Fall of 2014. 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.

Albert Werner obtained his PhD at the Leibniz University of Hannover in 2013 on propagation properties of quantum walks. He then joined Jens Eisert's group at the FU Berlin for a postdoc working on disordered quantum many-body systems. Albert has joined the QMath department as a postdoc – with a Feodor Lynen Fellowship (a Humboldt Foundation sponsorship). He is associated with the section for Geometric Analysis and Mathematical Physics and works within Matthias Christandl's Quantum Information Theory group and with Michael J. Kastoryano at the NBIA.

Meng-Ru Wu works on theoretical particle- and nuclear- astrophysics with particular focuses on neutrinos, core-collapse supernovae, neutron star mergers, and the formation of elements in the Universe.

PhD Students

Thomas Berlok 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 (NBIA) on simulations of collisionless plasmas.

Laure Berthier initially studied engineering in France, but then went to the University of Cambridge where she completed a masters in applied mathematics and theoretical physics. She joined the NBIA in 2014 to do her PhD. Her research has been focused on setting constraints on new physics beyond the Standard Model using Electroweak data and the general framework of effective field theory. An important aspect of her research was to develop a new fitting method to fit for small parameters with missing higher order corrections. She now works on non relativistic UV completion of the Standard Model to obtain a naturally light Higgs with Kevin Grosvenor.

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

Christine Hartmann 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. Christine finished her PhD in July 2016.

Leonardo Krapp obtained his degree of Licenciado from Cordoba University in Argentina in 2015 and started his PhD working with Oliver Gressel at the NBIA in 2016. His research interest involve studying dust dynamics and non-ideal magnetohydrodynamic effects in protoplanetary disk using the codes NIRVANA and FARGO3D. He is studying numerical algorithms to couple the Hall effect with ambipolar diffusion and Ohmic diffusion with the goal of performing non-ideal MHD simulations including non-equilibrium ionization calculations in a local model for a protoplanetary disks.

Meera Machado receiveded her Master's degree at the University of Sao Paulo. The thesis title was "*Event-by-event Hydrodynamics for LHC*". She currently works with Poul Henrik Damgaard and Ante Bilandzic on a PhD project entitled "*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.

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

Jeppe Trøst Nielsen began his studies in 2009 with a transition from accelerator physics through condensed matter and particle physics all the way to cosmology and the large scale structure of the universe in his PhD which he started at the International Academy in 2013. His work has focused on the framework of interpreting experiments though theories. With rigorous statistics as the main tool this resulted in a widely read and recognized paper in Nature Scientific Reports. His current research interests include determining to which degree future experiments may discriminate between theories of the early and old universe. Observing the CMB and large scale structures will only takes us so far!

Mads Søgaard completed his Ph.D. degree at NBIA in March with Poul Henrik Damgaard and Emil Bjerrum-Bohr as advisors. In his thesis, he worked on mathematical aspects of quantum field theory scattering amplitudes.

Philipp Weber obtained his MSc from Heidelberg in 2016 and subsequently started his PhD at NBIA working with Oliver Gressel. He is developing an advanced implementation of dust in protoplanetary disks for the FARGO3D and NIRVANA codes. This development will enable realistic studies of disk features such as planet-opened gaps and vortices. Previously, often a static vertical profile had to be assumed, but our framework will allow the self-consistent study of the vertical disk structure of the coupled gas and dust.

MSc Students

Erik Alexander Andersen	Particle Physics
Emil Andre	Particle Physics
Jon Brogaard	Particle Physics
Christian Berrig	Quantum Information
Gitte Elgaard Clausen	Particle Physics
Carsten Frizner Frødstrup	Particle Physics
Dennis Hansen	Particle Physics
Asta Heinesen	Astroparticle Physics
Veronica Kirsebom	Astroparticle Physics
Rasmus Peter Larsen	Particle Physics
Quentin Marolleau	Quantum Information
Janet Rafner	Theoretical Physics/Art
Bo Schmidt	Astroparticle Physics
Anders Schreiber	Particle Physics

Visiting Professors 2016

- **Jens Oluf Andersen**
- **So Matsuura**
- **Viatcheslav Mukhanov**
- **Bo Reipurth**

Adjuncts and Associates

- **Per Rex Christensen**
- **Zohar Komargodski**
- **Benny Lautrup**
- **Alan Luther**
- **Åke Nordlund**
- **Igor Novikov**
- **Anders Tranberg**

Administrative Staff

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 is the finance officer responsible for the grants received by the researchers at the NBIA.

NBIA Visitors 2016

K. Bering
15.12.2016-22.12.2016

J. Wells
14.12.2016-16.12.2016

M. Henneaux
06.12.2016-08.12.2016

F. Englert
04.12.2016-07.12.2016

P. Serpico (LAPTh, Annecy)
04.12.2016-07.12.2016

F. Wilczek
25.11.2016-26.11.2016

W. Waalewijn (Amsterdam)
23.11.2016-25.11.2016

L. Verde
22.11.2016-22.11.2016

A. Katz (CERN and Geneva U.)
16.11.2016-18.11.2016

T. Tenkanen
14.11.2016-23.11.2016

C. Weniger (Amsterdam U.)
08.11.2016-09.11.2016

M. Søgaard
07.11.2016-15.01.2017

W. Shepherd
06.11.2016-09.11.2016

M. Meyer (OKC Stockholm)
31.10.2016-03.11.2016

P. Kneschke
31.10.2016-04.11.2016

C. Burgess (Perimeter Institute)
29.10.2016-02.11.2016

R. Penrose (Oxford)
20.10.2016-22.10.2016

G. Pimentel
19.10.2016-22.10.2016

S. Wolf (Kiel University)
18.10.2016-21.10.2016

Q. Marolleau
13.10.2016-01.07.2017

M. Mangano (CERN)
11.10.2016-12.10.2016

M. Pohl (DESY Zeuthen, University of Potsdam)
10.10.2016-12.10.2016

S. Okuzumi
09.10.2016-14.10.2016

M. Ahlers (Wisconsin U.)
03.10.2016-06.10.2016

X. Ramos
01.10.2016-31.05.2017

A. Nizami
27.09.2016-29.09.2016

T. Ensslin (MPA, Garching)
19.09.2016-22.09.2016

F. Queiroz (MPIk Heidelberg)
31.08.2016-02.09.2016

S. Abel (IPPP Durham)
23.08.2016-31.08.2016

S. Hawking
19.08.2016-25.08.2016

P. Hunt (LMU Munich)
18.08.2016-24.08.2016

Y. Tsukamoto
15.08.2016-19.08.2016

S. Perez
08.08.2016-12.08.2016

P. Adhikari
07.08.2016-28.08.2016

J.O. Andersen
01.08.2016-21.12.2016

S. Mukhanov
01.08.2016-31.12.2016

H. Fukaya
01.08.2016-03.08.2016

S. Hannestad (Aarhus U)
01.08.2016-05.08.2016

E. Lisi (INFN Bari)
31.07.2016-05.08.2016

T. Montaruli (Geneva U)
31.07.2016-05.08.2016

G. Johnson (Oxford U)
25.07.2016-25.08.2016

B. Feng
15.07.2016-29.08.2016

A. Lande
12.07.2016-15.08.2016

C. Shen
10.07.2016-18.07.2016

M. von Hippel
09.07.2016-13.07.2016

P. Jain (IIT Kanpur)
28.06.2016-29.06.2016

T. Karzig (Microsoft Station Q)
22.06.2016-25.06.2016

A. Timmins
22.06.2016-24.06.2016

H. Dreiner (Bonn U)
21.06.2016-22.06.2016

K. Schmidt-Hoberg (DESY)
20.06.2016-22.06.2016

A.T. Mendes (CERN)
15.06.2016-16.06.2016

M. Gullans (JQI/NIST)
15.06.2016-18.06.2016

Y. Chien
15.06.2016-17.06.2016

S. Patil (Geneva U)
14.06.2016-21.06.2016

M. Abramowicz (Gothenburg+Warsaw)
11.06.2016-14.06.2016

S.V. Kusminskiy (Erlangen)
08.06.2016-10.06.2016

M. Burrello (MPQ)
06.06.2016-08.06.2016

C. Murphy
03.06.2016-04.06.2016

F. Yu
02.06.2016-08.06.2016

D. O'Connell
25.05.2016-29.05.2016

M. Bustamante (Ohio State U.)
12.05.2016-16.05.2016

L. Krapp (Cordoba University)
10.05.2016-16.05.2016

L. Banchi
03.05.2016-06.05.2016

N. Afshordi
03.05.2016-03.05.2016

J.-M. Alimi (Paris Observatory)
02.05.2016-07.05.2016

P. Weber (ITA, Heildelberg)
01.05.2016-04.05.2016

L. Vernazza
01.05.2016-05.05.2016

S. Mori
25.04.2016-29.04.2016

A. Joseph
20.04.2016-22.04.2016

D. Wiltshire (Canterbury U)
17.04.2016-19.04.2016

C. Llewellyn Smith (Oxford)
14.04.2016-16.04.2016

K. Mimasu (U Sussex)
12.04.2016-15.04.2016

B. van Rees
11.04.2016-15.04.2016

P. Benitez-Llambay (Cordoba University)
09.04.2016-06.05.2016

A. Mazumdar (Lancaster U)
05.04.2016-06.04.2016

L.F. Alday
30.03.2016-03.04.2016

M. Menu (Paris Observatory)
22.03.2016-30.06.2016

S. Mukherjee (IUCAA Pune)
21.03.2016-15.04.2016

M. Kalinowski (CTBTO)
11.03.2016-13.03.2016

Z. Grujic
07.03.2016-11.03.2016

S. Matsuura
01.03.2016-31.03.2017

A. Stutz (MPIA, Heildelberg)
28.02.2016-02.03.2016

C. Englert
29.02.2016-03.03.2016

T. Shimada
23.02.2016-29.03.2016

M. Serbyn (UC Berkeley)
14.02.2016-16.02.2016

T. Kauffmann
08.02.2016-09.02.2016

A. Cherman
30.01.2016-13.02.2016

W. Verkeke
25.01.2016-26.01.2016

J. Santos
17.01.2016-20.01.2016

D. Kobyakov (Darmstadt)
11.01.2016-15.01.2016

R. Durrer (Geneva U)
07.01.2016-08.01.2016

J. Colin (IAP Paris)
01.09.2015-31.08.2016

R. Mohayaee (IAP Paris)
01.09.2015-31.08.2016

J. Rafner
19.08.2015-30.06.2016

C. Liu
01.06.2015-31.05.2016

Workshops & PhD Schools 2016

- Sixth Annual NBIA Workshop on ESS Science (NBIA6): Structure and Dynamics in Confinement (November 7-8)
- Higgs Effective Field Theory workshop (October 26-28)
- First Workshop on the Physics of Excitatory Membranes (August 29-31)
- 4th ICM Theory and Computation Workshop (August 22-24)
- Simons Program: Current Themes in High Energy Physics and Cosmology (August 15-26)
- Fault-Tolerant Quantum Technologies (August 14-27)
- NBIA PhD School: Neutrinos Underground and in the Heavens II (August 1-5)
- Simons Program: Relativistic Astrophysics and Gravitational Waves (July 27-28)
- Strong and Electroweak Matter 2016 (July 14-27)
- QDev/NBIA 2016 Summer School (July 3-8)
- Formation, Evolution, and Dynamics of Young Solar Systems (April 18-22)
- Nordic Conference on Particle Physics (January 2-7)

NBIA Colloquia 2016

- Frank Wilczek (MIT) — 25.11.2016

  “Augmenting Reality: Axions, Anyons, and Entangled Histories”

- Roger Penrose (Oxford University) — 21.10.2016

  “Fashion, Faith and Fantasy in the New Physics of the Universe”

- Marek Abramowicz (Gothenburg University) — 13.06.2016

  “Gravitational wave theory: the history”

- Chris Llewellyn-Smith (Oxford University) — 15.04.2016

  “Can Future Energy Needs be Met Sustainably?”

- Martin Kalinowski (CTBTO) — 11.03.2016

  “The International Monitoring System – Scanning the Earth for Possible Signals from Nuclear Explosions”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Publications 2016

1. **Production of the entire range of r-process nuclides by black hole accretion disc out- flows from neutron star mergers**, Wu, M.-R., Fernández, R., Martínez-Pinedo, G. et al., 2016, MNRAS, 463, 2323-2334 - ArXiv: 1607.05290.
2. **Proof of the Wehrl-type Entropy Conjecture for Symmetric SU(N) Coherent States**, Lieb, E. H., Solovej, J. P., 2016, Communications in Mathematical Physics, 348, 567-578 - ArXiv: 1506.07633.
3. **A facility to search for hidden particles at the CERN SPS: the SHiP physics case**, Alekhin, S., Altmannshofer, W., Asaka, T. et al., 2016, Reports on Progress in Physics, 79, 124201 - ArXiv: 1504.04855.
4. **Localization Lifetime of a Many-Body System with Periodic Constructed Disorder**, Schecter, M., Shapiro, M., Dykman, M. I. et al., 2016 - ArXiv: 1611.05713.
5. **Latest results from lattice N=4 supersymmetric Yang–Mills**, Schaich, D., Catterall, S., Damgaard, P. H. et al., 2016 - ArXiv: 1611.06561.
6. **The contribution of Fermi-2LAC blazars to the diffuse TeV-PeV neutrino flux**, IceCube Collabora- tion, Aartsen, M. G., Abraham, K. et al., 2016 - ArXiv: 1611.03874.
7. **The contribution of Fermi-2LAC blazars to the diffuse TeV-PeV neutrino flux**, IceCube Collabora- tion, Aartsen, M. G., Abraham, K. et al., 2016 - ArXiv: 1611.03874.
8. **The Z decay width in the SMEFT: yt and λ corrections at one loop**, Hartmann, C., Shep- herd, W., Trott, M. et al., 2016 - ArXiv: 1611.09879.
9. **Toward realistic simulations of magneto-thermal winds from weakly-ionized proto- planetary disks**, Gressel, O., 2016 - ArXiv: 1611.09533.
10. **Shortening Anomalies in Supersymmetric Theories**, Gomis, J., Komargodski, Z., Ooguri, H. et al., 2016 - ArXiv: 1611.03101.
11. **Interpreting W mass measurements in the SMEFT**, Bjørn, M., Trott, M., 2016, Physics Letters B, 762, 426-431 - ArXiv: 1606.06502.
12. **Magnon inflation: slow roll with steep potentials**, Adshead, P., Blas, D., Burgess, C. P. et al., 2016, J. Cosmology Astropart. Phys., 11, 009 - ArXiv: 1604.06048.
13. **The E-expansion for QED**, di Pietro, L., Komargodski, Z., Shamir, I. et al., 2016, Interna- tional Journal of Modern Physics A, 31, 1645039.
14. **Handbook of LHC Higgs Cross Sections: 4. Deciphering the Nature of the Higgs Sec- tor**, de Florian, D., Grojean, C., Maltoni, F. et al., 2016 - ArXiv: 1610.07922.
15. **The Standard Model Effective Field Theory and Next to Leading Order**, Passarino, G., Trott, M., 2016 - ArXiv: 1610.08356.
16. **Quantized magnetization density in periodically driven systems**, Nathan, F., Rudner, M. S., Lindner, N. H. et al., 2016 - ArXiv: 1610.03590.
17. **Addressing the too big to fail problem with baryon physics and sterile neutrino dark matter**, Lovell, M. R., Gonzalez-Perez, V., Bose, S. et al., 2016 - ArXiv: 1611.00005.
18. **Properties of Local Group galaxies in hydrodynamical simulations of sterile neutrino dark matter cosmologies**, Lovell, M. R., Bose, S., Boyarsky, A. et al., 2016 - ArXiv: 1611.00010.
19. **Partition functions with spin in AdS2 via quasinormal mode methods**, Keeler, C., Lisbão, P., Ng, G. S. et al., 2016, Journal of High Energy Physics, 10, 60 - ArXiv: 1601.04720.
20. **Scalable Designs for Quasiparticle-Poisoning-Protected Topological Quantum Compu- tation with Majorana Zero Modes**, Karzig, T., Knapp, C., Lutchyn, R. et al., 2016 - ArXiv: 1610.05289.
21. **Complementarity of DM searches in a consistent simplified model: the case of Z’**, Jacques, T., Katz, A., Morgante, E. et al., 2016, Journal of High Energy Physics, 10, 71- ArXiv: 1605.06513.

22. **Fast Pairwise Conversion of Supernova Neutrinos: Dispersion-Relation Approach**, Izaguirre, I., Raffelt, G., Tamborra, I. et al., 2016 - ArXiv: 1610.01612.

23. **Very High-Energy Gamma-Ray Follow-Up Program Using Neutrino Triggers from IceCube**, IceCube Collaboration, Aartsen, M. G., Abraham, K. et al., 2016 - ArXiv: 1610.01814.

24. **The Single Mirror Small Sized Telescope For The Cherenkov Telescope Array**, Heller, M., Schioppa, jr, E., Porcelli, A. et al., 2016 - ArXiv: 1610.01867.

25. **Radial Profile of the 3.5 keV Line Out to R200 in the Perseus Cluster**, Franse, J., Bulbul, E., Foster, A. et al., 2016, ApJ, 829, 124 - ArXiv: 1604.01759.

26. **One-point fluctuation analysis of the high-energy neutrino sky**, Feyereisen, M. R., Tamborra, I., Ando, S. et al., 2016 - ArXiv: 1610.01607.

27. **Spiral magnetic order and topological superconductivity in a chain of magnetic adatoms on a two-dimensional superconductor**, Christensen, M. H., Schecter, M., Flensberg, K. et al., 2016, Phys. Rev. B, 94, 144509 - ArXiv: 1607.08190.

28. **Exact State Revival in a Spin Chain with Next-To-Nearest Neighbour Interactions**, Christandl, M., Vinet, L. et al., 2016 - ArXiv: 1610.04796.

29. **Contributions of the Cherenkov Telescope Array (CTA) to the 6th International Symposium on High-Energy Gamma-Ray Astronomy (Gamma 2016)**, CTA Consortium, T., Abchiche, A. et al., 2016 - ArXiv: 1610.05151.

30. **Misaligned Disks in the Binary Protostar IRS 43**, Brinch, C., Jørgensen, J. K., Hogerheijde, M. R. et al., 2016, ApJ, 830, L16 - ArXiv: 1610.03626.

31. **Stratifying on-shell cluster varieties: the geometry of non-planar on-shell diagrams**, Bourjaily, J. L., Franco, S., Galloni, D. et al., 2016, Journal of High Energy Physics, 10, 3 - ArXiv: 1607.01781.

32. **Statistics of predictions with missing higher order corrections**, Berthier, L., Trøst Nielsen, J., 2016 - ArXiv: 1610.01783.

33. **Interacting composite fermions: Nature of the 4/5, 5/7, 6/7, and 6/17 fractional quantum Hall states**, Balram, A. C., 2016, Phys. Rev. B, 94, 165303 - ArXiv: 1607.00568.

34. **String-Like Dual Models for Scalar Theories**, Baadsgaard, C., Bjerrum-Bohr, N. E. J., Bourjaily, J. L. et al., 2016 - ArXiv: 1610.04228.

35. **Boundary Causality vs Hyperbolicity for Spherical Black Holes in Gauss-Bonnet**, Andrade, T., Caceres, E., Keeler, C. et al., 2016 - ArXiv: 1610.06078.

36. **All-flavour search for neutrinos from dark matter annihilations in the Milky Way with IceCube/DeepCore**, Aartsen, M. G., Abraham, K., Ackermann, M. et al., 2016, European Physical Journal C, 76, 531.

37. **Search for Sources of High-energy Neutrons with Four Years of Data from the IceTop Detector**, Aartsen, M. G., Abraham, K., Ackermann, M. et al., 2016, ApJ, 830, 129.

38. **Search for bottom squark pair production in proton-proton collisions at $\sqrt{s}$ =13 TeV with the ATLAS detector**, Aaboud, M., Aad, G., Abbott, B. et al., 2016, European Physical Journal C, 76, 547 - ArXiv: 1606.08772.

40. **Search for scalar leptoquarks in pp collisions at $\sqrt{s}$** = 13 **TeV with the ATLAS experiment**, The ATLAS Collaboration, Aaboud, M., Aad, G. et al., 2016, New Journal of Physics, 18, 093016 - ArXiv: 1605.06035.

41. **Direct Probe of Topological Invariants Using Bloch Oscillating Quantum Walks**, Ramasesh, V. V., Flurin, E., Rudner, M. S. et al., 2016 - ArXiv: 1609.09504.

42. **Planck 2015 results. XXII. A map of the thermal Sunyaev-Zeldovich effect**, Planck Collaboration, Aghanim, N., Arnaud, M. et al., 2016, A&A, 594, A22 - ArXiv: 1502.01596.

43. **Planck 2015 results. XI. CMB power spectra, likelihoods, and robustness of parameters**, Planck Collaboration, Aghanim, N., Arnaud, M. et al., 2016, A&A, 594, A11 - ArXiv: 1507.02704.

44. **Planck 2015 results. VI. LFI mapmaking**, Planck Collaboration, Ade, P. A. R., Aghanim, N. et al., 2016, A&A, 594, A6 - ArXiv: 1502.01585.

45. **Planck 2015 results. II. Low Frequency Instrument data processings**, Planck Collabora- tion, Ade, P. A. R., Aghanim, N. et al., 2016, A&A, 594, A2 - ArXiv: 1502.01583.

46. **Planck 2015 results. XXI. The integrated Sachs-Wolfe effect**, Planck Collaboration, Ade, P. A. R., Aghanim, N. et al., 2016, A&A, 594, A21 - ArXiv: 1502.01595.

47. **Planck 2015 results. XVIII. Background geometry and topology of the Universe**, Planck Collaboration, Ade, P. A. R., Aghanim, N. et al., 2016, A&A, 594, A18 - ArXiv: 1502.01593.

48. **Planck 2015 results. XIV. Dark energy and modified gravity**, Planck Collaboration, Ade, P. A. R., Aghanim, N. et al., 2016, A&A, 594, A14 - ArXiv: 1502.01590.

49. **Planck 2015 results. XXIV. Cosmology from Sunyaev-Zeldovich cluster counts**, Planck Collaboration, Ade, P. A. R., Aghanim, N. et al., 2016, A&A, 594, A24 - ArXiv: 1502.01597.

50. **Planck 2015 results. XV. Gravitational lensing**, Planck Collaboration, Ade, P. A. R., Aghanim, N. et al., 2016, A&A, 594, A15 - ArXiv: 1502.01591.

51. **Planck 2015 results. XIII. Cosmological parameters**, Planck Collaboration, Ade, P. A. R., Aghanim, N. et al., 2016, A&A, 594, A13 - ArXiv: 1502.01589.

52. **Planck 2015 results. XII. Full focal plane simulations**, Planck Collaboration, Ade, P. A. R., Aghanim, N. et al., 2016, A&A, 594, A12 - ArXiv: 1509.06348.

53. **Planck 2015 results. XXVII. The second Planck catalogue of Sunyaev-Zeldovich sources**, Planck Collaboration, Ade, P. A. R., Aghanim, N. et al., 2016, A&A, 594, A27 - ArXiv: 1502.01598.

54. **Planck 2015 results. XX. Constraints on inflation**, Planck Collaboration, Ade, P. A. R., Aghanim, N. et al., 2016, A&A, 594, A20 - ArXiv: 1502.02114.

55. **Planck 2015 results. XVII. Constraints on primordial non-Gaussianity**, Planck Collab- oration, Ade, P. A. R., Aghanim, N. et al., 2016, A&A, 594, A17 - ArXiv: 1502.01592.

56. **Planck 2015 results. XXVI. The Second Planck Catalogue of Compact Sources**, Planck Collaboration, Ade, P. A. R., Aghanim, N. et al., 2016, A&A, 594, A26 - ArXiv: 1507.02058.

57. **Planck 2015 results. XXV. Diffuse low-frequency Galactic foregrounds**, Planck Collab- oration, Ade, P. A. R., Aghanim, N. et al., 2016, A&A, 594, A25 - ArXiv: 1506.06660.

58. **Planck 2015 results. VII. High Frequency Instrument data processing: Time-ordered information and beams**, Planck Collaboration, Adam, R., Ade, P. A. R. et al., 2016, A&A, 594, A7.

59. **Planck 2015 results. X. Diffuse component separation: Foreground maps**, Planck Col- laboration, Adam, R., Ade, P. A. R. et al., 2016, A&A, 594, A10 - ArXiv: 1502.01588.

60. **Planck 2015 results. I. Overview of products and scientific results**, Planck Collaboration, Adam, R., Ade, P. A. R. et al., 2016, A&A, 594, A1 - ArXiv: 1502.01582.

61. **Microscopic Processes in Global Relativistic Jets Containing Helical Magnetic Fields**, Nishikawa, K.-I., Mizuno, Y., Niemiec, J. et al., 2016, Galaxies, 4, 38 - ArXiv: 1609.09363.

62. **Sustained Turbulence in Differentially Rotating Magnetized Fluids at Low Magnetic Prandtl Number**, Nauman, F., Pessah, M. E., 2016 - ArXiv: 1609.08543.

63. **Satellite galaxies in semi-analytic models of galaxy formation with sterile neutrino dark matter**, Lovell, M. R., Bose, S., Boyarsky, A. et al., 2016, MNRAS, 461, 60-72 - ArXiv: 1511.04078.

64. **Quantized conductance doubling and hard gap in a two-dimensional semiconductor- superconductor heterostructure**, Kjaergaard, M., Nichele, F., Suominen, H. J. et al., 2016, Nature Communications, 7, 12841 - ArXiv: 1603.01852.

65. **Quantum Circuits for Quantum Channels**, Iten, R., Colbeck, R., Christ et al., 2016 - ArXiv: 1609.08103.

66. **All-sky search for time-integrated neutrino emission from astrophysical sources with 7 years of IceCube data**, IceCube Collaboration, Aartsen, M. G., Abraham, K. et al., 2016 - ArXiv: 1609.04981.

67. **First search for dark matter annihilations in the Earth with the IceCube Detector**, IceCube Collaboration, Aartsen, M. G., Abraham, K. et al., 2016 - ArXiv: 1609.01492.

68. **Large wood recruitment and transport during large floods: A review**, Comiti, F., Lucía, A., Rickenmann, D. et al., 2016, Geomorphology, 269, 23-39.

69. **Asymptotic tensor rank of graph tensors: beyond matrix multiplication**, Christandl, M., Vrana, P. et al., 2016 - ArXiv: 1609.07476.

70. **Private states, quantum data hiding and the swapping of perfect secrecy**, Christandl, M., Ferrara, R. et al., 2016 - ArXiv: 1609.04696.

71. **Poking holes and cutting corners to achieve Clifford gates with the surface code**, Brown, B. J., Laubscher, K., Kesselring, M. S. et al., 2016 - ArXiv: 1609.04673.

72. **Dimensional reduction of the Standard Model coupled to a new singlet scalar field**, Brauner, T., Tenkanen, T. V. I., Tranberg, A. et al., 2016 - ArXiv: 1609.06230.

73. **Light-like Scattering in Quantum Gravity**, Bjerrum-Bohr, N. E. J., Donoghue, J. F., Hol- stein, B. R. et al., 2016 - ArXiv: 1609.07477.

74. **Manifesting color-kinematics duality in the scattering equation formalism**, Bjerrum- Bohr, N. E. J., Bourjaily, J. L., Damgaard, P. H. et al., 2016, Journal of High Energy Physics, 9, 94 - ArXiv: 1608.00006.

75. **Incorporating doubly resonant W± data in a global fit of SMEFT parameters to lift flat directions**, Berthier, L., Bjørn, M., Trott, M. et al., 2016, Journal of High Energy Physics, 9, 157 - ArXiv: 1606.06693.

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