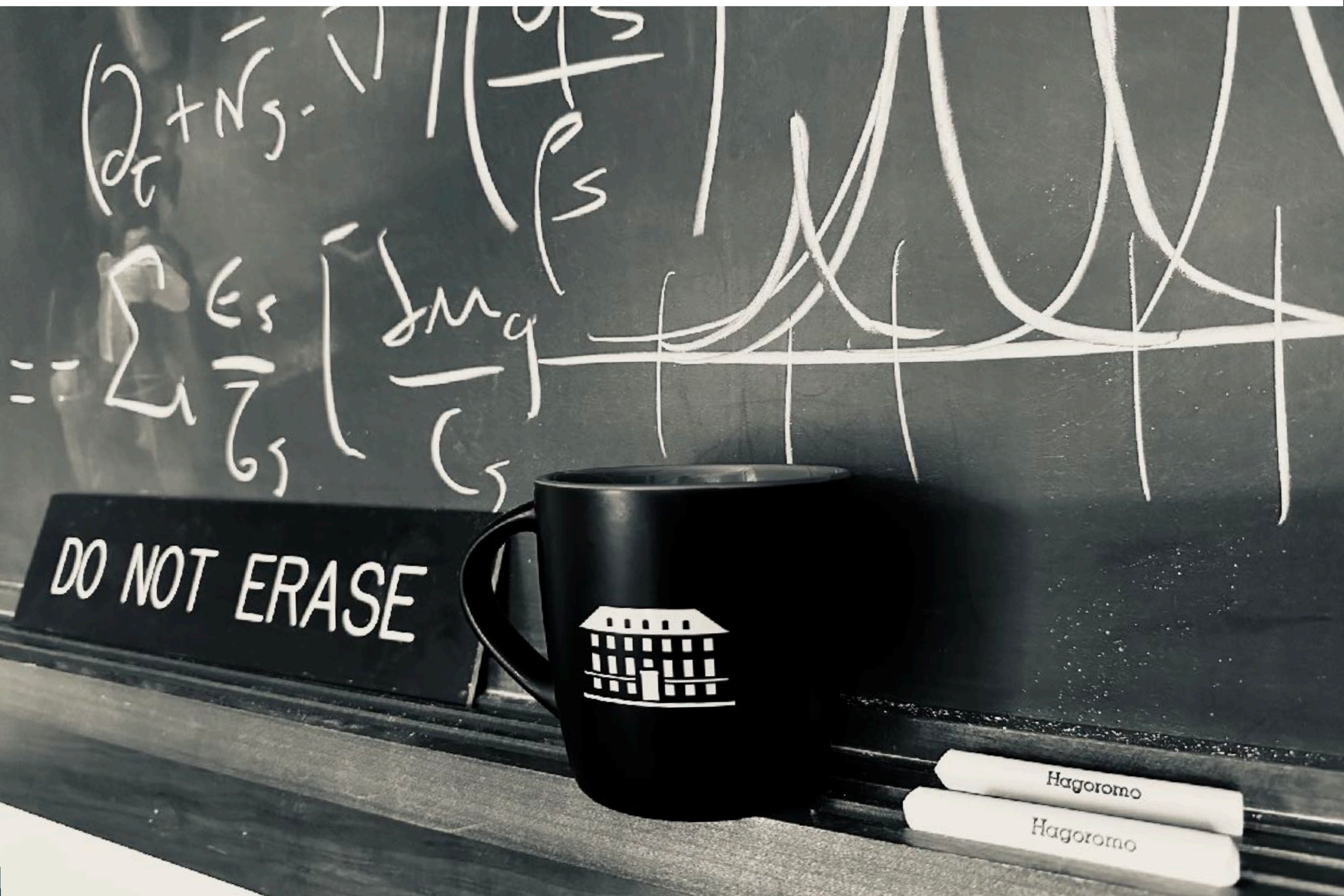
The Niels Bohr International Academy



Annual Report 2022

The Niels Bohr International Academy

Contact: Gosia Dekempe
NBIA Administrative Officer
Email: malgorzata.dekempe@nbi.ku.dk
Tel: +45 35 32 72 56

Web: http://www.nbia.nbi.ku.dk/

Editor: Martin E. Pessah
Professor, Deputy Director
Niels Bohr International Academy
Niels Bohr Institute

Email: mpessah@nbi.ku.dk

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The Academy

NBIA Governance

International Advisory Board and Director's Council:

The Niels Bohr International Academy receives scientific advice from an International Advisory Board consisting of leading names in today's theoretical and mathematical physics as well as important advice and support from its Director's Council, which consists of prominent members of Danish society.

Current Members of the International Advisory Board:

- **Poul Henrik Damgaard**, Niels Bohr Institute (Director)
- **Martin E. Pessah,** Niels Bohr Institute (Deputy Director)
- **David Gross**, KITP Santa Barbara
- **Charles Marcus**, Niels Bohr Institute (Interim Chairman)
- **Itamar Procaccia**, Weizmann Institute
- **Barry Simon**, California Institute of Technology
- **Paul Steinhardt**, Princeton University
- **Frank Wilczek**, Massachusetts Institute of Technology

Current Members of the Director's Council:

- **Peter Landrock** (Chairman)
  Founding Director of Cryptomathic, Professor of Mathematics and Fellow, Churchill College
- **Kirsten Smedegaard Andersen**
  Board Chair Movotec, Board member LD, Bodum, and other public and private organizations
- **Bertel Haarder**
  Former MP, Minister and former member of European Parlament
- **Niels Due Jensen** (Vice Chairman)
  Former CEO of Grundfos and former Chairman of Poul Due Jensen Foundation
- **Anne Birgitte Gammeljord**
  Lawyer, Rovsing & Gammeljord
- **Per Magid**
  Lawyer, Rovsing & Gammeljord
- **Bjørn Nørgaard**
  Prof. Royal Academy of Fine Arts, Guest Prof. China National Academy of Arts
- **Michael K. Rasmussen**
  Former Vice President, Brand in VELUX Group, private consultant

The Niels Bohr
International Academy

From the Director

All subjects in science develop into a higher and higher degree of specialization. Eventually they either close up and become obsolete or they enter “the books” as part of our ever-growing reservoir of knowledge. The counter-move to this trend is to encourage cross-talk across disciplines and hope that completely new ideas can emerge in the process. This facilitation of interdisciplinary science is at the heart of NBIA's raison d'etre.

But interdisciplinary science can only produce miracles when the setup is right and when the right people are gathered. Experts who are continually only exposed to the same subjects, and perhaps even in an ever-narrowing sense, simply dry out of ideas. Put such experts with the right mindset and from different disciplines together and amazing new directions and novel insight can suddenly appear. This requires open minds and a willingness to think out of the box. As always, do not expect new and brilliant ideas to emerge effortlessly. But when they do emerge they can be transformative. This is what NBIA gambles on. In the daily work there are still the underlying disciplines but the environment to receive unexpected new input is there. It is at the coffee machine or in a colloquium or at the chance encounter with a visitor that we have the opportunities to get exposed to ideas and concepts from outside our own scientific circles. Such an environment needs to be nurtured and one must constantly seek input from apparently unrelated directions.

An exciting new opportunity for strengthening interdisciplinary research at NBIA has arisen with the award of the Novo Nordisk Foundation Quantum Computing Program to the Niels Bohr Institute. Housed primarily in the buildings adjacent to NBIA, the potential for collaboration is enormous. Interestingly, the whole concept of a quantum computer was born in an interdisciplinary environment and most credit it to to the late Richard Feynman, one of the most open, creative, and curious physicists of the last century. Feynman had, a bit out of the blue, gotten interested in classical computing and had started to speak with experts in computer science. This included long-time NBIA associate Charles Bennett who had made seminal contributions on the concept of reversible computation. Feynman kept thinking of computational limits as you approached atomic scales and suddenly had the then outrageous idea that one might be able to construct a computer that would not just “simulate” quantum systems, it would be a quantum system, with the laws of computation following the laws of quantum mechanics. In 1981 he delivered a now famous talk on this at a conference on computer science. The opening line was “On the program it says this is a keynote speech — and I don't know what a keynote speech is”. Clearly the Nobel Prize Feynman had received in 1965 had not gone to his head. That speech is by many seen as the launch of the quantum computer era.

At the time of writing, the buildings for the new center are already being vacated and as a consequence NBIA is now as packed as never before. Curiously, this by itself leads to new scientific connections, although this time not by design. In the NBIA lounge there is now a constant buzz of discussions on subjects from black holes, cell migration in living matter, neutrinos released in supernova explosions, integrable spin systems, gravitational wave predictions from particle physics, the mathematics of quantum field theory amplitudes, and whatever other subjects are on people's minds. Soon all the tantalizing possibilities of quantum information theory and quantum computing will be discussed as well.

Poul Henrik Damgaard

From the Chairman of the Council

2022 has been an exceptional year for Quantum Mechanics (QM) and NBI. It was the year when we, with some delay, could celebrate the 100th anniversary of Niels Bohr receiving the Nobel Prize in physics and the creation of NBI. Niels Bohr's legendary atom model with the orbits of electrons initiated the development of QM, and until Bohr's death in 1962 NBI was "the world centre for research in theoretical physics" as Andrew Whitaker wrote in his book "Einstein, Bohr and the Quantum Dilemma", CUP 2nd ed 2006. The next 60 years would of course see other significant centres arriving, in particular in the USA and other places but, remarkably, with limited resources NBI remained a significant player and through a combination of excellent researchers and risk willing financial support from, e.g. Research Councils, the EU and not least the Villum Foundation (Velux), it has managed to remain in the exclusive top-notch world centres in QM, one of the reasons Microsoft came to town with a significant investment in 2018.

In 2022 the reward came for this persistent thrive for excellence. First the selection of Denmark and the Niels Bohr Institute as the location for the NATO Accelerator and test site for Quantum Technologies and shortly after, even more remarkably, the Novo Nordisk Foundation donated 1.5 billion DKK for a very ambitious Quantum Computing Programme being launched with NBI as the main player. It is thus decades of significant research contributions that gives NNF the confidence this can be achieved based on the NBI expertise and other important resources and universities in Denmark.

The declared goal of the Programme — after several decades of quest for so-called computational supremacy over classical computers — is to actually build a quantum computer which will enable the development of, e.g., new medicine and provide new insight into climate change and the green transition. Computational supremacy

cannot be achieved with classical computers, the key point being that in computers today a bit is a bit which is always 0 or 1, as opposed to a qubits which by the very nature of QM can be in various states governed by inherent probabilities.

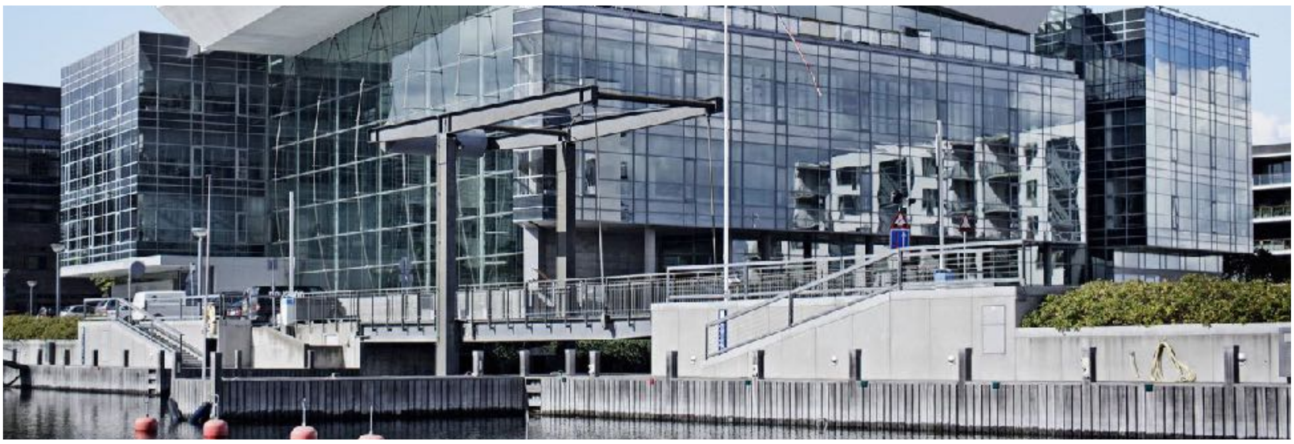
The clear aim is thus to build rather than "merely" improve the theory. It is recognized that there are still unresolved challenges, but they appear to be addressed one by one, such as the just announced new breakthrough at NBI, where Peter Lodahl's group in collaboration with Bochum University have solved a problem that has caused headaches for years. They can now control two quantum light sources rather than just one, which allows a practical realisation of "entanglement", perhaps the most baffling property that follows from the mathematical theory behind QM. Personally, I have remained somewhat sceptical as to whether a really powerful quantum computer will ever be built, but the whole approach taken with this programme cannot but impress me. It will be very exciting to follow, and I am sure something astonishing will come out of it.

John D. Rockefeller, who founded the University of Chicago in 1893 later said this was the best investment he ever made. Perhaps the State of Denmark can one day say the same about its decision to build the Niels Bohr Institute. The founder of Novo Nordisk, the company behind NNF, August Krogh worked and lived for many years in a beautiful building at Copenhagen University, the Rockefeller Institute not far from NBI, another "investment" of JDR. Sadly, this was demolished not too many years ago. Let's hope this will never happen to the Niels Bohr Institute.

Peter Landrock

Novo Nordisk Foundation Grant

The largest institutional grant to NBIA since the endowed Villum Kann Rasmussen Professorship in 2007 came from the Novo Nordisk Foundation in 2018. This grant of 35 MDKK aims at establishing up to five Novo Nordisk Foundation Assistant Professors, Novo Nordisk Foundation Associate Professors, or Novo Nordisk Foundation Full Professors at NBIA. The new research directions should have potential for relevance within life science research. The time is indeed ripe for this expansion into areas in life sciences that are bordering physics, and it has for several years been the ambition of NBIA to again establish a stronghold in theoretical biological physics (one of the first topics of research when NBIA was founded in 2007). The large grant from the Novo Nordisk Foundation takes this to a much larger scale. It will massively support research at the NBIA that may potentially have large impact on the life sciences. For NBIA new areas of focus are (apart from biological physics and the more general area of biocomplexity): systems biology, computational biology, modern genetic studies and even close contact to laboratory work in the biological sciences. All of these are areas where physics-driven methods may provide new and groundbreaking results. In addition to making these new fixed-term appointments NBIA will provide the interdisciplinary atmosphere, the close contact with both theoretical physicists and mathematicians, and the steady flow of leading scientists that normally visit NBIA every year. The first Novo Nordisk Foundation Assistant Professor Amin Doostmohammadi started his NBIA appointment in the fall of 2019 and based on a personal Villum Young Investigator grant, support from Independent Research Fund Denmark, the NERD program under the Novo Nordisk Foundation, and, most recently, an ERC Starting Grant, he has already established his own junior research group. In 2021 Amin Doostmohammadi was joined by two new Novo Nordisk Foundation Assistant Professors: Weria Pezeshkian who works on computational biophysics and Karel Proesmanns who works on applying thermodynamic and statistical mechanics methods to biological systems. Weria Pezeshkian has already established his own junior research group based on Sapere Aude grant from Independent Research Fund Denmark and a project grant from the Novo Nordisk Foundation. Karel Proesmanns has just received an EU Marie Curie Fellowship and has already started his own junior research group based on a project grant from the Novo Nordisk Foundation. New and unexpected links to life sciences are thus blossoming at NBIA and plans are underway to make one new hire in 2023 in promising new directions.



Louis-Hansen Foundation Grant

In 2018 the Aage & Johanne Louis-Hansen Foundation provided NBIA with an important grant of 10 MDKK to hire Louis-Hansen Foundation Assistant Professors on 5-year fixed-term contracts at NBIA. The grant is totally flexible and will allow NBIA to seek the brightest young scientists in all areas of the physical sciences. This strategy is at the heart of the foundation of NBIA and it opens up the opportunity to strike out in brand-new research directions that are not currently pursued at NBIA or at the Niels Bohr Institute itself. The overarching principle when making these new appointments is to let the individual talent of applicants be the decisive criterion while simultaneously hoping for a renewal of research topics. Fortunately, these two strategic points of view often merge together, demonstrating that the best scientists move towards areas that are most promising. No one has better noses for this than young scientists who have had a PhD-education from some of the best universities in the world, followed by some post-doctoral years where they have been able to liberate themselves from their thesis topics and thus defined their own research directions. These are scientists who can drive the NBIA in the coming years and who we now invite to join us. The generous grant from the Louis-Hansen Foundation is a most important milestone in the short history of NBIA and it is leaving its strong mark. Current Louis-Hansen Foundation Assistant Professor Johan Samsing has already received an individual EU Marie Curie Fellowship, a Villum Young Investigator grant, and, most recently, an ERC Starting Grant which enables him to establish his own junior research group. A new Louis-Hansen Foundation Assistant Professor is expected to start in 2023.

Husman Foundation Grant

A large donation from the Ernst & Vibeke Husman Foundation given to NBIA allows us to attract top talent from around the world as Husman Foundation Visiting Scholars. After a two-year hold 2020-21 due to the pandemic, the Husman Foundation Visiting Scholar program is now up and running. Stays at the NBIA can last from less than a week for researchers invited to speak in our series of NBIA Colloquia and/or more specialized seminars, and up to four or six weeks for longer research visits as well as Husman Foundation Visiting Professorships. This program builds on and expands the internationalization that is at the core of NBIA's activities, and which is so important for keeping scientists at NBIA abreast of new scientific developments. Husman Foundation Scholarships are also available for invitations of collaboration partners for NBIA scientists and funds from the grant can be used to organize specialized smaller workshops.

ERNST & VIBEKE HUSMANS FOND

INTERACTIONS — EU-COFUND

Close interactions among scientists from a wide range of cultures is in the DNA of the Niels Bohr International Academy and it is a tradition dating back to the original institute Niels Bohr created on the premises on Blegdamsvej one century ago. In 2019, with the valuable support of the European Commission through the COFUND program under the Marie Skłodowska-Curie Actions, NBIA launched an ambitious Fellowship Program with the aim to enhance interactions among young scientist across theoretical physics and across Europe.

The INTERACTIONS Fellowship Program promotes and ensures exposure of the fellows to other scientists within neighboring areas. The program also encourages interactions among scientists with different cultural backgrounds and from different scientific traditions. To this end, NBIA has teamed up with five of the strongest theoretical physics institutes in Europe who are partners of the INTERACTIONS program:

- University of Cambridge — Department of Applied Maths & Theoretical Physics
- University of Oxford — Department of Theoretical Physics
- Max Planck — Institute for Astronomy, Heidelberg
- CERN — Theoretical Physics Department
- Saclay — Institut de Physique Theorique

These institutions have been chosen for their excellence in research, for their existing strong ties to NBIA, for their breadth in theoretical physics, and for their wide distribution both geographically and in terms of science culture. It is a unique opportunity for fellows to be introduced to different research environments, to build personal networks within Europe, and to intensify long-term collaborations between these institutions. This increases the network and research opportunities for the fellows, and at the same time has the potential to bring our institutions closer together. Eleven new INTERACTIONS fellows have been employed under this program in 2022 after the third call for applications closed in late 2021. More detailed information can be found at http://nbia.nbi.ku.dk/interactions.

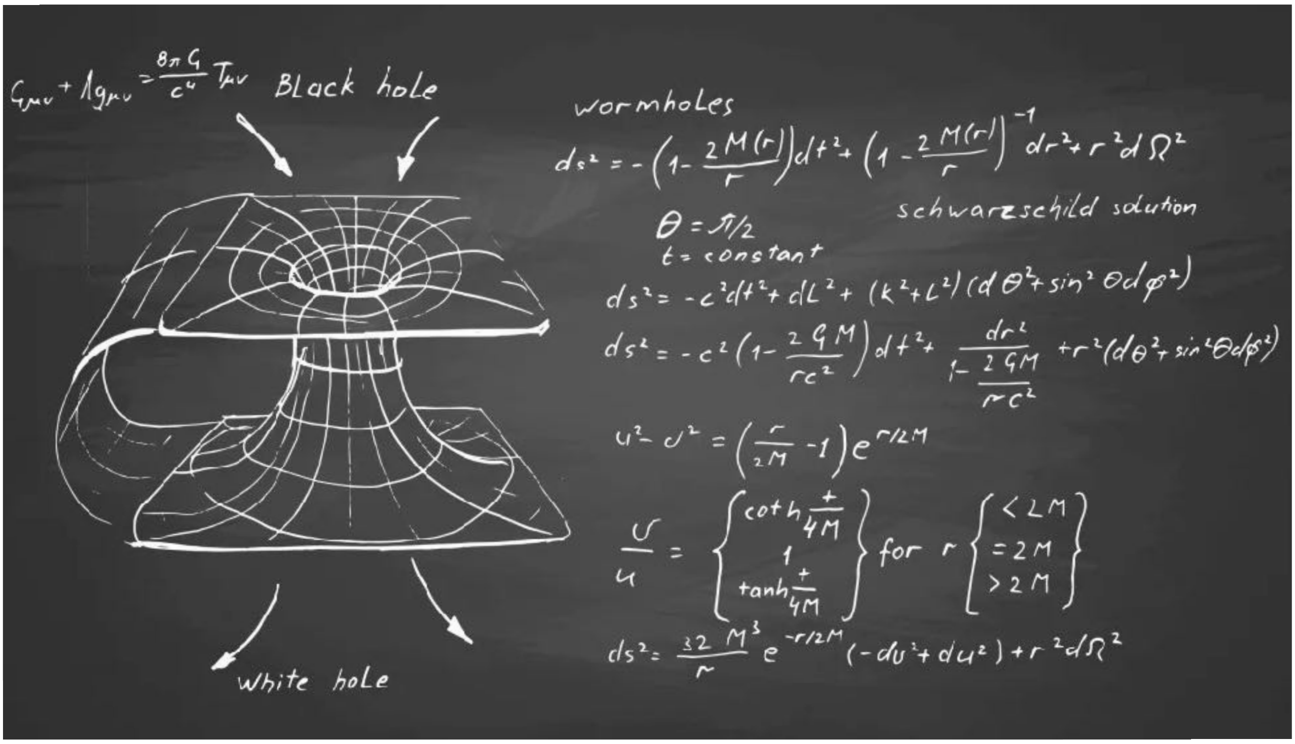
NBIA Research

Theoretical Particle Physics

Research in the theoretical particle physics group at NBIA has been expanding in the direction of classical gravity over the past few years. Remarkably, quantum field theory methods have proven to be extremely efficient for computing classical quantities in general relativity. At the core are new developments that have revolutionized the way we calculate scattering amplitudes. These methods transcend the original practical goals and point toward completely new ways of understanding perturbative quantum field theory. One starts with an approximation (“tree level”) and then builds up a sum of new terms (“loops”), now involving integrations. Work at NBIA has moved strongly ahead on how to integrate these expressions, often revealing unexpected relations to abstract concepts in mathematics. The big surprise is that these amplitude methods can be directly carried over to classical gravity, where the integrations can be understood as generalized Fourier transforms of the real-space dynamics of, for example, the scattering of two black holes. Such computations are of crucial importance for accurate determination of physical parameters such as masses and spins of merging black holes from observations of gravitational waves.

The NBIA group has contributed to the foundational basis of these new developments by demonstrating the equivalence of two competing analytical methods, and by deriving a direct relationship between parameters of the effective potential governing the two-body interactions and the classical part of the amplitudes as computed in perturbation theory. During 2022 new directions pursued at NBIA includes the analysis of scattering of two black holes with spin in both the test-body limit and in the most general case by an expansion in both gravitational coupling and spin parameters. The general framework is that of the so-called Post-Minkowskian expansion of Einstein's theory of general relativity in which no expansion in velocity (as in the traditional Post-Newtonian expansion) is needed. Calculations performed by NBIA scientists now reach up to fourth Post-Minkowskian order, the leading result world-wide. This is based on a world-line formulation of classical gravitational scattering that is closely related to the amplitude-based approach although on a conceptually quite different footing. Another approach to classical general relativity from a field theoretic perspective comes from the study of non-relativistic limits of gravity which highlight the possibility of defining ordinary Newtonian gravity from a geometric perspective.

Scattering amplitudes have also been most urgently needed for experiments based on the so-called Standard Model of particle physics, a theory with gauge bosons, fermions, and a single scalar particle, the Higgs particle. Most prominent scattering processes relevant for the Large Hadron Collider (LHC) at CERN are known up to third order in perturbation theory, corresponding to what is known in the field as two-loop order. Current efforts of the particle theory group consist in extending this in several directions. First, it is widely believed that what is today called the Standard Model of particle physics is



only a small part of the full story, valid at the energies accessible today at the LHC. At higher energies new interactions are almost certain to emerge, hidden today by the large amount of energy required to see even small traces of them. Second, computations within the Standard Model must be pushed to high accuracy in order to match experimental precision. In the latter direction, the NBIA particle physics group has focused on the predictions for Higgs particle production at the LHC. A major direction of research in the particle physics group at the NBIA concerns the efficient computation of scattering amplitudes in quantum field theories in bigger generality. The immediate impact of this program is the availability of new methods that allow other groups to compute scattering amplitudes in the Standard Model to yet higher order. Moreover, the general development in just these years shows that the original methods for such computations (based on so-called Feynman diagrams) have become completely replaced by modern techniques that have allowed computations up to complexities that just a few years ago were thought impossible. This concerns both the number of particles in the final states of the processes, and the order in perturbation theory for a given fixed number of particles in the final states. The latter problem, the computation of scattering amplitudes at what is known as high loop order is generically a daunting task. Fundamental relationships among different parts of amplitudes that date back to first studies by Landau and, later, Steinmann, have been reanalyzed by the NBIA group in the light of modern mathematical developments. In another interesting development, intersection theory from mathematics has been demonstrated to yield unexpected new ways to simplify loop-order calculations by defining new and simplified ways to project loop integrals on suitable basis integrals.

Much progress in theoretical particle physics appears through first understanding the complexities in a theory similar to the Standard Model of particle physics, but with a large amount of so-called supersymmetry. The group at the NBIA has been very actively pursuing this program of high loop order calculations. Also the understanding of quantum field theories such as ABJM theory in three dimensions and spin matrix theory in four dimensions owes much to the high degree of supersymmetry. The discovery of a so-called antipodal self-duality relating form factors to scattering amplitudes is one of the highlights of the NBIA group this past year. Many surprises have thus appeared in the theory with large amount of supersymmetry, and they will surely leave their marks also on high loop-order calculations in the Standard Model of particle physics.

Particle Astrophysics

The research of the Particle Astrophysics Group lies at the rich interface between astrophysics, cosmology, and fundamental physics. We are particularly interested in exploring the Universe through cosmic rays (energetic charged particles), photons, neutrinos, and gravitational waves. The range of scientific questions that can be addressed with these cosmic messengers is quite broad.

A strong focus of our research lies on neutrinos. Neutrinos are weakly interacting elementary particles emitted from various terrestrial, astrophysical and cosmological sources over a wide energy range. We work to grasp the role of neutrinos in powering their sources, use them as powerful probes of the hidden source interiors, and seek to unveil the fundamental properties of neutrinos from investigating their interactions in dense environments, on cosmic backgrounds, as well as from their detection in neutrino telescopes.

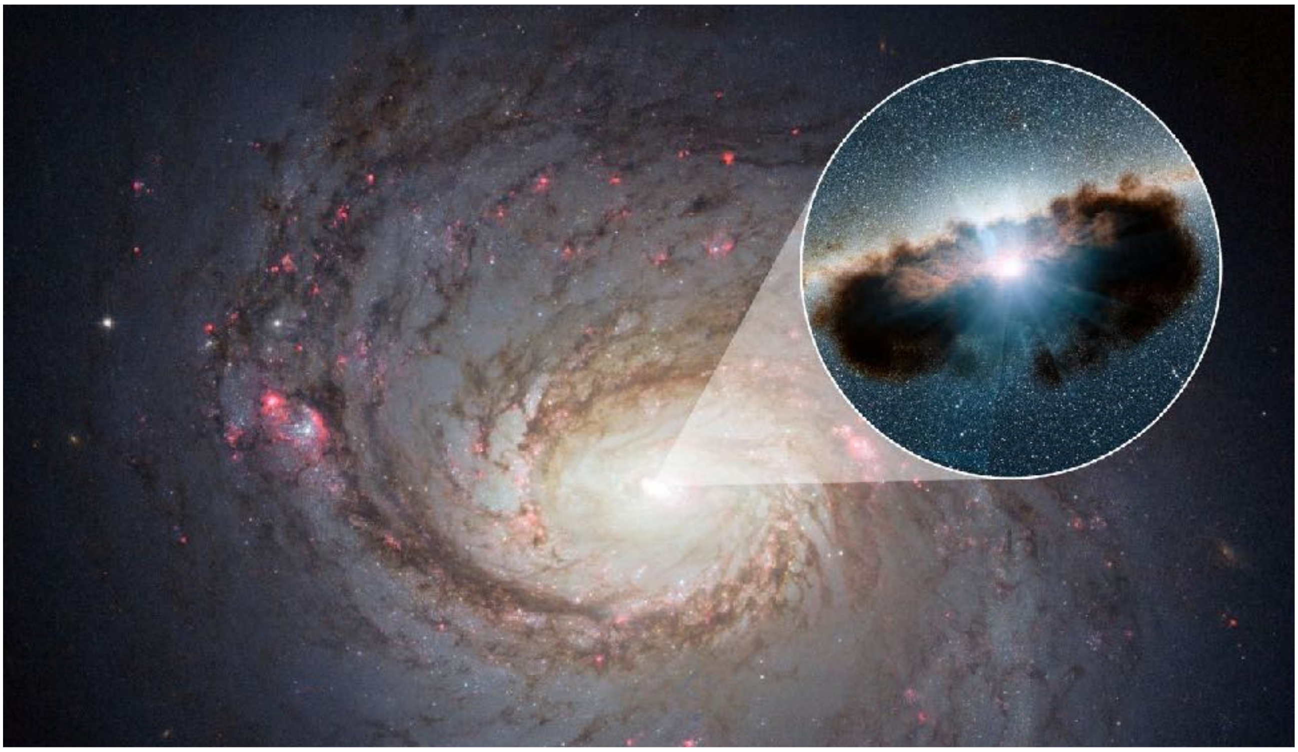
Presently, the most sensitive neutrino telescope in the TeV-PeV energy range is the IceCube observatory at the South Pole. Our group maintains a strong collaboration with the experimental IceCube group at NBI. In 2013, IceCube made the first observation of high-energy (TeV-PeV) neutrinos whose origin is presently unknown and one of the main scientific questions presently addressed in our research. This observation does not only probe the origin of cosmic rays, but also allows to test fundamental neutrino physics at extreme energy and distance scales, and probe the physics of extreme cosmic accelerators.

One of the most exciting results from IceCube in 2022 was the detection of the first steady-state source of high-energy astrophysical neutrinos, NGC 1068. This galaxy, located at 47 million light-years from Earth, hosts an active galactic nucleus that is able to generate neutrinos of up to several tens of TeV. NGC 1068 is only the second source of high-energy neutrinos discovered by IceCube, the first one being the transient emission from blazar TXS 0506+056 in 2017. Continued monitoring of NGC 1068 in the coming years will help to understand the mechanism by which it makes high-energy neutrinos, and how other sources might also make them.

In 2022, we have modeled the production of neutrinos in the gamma-ray bursts originating in the aftermath of the death of massive stars as supernova explosions. We have shown that it is crucial to understand the mechanism powering these energetic sources since, in contrast to the routinely observed electromagnetic radiation, the neutrino signal strongly depends on the mechanism powering the source. We have also found that much insight on electromagnetic features of these objects (such as jumps in their observed optical lightcurve), currently poorly understood, could be gained through neutrinos. With the advent of real-time neutrino astronomy, we have explored the exciting possible associations of neutrino events detected by IceCube with the electromagnetic emission from extreme astrophysical transients, such as the tidal disruption of a star in the proximity of a supermassive black hole or superluminous supernovae.

The astroparticle group is also working on understanding the origin of cosmic rays and mechanisms of cosmic ray transport in Galactic and extragalactic environments. We have been working on cosmic ray transport and acceleration associated with strong winds associated with star clusters, star-formation/starburst galaxies, and active galaxies. The multi-messenger emission in the form of gamma-rays and neutrinos allows to test these astrophysical model predictions with experimental data. We were also active in the analysis and interpretation of weak anisotropies in cosmic ray arrival directions.

One of the most burning questions in Particle Astrophysics today revolves around the role of neutrinos in compact astrophysical sources. In parti-



cular, the early universe, compact binary mergers, and core-collapse supernovae host a high density of neutrinos such that neutrino-neutrino interactions are not negligible. We have focused on understanding under which conditions such interactions could lead to non-negligible flavor conversions. Because of the complications intrinsic to the numerical modeling of this problem, we have also outlined a strategy to forecast the outcome of flavor mixing in dense source without solving the equations of motion numerically.

Neutrinos have been studied for a long time. However, some of their properties, e.g., their possible interactions beyond the ones foreseen by the Standard Model, remain to be unraveled. Our group has focused on modeling and constraining various scenarios of non-standard physics by employing neutrinos of astrophysical and cosmological origin. For example, we have worked on understanding how the physics of light sterile neutrinos in compact binary mergers. At higher neutrino energies, we have studied the prospects of using the relative number of each type of neutrino that arrives at Earth to test non-standard neutrino properties.

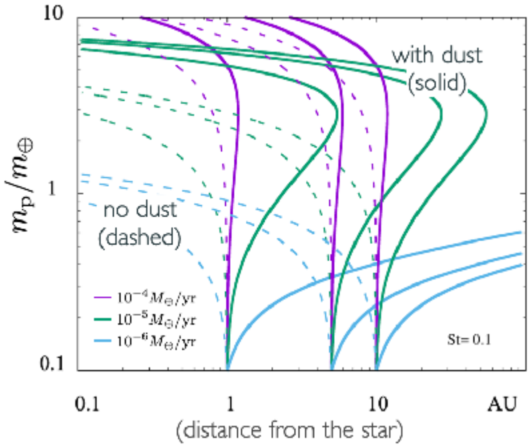
In 2022, scientists in our group have maintained strong ties with researchers at the Max Planck Institutes in Garching through the Collaborative Research Center sponsored by the Deutsche Forschungsgemeinschaft. We have also led part of the efforts of the Particle Physics Community Planning Exercise (“Snowmass”) organized by the American Physical Society. We have been active in a number of outreach activities, in particular through an ongoing research project at the interface between art and science, which has received the 2021 Vision Exhibition Award and will culminate through an art exhibition in summer 2023.

Members of our group joined forces in 2022 to organize the second edition of the NBIA International PhD Summer School on Neutrinos: "Here, There & Everywhere." This one-week school brought graduated students up to date with the latest developments in neutrino physics, from theoretical issues to experimental results, including astrophysical and cosmological aspects. The school was attended by about 65 PhD and advanced MSc students from Europe, North and South America, and Asia. Unlike 2021, when the school was fully virtual, the 2022 edition was held in person in Auditorium A (with a small number of online participants). Like before, the student and lecturer feedback was overwhelmingly positive and we are presently planing the next installment for 2023.

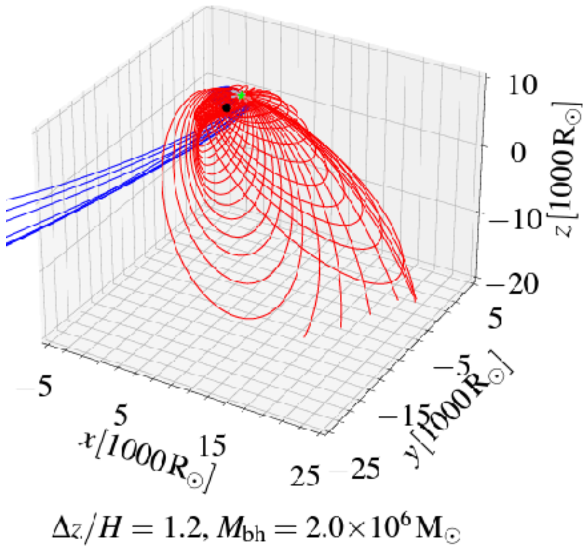
Theoretical Astrophysics

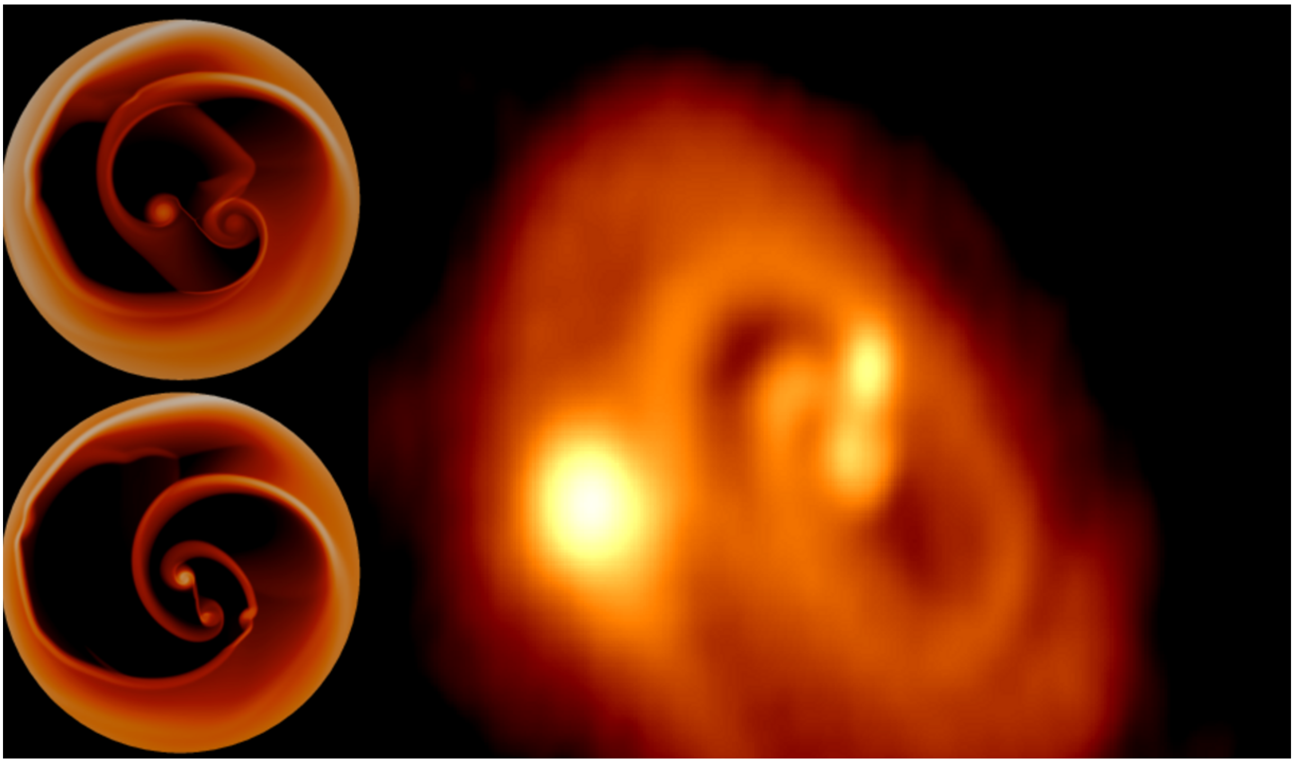
The Theoretical Astrophysics Group at the Niels Bohr International Academy strives for a comprehensive approach to astrophysics. Current research areas encompass protoplanetary disks and planet formation, black hole accretion disks, the physics of gravitational-wave sources, and tidal disruption events. All of these problems are tackled with a very wide perspective, ranging from fundamental theoretical aspects to state-of-the-art simulations that make it possible to link theory with observations.

The formation and evolution of planetary systems, including our own, remains a major open problem. Fast inward migration of planetary cores embedded in gaseous disks is a common problem in the current planet formation paradigm. Even though dust is ubiquitous in protoplanetary disks, its dynamical role in the migration history of planetary embryos has not been considered until recently. We have recently shown that the scattered pebble-flow induced by a low-mass planetary embryo leads to an asymmetric dust-density distribution that is able to exert a net torque. Building on the results of a large suite of numerical simulations for measuring this dust torque under a wide range of conditions, we have carried out the first study showing that dust torques can have a significant impact on the migration and formation history of planetary embryos.



Tidal disruption events occur when a star is disrupted by a supermassive black hole, resulting in an elongated stream of gas that partly falls back to pericenter. Due to apsidal precession, the returning stream may collide with itself, leading to a self-crossing shock that launches an outflow. If the black hole spins, this collision may additionally be affected by Lense-Thirring precession that can cause an offset between the two stream components. We study the impact of this effect on the outflow properties and found that as the offset increases, the outflow becomes less spherical and more collimated along the directions of the incoming streams. However, even the most grazing collisions we consider significantly affect the trajectories of the colliding gas, likely promoting subsequent strong interactions near the black hole and rapid disc formation. We find that even slowly spinning black holes can cause both strong and grazing collisions. We propose that the deviation from outflow sphericity may enhance the self-crossing shock luminosity due to a reduction of adiabatic losses, and cause significant variations of the efficiency at which X-ray radiation from the disc is reprocessed to the optical band depending on the viewing angle. These potentially observable features hold the promise of constraining the black hole spin from tidal disruption events.





Gravitational wave astrophysics has opened as a new branch in the Theoretical Astrophysics Group. Since the first pioneering gravitational wave observation in 2015 of two merging black holes, we have now seen ~90 stellar mass black hole mergers with many more to come in the near future. This has sparked a new research field with unique potential to gain insight into how black holes form, grow and interact over cosmic time. In the Theoretical Astrophysics group we are developing new ideas and computational tools for describing these processes over a wide range of black hole masses and astrophysical environments. We have committed special focus to the dynamical formation of the stellar mass black holes in dense star clusters and in active galactic nuclei. We are also working on the yet undetected mergers of supermassive black holes. Such events result from the pairings of black holes millions to billions of times more massive than our Sun in the center of galaxies. Detection of supermassive black hole mergers, expected in the coming decade, will offer the next great milestone in gravitational wave astrophysics, lending insight into the formation of the biggest black holes in our Universe, and their mutual evolution with their host galaxies. The Theoretical Astrophysics group is modeling the physical processes that bring these monstrous black holes together, specifically focusing on the interaction of these pairs with surrounding gas. This will help us to predict how often such mergers should happen and importantly what imprints of formation will be visible in the emitted gravitational waves, as well as through the electromagnetic emission that results from gas accretion onto the black holes. Ultimately, we aim to build a multi-messenger approach, providing predictions that combine both electromagnetic and gravitational wave observables into a tool kit that will help us to unravel the mysteries of black hole binary formation and merger from the smallest to the biggest black holes in our Universe.

Group members are also focusing on problems at the intersection between stellar dynamics and kinetic plasma theory, two fields that share much in terms of formalism and mathematical machinery, which makes an exchange of ideas particularly fruitful. A collaborative effort involving members from both NBIA and the Institute for Advanced Study in Princeton has demonstrated that the linear response of a stellar system is free of divergences as the system becomes unstable. Such divergences have previously been invoked to explain various physical phenomena. In light of this finding, many classical results in this field may need to be revised.

Condensed Matter Physics

The condensed matter theory group at NBIA aims at discovering new quantum phenomena and phases of matter. Our work is focused on the low-temperature physics of solid-state nanosystems, hybrid semiconducting-superconducting devices and topological materials. Our objective is to unveil the general quantum many-body aspects of their properties and dynamics, and to envision their application for quantum information technologies. We maintain close ties with experimentalists at the Center for Quantum Devices as well as other groups worldwide.

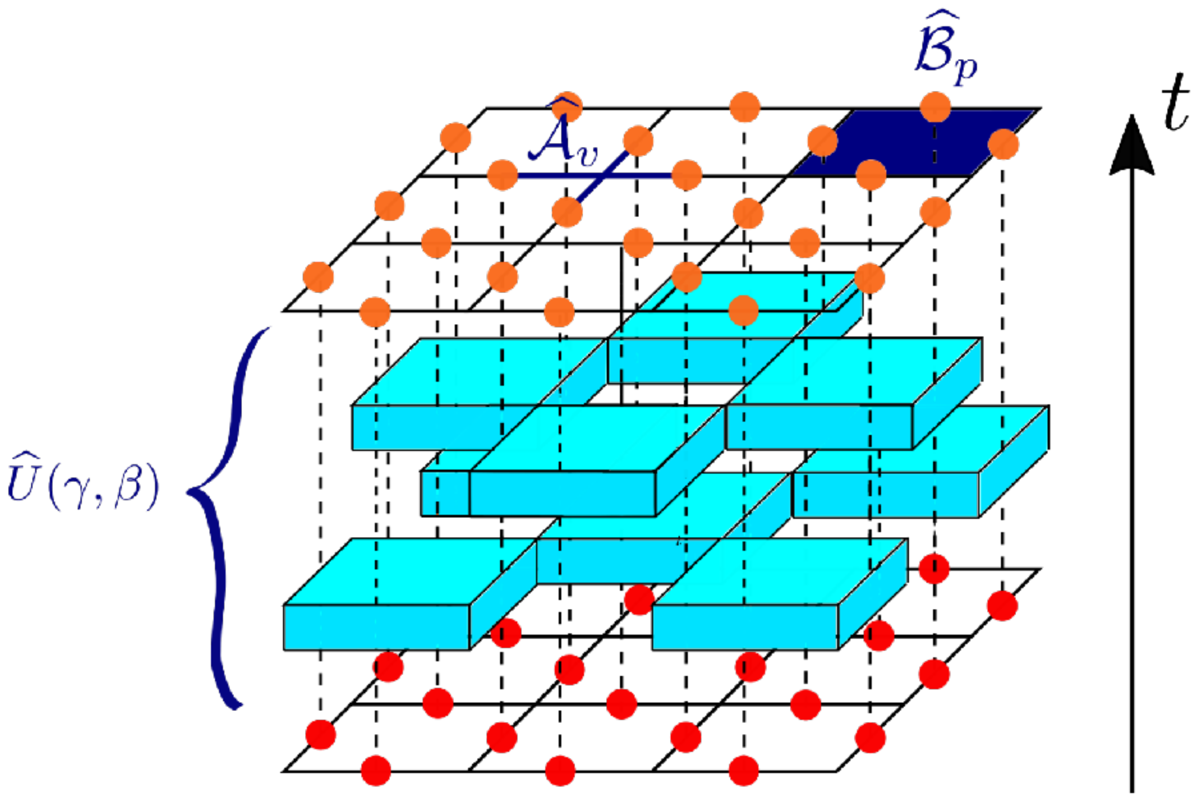
The study of condensed matter is at the core of the development of novel quantum devices. In the last years, small-scale quantum computers and other platforms for quantum simulations have become a reality, and the theory of many-body quantum systems provides the tools to describe, design and manipulate these physical platforms. Many research applications of current quantum technologies are inspired by open problems in this field, and many of the techniques to create stable and reliable quantum memories stem from achievements in condensed matter theory.

One of the most pervasive subjects in the field is the study of topological phenomena. These phenomena are peculiar due to their incredible robustness against perturbations, and provide intriguing possibilities for engineering quantum platforms protected against local noise and quantum algorithms for error correction.

A prominent example of the implications of topology in condensed matter setups is the quantized Hall effect: when a two-dimensional electron system (as found in common semiconductor heterostructures, or graphene) is subjected to a strong magnetic field, the system's Hall conductance acquires a precisely quantized value, equal to an integer or a simple rational fraction times a combination of fundamental constants (the electron charge and Planck's constant). What is so amazing about this phenomenon is that the quantization of this macroscopically measurable quantity is accurate to better than one part in one billion, independent of sample size and shape, as well as material composition, and survives in the presence of all of the "dirt" that inevitably permeates real-world solid state devices. Due to the exquisite precision of this effect, the quantized Hall conductance is now used as a measurement standard for the definition of resistance.

From a fundamental point of view, the robustness of the quantized Hall effect arises from the beautiful mathematical (topological) structure of the quantum mechanical wave function of the electrons in the system. This theoretical realization spurred a worldwide effort to seek out additional types of robust phenomena that could support a similar level of "topological protection." Intriguingly, when realized in one- or two-dimensional materials, topological systems are predicted to host exotic new types of emergent particles, with peculiar properties that have no analogues in the familiar world of the "usual" fundamental particles living in our full three-dimensional universe. These properties constitute the basis for powerful and fault-tolerant architectures for quantum computing, currently at the center of the experimental activities of many groups worldwide. Seeking means to realize the quantum states necessary for observing the emergence of these new particles comprises an important piece of our research at NBIA. Toward this end, we are developing new paradigms for obtaining topological states, observing them in experiments and studying their dynamics. Our research is built on a combination of analytical work and numerical simulations that allow us to explore regimes beyond where analytical techniques can be applied.

Quantum simulations of the dynamics of manybody systems



The study of quantum many-body systems is indeed a very challenging field and the condensed matter theory group at NBIA is pioneering the use of novel numerical techniques for advancing the science of our field. This is a multi-pronged effort which includes the application of machine learning and tensor networks for the study of many-body systems. On one side, we are exploring how learning machines can assist in the design of new quantum information processing protocols, as well as in the efficient simulation of quantum dynamics. In this respect, we are working closely with experimentalists at the Center for Quantum Devices to develop machine learning based techniques for quantum experiments. On the other side, we are developing tools based on tensor networks for the simulation of devices in which the electron interactions play a crucial role, including several platforms for the experimental observation of topological phenomena.

Machine learning based techniques allow for enhanced measurement and data processing capabilities, as well as for automatic tuning of quantum platforms. Both of these are especially relevant for the development of near term quantum devices. The former enables real-time feedback for manipulating the quantum state, by improving the readout accuracy and speed. The latter enables tuning of devices with a multitude of parameters that all depend on each other in a complex way. Manually tuning large and dependent sets of parameters becomes tedious if not impossible ó already for near term quantum devices.

We also use other concepts coming from machine learning to investigate more fundamental questions, such as whether artificially intelligent (AI) agents can learn to harness quantum resources. This can come in the form of AI agents learning to do quantum cryptography, or in the form of AI agents learning to control quantum systems using (weak) measurements.

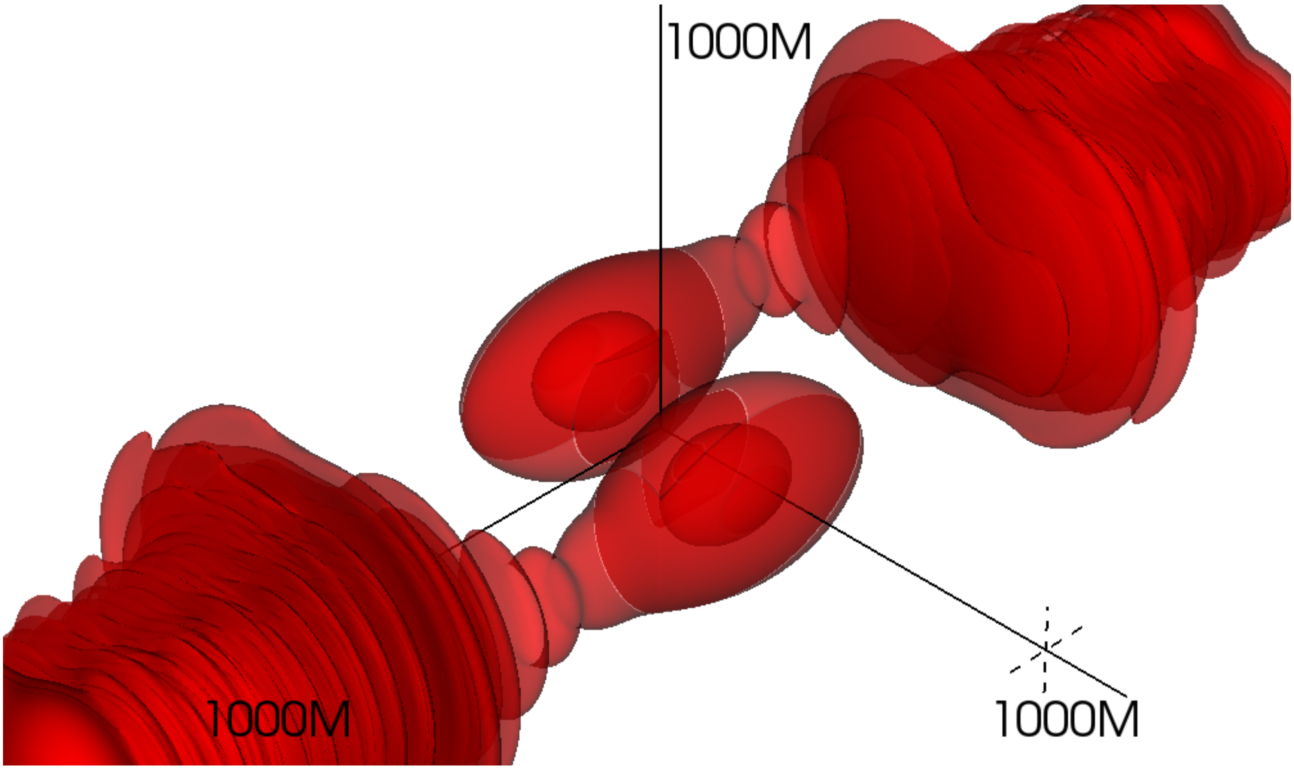
Gravitational Physics

The Strong group at the NBIA studies fundamental questions, which relate to gravity in mostly unexplored regimes. We want to shine light on the biggest unknowns in the cosmos: is gravity described by Einstein's theory? Do black holes exist? What happened at the beginning of the Universe? Can we use black holes as probes of other interactions? To realize the tremendous underlying discovery potential, we combine unique know-how in theory together with observations.

Our ability to understand gravity is at a turning point. Increasingly precise LIGO/Virgo gravitational-wave observations and imaging of black hole shadows by long-baseline radio interferometry opened unprecedented windows onto gravity at its strongest. The decision of the European Space Agency to devote its third large-class mission to a gravitational-wave observatory (LISA) highlights the timeliness and relevance of the topic. During the next few years, we expect to observe hundreds of black-hole mergers from operating detectors worldwide. Strong-field gravity is expanding beyond the domain of mathematical physics to become a precision experimental science. Black holes are the simplest, most compact, and physically elusive macroscopic objects in the Universe, playing a central role in this new era. Among astronomical targets, they are extraordinary in their ability to convert energy into radiation, and the study of their stability and dynamics challenges our knowledge of partial differential equations and of numerical methods. Meanwhile, the information paradox and the existence of unresolved singularities in classical general relativity point to deep inconsistencies in our current understanding of gravity and quantum mechanics. It is clear that the main conceptual problems in black hole physics hold the key to many fundamental issues in physics.

One of the holy grails of gravitational-wave astronomy is to provide observational evidence for the general relativistic prediction that black holes in our universe belong to the Kerr family. An exciting tool to address this issue is *black hole spectroscopy*, introduced and led by the Strong team, and explored by a wide community worldwide. Here, black hole vibration spectra are used to infer its properties, relying on uniqueness results of General Relativity and the ensuing simplicity of vacuum black holes. We pioneered innovative analysis techniques rigorously incorporating statistical and systematic uncertainties, included nonlinearities as well as predictions of theories that extend General Relativity. Gravitational waves are direct probes of gravity down to the horizon scale and can also shed light on one of the outstanding open issues in physics: the nature of compact, dark objects. It has been tacitly assumed that these are black holes, but several arguments suggest that new physics might set in during gravitational collapse. Large efforts of our group are devoted to the challenge of quantifying the presence of horizons in spacetime. These efforts have shown that gravitational waves have the potential to inform us on the nature of compact objects (do black holes exist?) and on the strong-field behavior of gravity (do they behave as in General Relativity?). One of the unexpected findings by our team concerns the sensitivity of the spacetime response to fluctuations close to resonances, and the instability of the spectrum itself under small perturbations of the scattering potentials. Because astrophysical black holes are not isolated, this question is of paramount importance, as it may have an impact across disciplines.

A complementary opportunity to probe the nature of black holes and their dynamics is offered by gravitational waves produced by small black holes orbiting massive ones. The small black hole acts as a sensitive probe mapping the geometry of the massive one (and possibly its environment), providing unequaled measurements of its properties as predicted by General Relativity.



We have world-leading expertise in the modeling of such extreme mass-ratio inspirals as a perturbative series in the smaller mass, i.e., the gravitational self-force formalism.

With precise tests of the black hole geometry under control with spectroscopy, one needs to step away from the vacuum paradigm. There is overwhelming evidence for the existence of dark matter interacting gravitationally. Understanding its microscopic nature is arguably one of the outstanding challenges. The Strong team at NBIA is a well-known leader in the study of the gravitational physics of new fundamental fields. We showed that massive bosons outside black holes lead to smoking-gun effects (superradiant instabilities and floating orbits), allowing new competitive constraints on their masses and couplings.

In addition to encoding details about their sources, gravitational waves carry precious information about their astrophysical environments. It is hard to overstate the role of black holes in the search for new fields or environmental properties. However, to realize the immense potential of gravitational-wave astronomy, it is imperative to model accurately the interaction with matter. For example, to quantify the impact of an entire galaxy on the propagation of gravitational waves, one needs to model accurately the geometry, and to solve the dynamics of the binary in this complex environment.

As the sensitivity of detectors improves, more distant black holes will be observed. Inevitably, along the billions of years of travel, gravitational waves will encounter inhomogeneities, in the form of galaxies at the largest scales or compact objects at the smallest scales. Lensing of gravitational waves opens unique frontiers to understand the foundations of our Universe. It allows us to map the dark matter distribution in uncharted regions of the cosmos, and it offers a precise gravity laboratory, where gravitational fields can be constrained to their limits. The Strong group leads the search for lensed waves and their implications for fundamental physics.

We are exploring foundational issues, deepening our understanding of matter and of gravitation as a fundamental interaction. Wherever possible, we will confront our predictions with gravitational waves and other observational data, addressing critical problems: how can we use current and future gravitational-wave data to test fundamental physics? How can we optimally design next-generation detectors to probe the nature of black holes? The road ahead is challenging, but exciting.

Soft Matter Physics & Active Matter

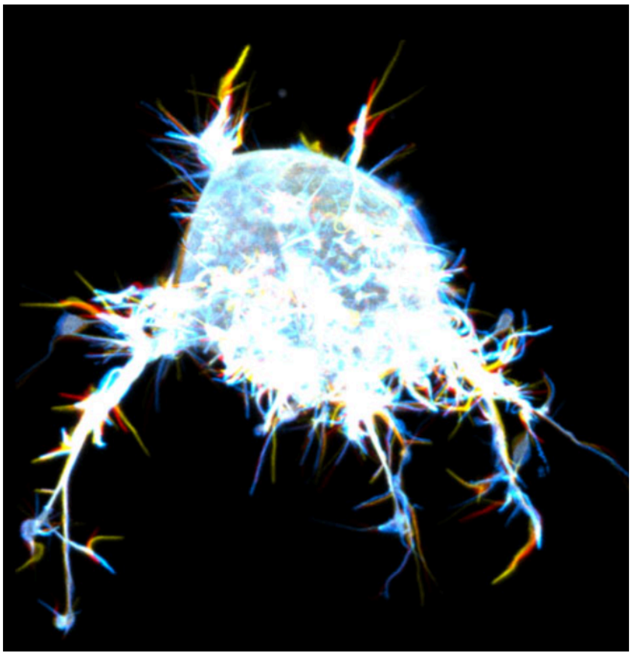
Soft matter physics lies at the heart of a quantitative understanding of many biological processes. From subcellular protein-driven flows to multicellular organ formation, biological matter continuously drives itself away from thermodynamic equilibrium using internal biochemical processes. In addition to their important biological roles, these intrinsically multiscale systems provide novel ideas for fundamental theories of non-equilibrium statistical physics and biomimetic inspiration for synthetic micro-machines capable of locomotion and self-organization. To tackle these diverse subjects, NBIA has recently launched an exciting new initiative to expand into soft matter physics and in particular the hot topic of active, self-organizing matter. Specifically, the research is focused on several fundamentally important areas in biophysics:

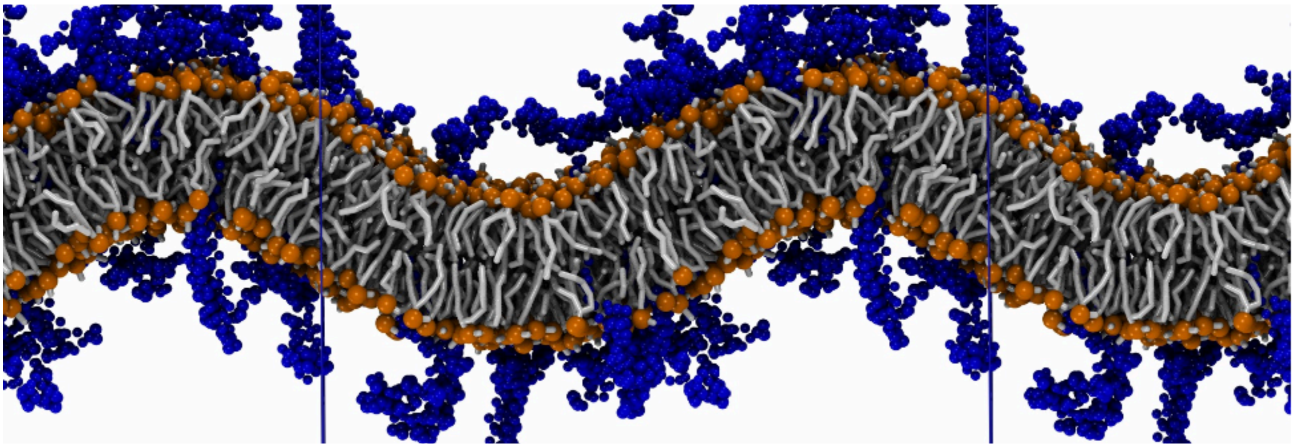
Bioinspired, Self-Organizing Active Matter — A material that organizes itself? Odd as this might sound, nature has found ways to make it happen: bacterial colonies, cellular tissues, and filaments inside living cells, all work as engines converting the chemical energy of their environment into motion, and are classified as "active materials". The unifying feature of active materials is the continuous conversion of chemical energy to motion by individual particles, and the ability to create motion on scales that are significantly larger than the size of an individual. This swarm-like behavior is termed collective motion: simple building blocks organize into moving structures that are often complex and chaotic.

Under the right conditions, active systems are capable of self-organization from chaotic flows into coherent flows: groups of active particles move together as a unit in a directed manner, forming a self-pumping fluid. However, the exact nature of these 'right conditions' is currently the focus of intense study as many biological processes - including subcellular flows, formation of bacterial biofilms, morphogenesis, and collective tumor invasion – demonstrate active coherent flows. An outstanding question is how the activity of particles at the individual particle level is translated into self-sustained coherent flows.

The core idea is to design a novel class of Living Matter (as seen in the next page), comprised of a viscoelastic and adaptive phase freely embedded within spontaneously flowing biofluids. Funded by a Villum Young Investigator Award and Novo Nordisk's New Exploratory Research and Discovery (NERD) programme together with two Marie-Curie Fellowships awarded to Active & Intelligent Matter research group members, we have launched the development of a state-of-the-art modeling framework that combines artificial intelligence, with physical modelling of active matter, and mathematical modeling of complaint materials, to study the interaction of active matter with adaptable and responsive environments.

Mechanotransduction: How Mechanics Guides Biochemical Signaling — There is growing evidence that mechanical forces can activate biochemical signaling for tissue regeneration, stem cell differentiation, and morphogenesis. Importantly disruption of this effect by changes in the





microenvironment leads to pathological responses including tissue fibrosis and cancer. The connection between mechanical forces and cell response is the process of mechanotransduction: mechanical forces activate biochemical signals by changing the concentration of mechanosensing proteins inside the cells. For example, putting cells under excessive tension localizes proteins that control cell division inside cell nuclei, leading to hyper-proliferation. Diffusion of chemical signals is too slow to be able to convey the mechanical information across the tissue. On the contrary, the force transmission between the cells provides a fast and long-range mechanism for propagation of mechanical cues over large spatial scales. Therefore, it is essential to understand the mechanism of mechanotransduction in the context of multicellular aggregates.

Starting in September 2022, and funded by an ERC Starting Grant, the Active & Intelligent Matter Research Group combines multiscale modeling, discrete and continuum simulations of cell mechanics, with in-house experiments to reveal the impact of mechanical forces from multicellular motion on signaling and the mechanical feedback from the activation of biochemical signaling.

Thermodynamics in Biology — Currently, one main research interest in the group is on how thermodynamics puts constraints on biological processes. More specifically, the focus is on questions such as to what extend are biological processes, such as DNA replication, optimised, which role does thermodynamics play in biological evolution, and what are the thermodynamic constraints necessary to create non-equilibrium phenomena, such as chemical oscillations and motility-induced phase-separation. We also study the stochastic thermodynamics of synthetic biological circuits. Over the last two decades synthetic biology has lead to important applications s uch as drug delivery and biosensors. By creating a consistent framework for the thermodynamics of these circuits, we aim to propose new optimisation schemes and design principles for future a pplications.

Computational Microscopy — We develop and use computational microscopes to understand fundamental biological processes at the cellular level. For instance, how cells repair their membranes after injury or how toxic particles hijack cellular machinery for their entry. These mechanisms include many exciting physical phenomena such as fluctuations induced forces, phase transition, phase coexistence, and molecular condensations. Our latest works include obtaining the molecular architecture of SARS-CoV-2 virion envelope through integrative modeling techniques and the design of a division machine for a synthetic cell. Our current focus is to understand how biomolecules come together and form the architecture of the cellular powerhouse.

Finally, links with experiments are important in conducting this research. We have launched exciting collaborations with international experimental groups in France (University Paris Diderot) and Japan (Osaka University), as well as with the Novo Nordisk Foundation Center for Stem Cell Medicine to profile NBIA as one of the leading institutions in these rapidly growing areas of research.


NIELS BOHR INSTITUTET
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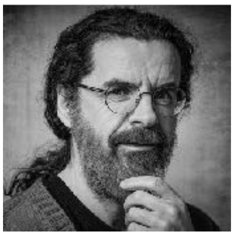
NBIA Staff

Faculty

Niels Emil J. Bjerrum-Bohr completed his Ph.D. in Copenhagen in 2004. He was a 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 - 2009. 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. He is currently a Lundbeck Foundation Junior Group Leader and Associate Professor at the NBIA. Emil's current research focuses on amplitudes in Yang-Mills theory and quantum gravity.

Jacob Bourjaily joined NBIA as Assistant Professor in 2014 and became Associate Professor in 2019. 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 2011-2014 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.



Vitor Cardoso did his PhD in Técnico Lisbon in 2003. He held research positions in Coimbra, WashU-Saint Louis, Oxford MS. Professor of Physics at Técnico since 2016, he was a Fellow at Amsterdam, Belém do Pará, CERN, Perimeter Institute, Rome and Waseda University. He joined NBIA in 2022, as a Villum Fonden Investigator and DNRF Chair and leader of the Strong team. His research interests are mainly focused on strong-gravity problems, with implications for gravitational-wave and black-hole physics, high-energy and particle physics. He is co-author of one book and of over 200 scientific papers. He is a member of the Lisbon Academy of Sciences. His research was recognized by the European Research Council, with three prestigious ERC Grants. He was awarded the "Ordem de Sant'Iago da Espada" presidential title, for contributions to science and is an "Honourable Citizen" of Póvoa de Varzim.

Matthias Christandl is a Professor at the Department of Mathematical Sciences in Copenhagen. His 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 - 2014 he was assistant professor at ETH Zurich. He moved to the University of Copenhagen in April 2014.

Faculty

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 electroweak baryogenesis from the Large Hadron Collider (LHC).

Troels Harmark is Associate Professor at NBIA. He received his PhD from NBI in 2001 and became postdoc at Harvard University with Andrew Strominger. He received grants from DFF and Carlsberg to work as researcher at NBI and subsequently an assistant professorship at Nordita in 2009. Since 2012 he has been at NBI, becoming permanent in 2015. From 2017 he held the large project grant from DFF (together with N. Obers). He has led the Theoretical High Energy, Astroparticle and Gravitational Physics section since 2018. His current research includes astrophysical applications of general relativity, such as magnetospheres of black holes and tidal forces on binary systems, as well as non-relativistic limits of the holographic principle and string theory.

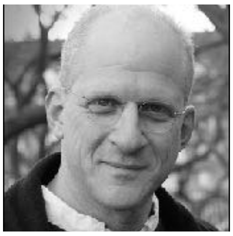
Tobias Heinemann joined NBIA as an Associate Professor after postdoctoral appointments at the IAS in Princeton, at the University of California at UC Berkeley, and at the Kavli Institute for Theoretical Physics in Santa Barbara. His research interests span a wide spectrum of problems in astrophysical fluid dynamics and magnetohydrodynamics. In recent years his research has focused increasingly on the intersection between stellar dynamics and kinetic plasma theory, two fields that share much in terms of formalism and mathematical machinery, which makes an exchange of ideas particularly fruitful. Together with Chris Hamilton (IAS) he has recently demonstrated that the linear response of a stellar system is free of divergences as the system becomes unstable. Such divergences have previously been invoked to explain various physical phenomena.

Andrew Jackson is Professor 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.

Faculty

Charlotte Fløe Kristjansen got her PhD from NBI and afterwards held postdoc positions at IPhT Saclay, Nordita and NBI where she became Associate Prof. in 2006 and Professor in 2011. She had long term visiting positions at Tokyo Institute of Technology and at the MPI for gravitational physics in Potsdam. Charlotte's research interests are centered around exact solutions to problems in quantum field theory and string theory. She is currently working on defect conformal field theories with holographic duals. Other key interests are integrability in the AdS/CFT correspondence, spin chains and graphene. Earlier she has worked on discrete models of quantum gravity and on random matrices. She has been a member of the national research council for six years.

D. Jason Koskinen is an Associate 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.



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 — and acting Chair of the International Advisory Board starting in 2021. Marcus' research interests involve 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.

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 in 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.

Niels Obers is Professor at NBIA. He did is undergraduate studies at Nijmegen University and received his PhD degree from the University of California, Berkeley in 1991. He subsequently held postdoctoral positions at Bonn, Ecole Polytechnique, CERN and Nordita. During 2000-2002 he was an assistant professor at Utrecht University and moved in 2002 to NBI for an associate professor position, becoming full professor in 2012. From 2012-2018 he was deputy head of departement as well as acting head of department for a period in 2017. He has done research on conformal field theory, non-perturbative string dualiies and the dynamics of higher-dimensional black holes and branes. Recently he has been developing non-relativistic gravity, string theory and holography using non-Lorentzian geometries.

Marta Orselli is an Associate Professor in Theoretical Physics at the University of Perugia (Italy) and, since 2015, Affiliated Associate Professor at the Niels Bohr Institute. She received her PhD in 2003 from the University of Parma (Italy) and, after a postdoc at the University of Perugia, in 2005 Marta moved to Nordita with a Marie Curie fellowship. Among the various grants, she has been awarded a grant from the Carlsberg Foundation, the European ERG grant and a STENO grant from the Danish Research Council. Marta's current research interests focus on black holes, General Relativity and gravitational waves. Since 2020 she has been a member of the LIGO-Virgo-KAGRA collaboration and in 2022 she joined the Einstein Telescope collaboration.

Martin Pessah obtained his first degree in Astronomy in 2000 from the University of La Plata, Argentina. He received his PhD in Theoretical Astro-physics 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 astrophysical fluid dynamics and magnetohydrodynamics, including fundamental aspects of accretion physics in young stars and black holes, the interstellar medium, and galaxy clusters.

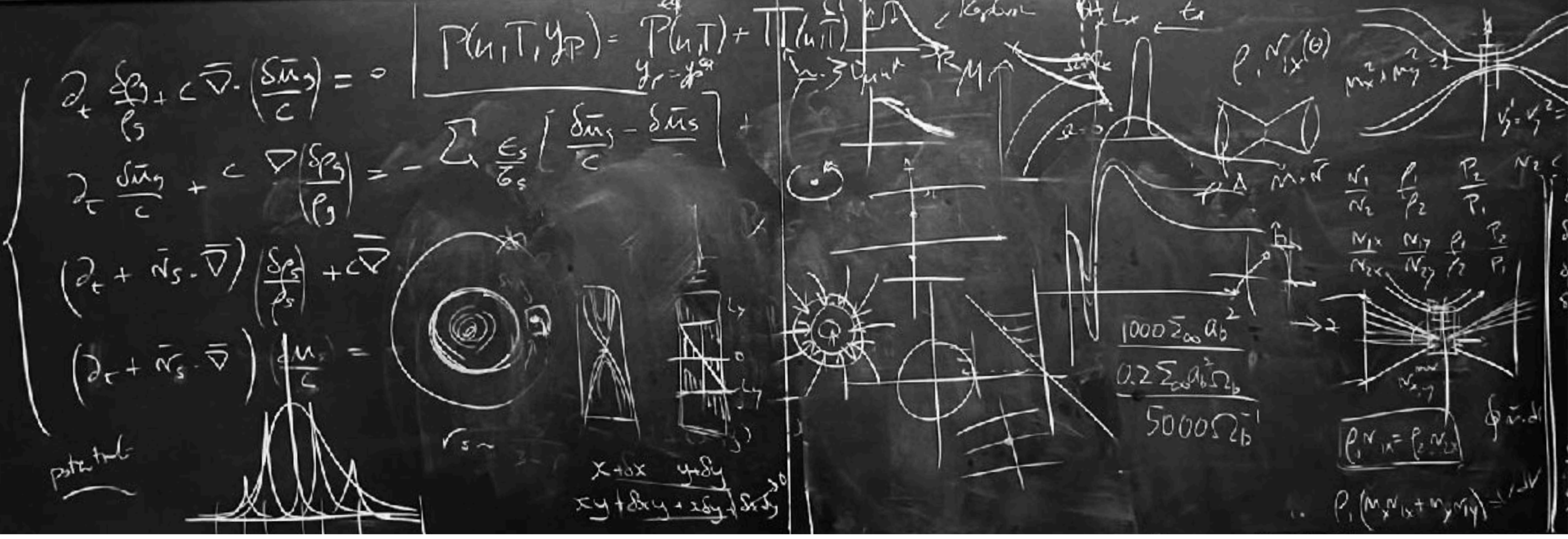
Christopher Pethick is Professor at NBIA. He did his undergraduate and graduate studies at Oxford, and received his D. Phil degree in 1965. After a period as a postdoc at the University of Illinois, he joined the teaching faculty there, be-coming full professor in 1973. In that year he also became a 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 neutron stars (especially the properties of their outer layers), and ultracold atomic gases.

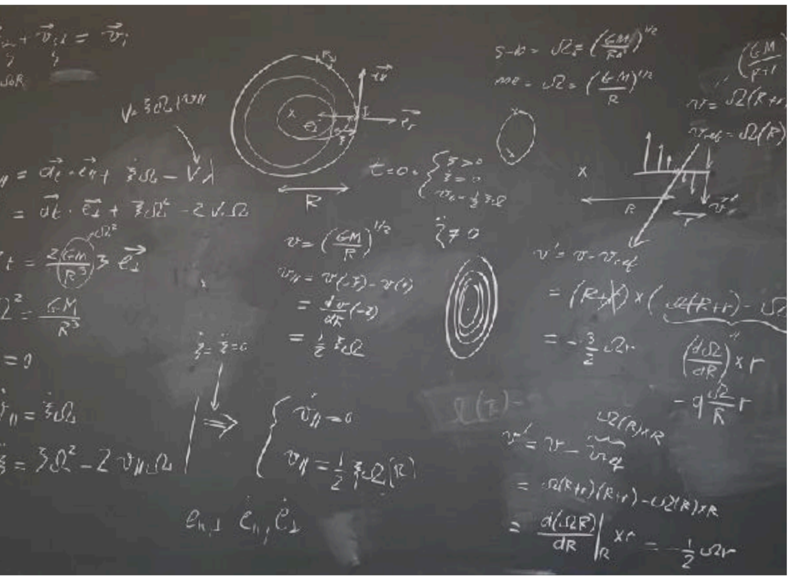
Faculty

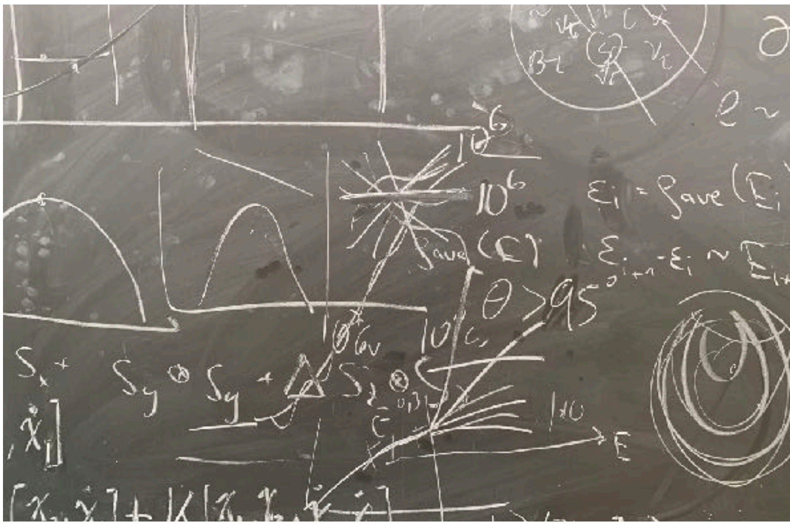
Jan Philip Solovej did his undergraduate studies in Copenhagen and his PhD in mathematics at Princeton in 1989. He was then a postdoc at University of Michigan, University of Toronto, and IAS Princeton before becoming Assistant Professorship at Princeton University 1991-1995. In 1995 he became a research professor at Aarhus University and in 1997 he became a full professor at the Mathematics Department in Copenhagen. He works in mathematical physics and in particular quantum physics. His current research interests include systems such as atoms, molecules, and gases of fermions and bosons. His research addresses issues such as stability of matter, superconductivity and -fluidity, and quantum information theory. He currently leads the Centre for the Mathematics of Quantum Theory (QMATH) in the Department for Mathematical Sciences.

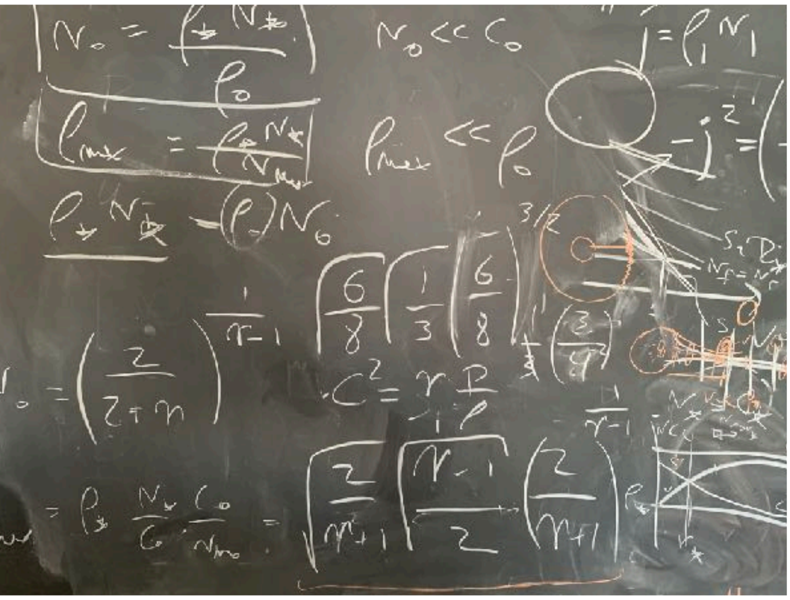
Irene Tamborra is Professor and leader of the AstroNu group. Irene obtained her PhD at the University of Bari in 2011. Before joining the Niels Bohr Institute in January 2016, Irene has held research appointments at the Max Planck for Physics in Munich, as the Alexander von Humboldt Fellow, and at GRAPPA, Center of Excellence of the University of Amsterdam. Irene's research activity is in the area of theoretical particle astrophysics and astrophysics. In particular, Irene is interested in exploring the role of weakly interacting particles, such as the neutrino, in astrophysics and cosmology. Within a multi-messenger framework, she also aims at unveiling what can be learnt by adopting neutrinos as probes of extreme astrophysical sites not otherwise accessible.

Konstantin Zarembo received his PhD from the Steklov Mathematical Institute in Moscow in 1997. After that he worked at UBC in Vancouver, Uppsala University and École Normale Supérieure in Paris. He became a Nordita Professor in 2010 and holds a joint appointment between NBI and Nordita since 2019. Konstantin's field of research is theoretical high-energy physics, with main interests in quantum field theory, string theory and integrable systems. He pioneered the use of integrability and the Bethe ansatz in the AdS/CFT correspondence, which gave rise to new nonperturbative methods in quantum field theory. He has also worked on various aspects of string theory, statistical mechanics, and mathematical physics.







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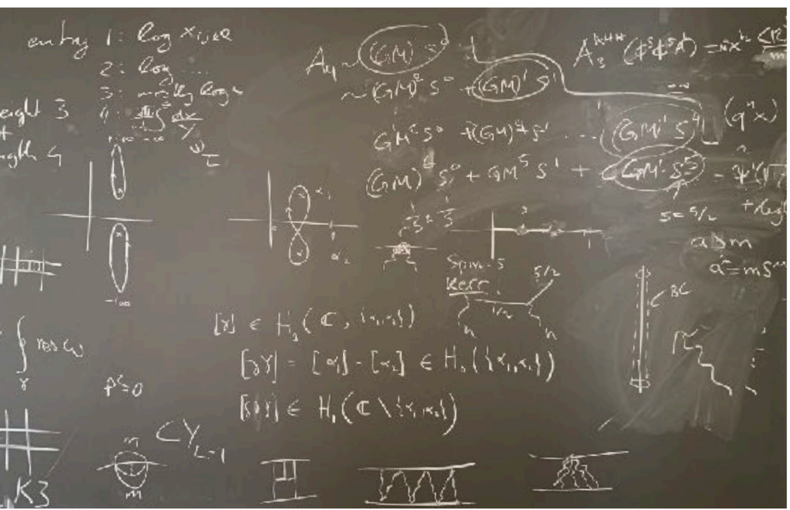
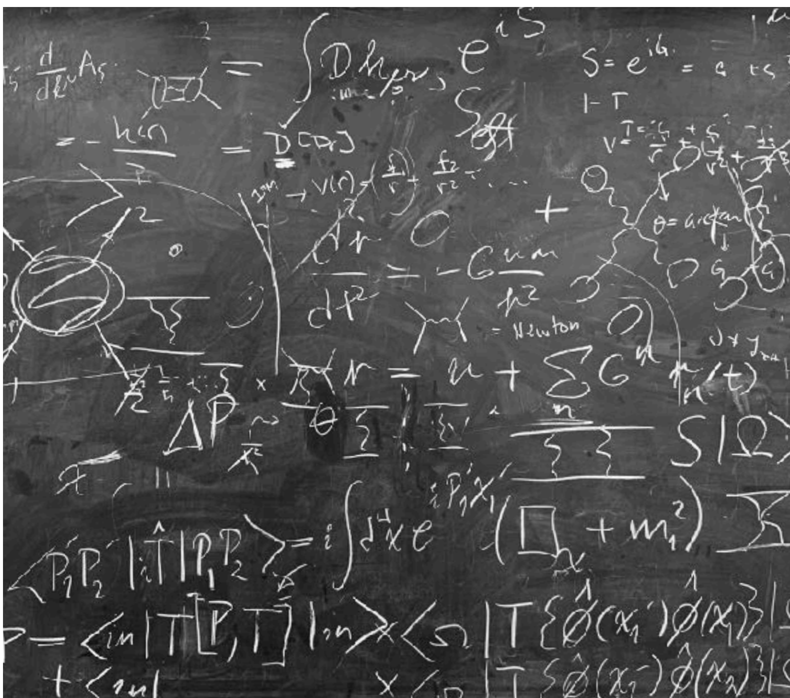




Junior Faculty

Markus Ahlers received his Ph.D. in Theoretical Particle Physics from the University of Hamburg (DESY) in 2007. He has been a Postdoc in Oxford and Stony Brook before becoming a John Bahcall Fellow for Neutrino Astronomy at the University of Wisconsin-Madison. He joined NBIA in 2017 as an Assistant Professor. Markus research focus is centered on astroparticle physics. He studies the origin and transport of cosmic rays, the associated emission in gamma rays and neutrinos as well as beyond-the-SM probes by cosmic messengers. He has been a member of the IceCube Collaboration since 2007.

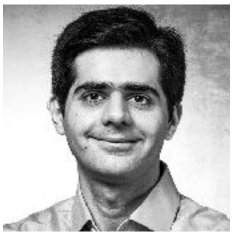
Pablo Benitez-Llambay received his Ph.D. at the University of Cordoba, Argentina, and moved to the NBIA as a postdoc in 2016. One year later, he was granted a Marie Curie Fellowship to extend his studies about planet and disk dynamics. Currently, Pablo is an Assistant Professor at the NBIA. Pablo's research focuses on studying the dynamics of multi-species protoplanetary disks linked to the formation and evolution of planetary systems. He is particularly interested in planet-disk interaction, gas/dust dynamics, disk instabilities, and high-performance computing. In 2022, Pablo became assistant professor at Universidad Adolfo Ibáñez in Chile.

Berislav Buca has joined NBIA in November 2022 as an Assistant Professor on a Villum Young Investigator grant. His field of research is theoretical physics of non-equilibrium quantum many-body systems. Berislav obtained his PhD (2015) at the University of Ljubljana discovering 'weak' and 'strong' symmetries in open quantum systems. During his postdoc (2017-2022) at Oxford University he discovered a novel algebraic principle determining the dynamics of quantum many-body-systems out-of-equilibrium. He lectured for Keble College Oxford and remains a visitor at Oxford. At NBIA Berislav will study exact solutions of dynamics in quantum many-body systems. This will enable discovery of novel kinds of phases of quantum matter out-of-equilibrium, which have not been theoretically accessible before.

Michele Burrello joined NBIA in 2016 and is Associate Professor in condensed matter theory. He completed his Ph.D. in statistical physics at SISSA (Trieste) in 2011, and worked as a postdoc in Leiden and at the Max Planck Institute for Quantum Optics. Since 2019 he has been leading the NBIA research group on topological phases of matter thanks to the generous support of the Villum Foundation. Michele's research focuses on the study of topological phenomena in many-body systems. He aims at applying their emergent and exotic properties to novel quantum technologies and platforms for quantum computation. Michele works on different low-temperature setups, including ultracold atoms and superconducting devices, and he is interested in the common theoretical frameworks underlying such diverse systems.

Junior Faculty

Mauricio Bustamante is an Assistant Professor at the NBIA. He completed his PhD at the University of Würzburg and DESY in 2014. Following that, he was a postdoc at the Center for Cosmology and AstroParticle Physics (CCAPP) of The Ohio State University before joining the Niels Bohr Institute in 2017. His research is in the field of astroparticle physics, with a focus on high-energy astrophysical neutrinos and ultra-high-energy cosmic rays. He is interested in two open issues with far-reaching implications in astrophysics and physics: what are the sources of high-energy cosmic rays, neutrinos, light, and gravitational waves — and how are these connected — and what can we learn about fundamental particle physics from astrophysical messengers with energies far above those achievable in the lab.



Amin Doostmohammadi is a Novo Nordisk Foundation Assistant Professor at the NBIA. He also has a cross-appointment as Specially Appointed Assistant Professor at Bioengineering in Osaka University, Japan. Amin received his PhD from the University of Notre Dame, followed by a postdoc in Oxford University and held a prestigious Royal 1851 Research Fellowship at Oxford before joining NBIA. Amin is leading the Active Intelligent Matter research group that works at the interface between physics and biology, modeling active materials as diverse as bacterial colonies, molecular motors and cellular tissues. In particular, their recent finding of the correlation between topological defects in tissues and the sites for cell death is a page-turner for the field of tissue biology, challenging the consensus, and bring physics of liquid crystals into studying diverse biological problems. Currently, the research at Amin's group enjoys generous support from Novo Nordisk Foundation and Villum Foundation and an ERC Starting Grant.

Jose M. Ezquiaga joined NBIA as an Assistant Professor in 2022. Previously, he was a NASA Einstein Fellow at the University of Chicago. He obtained his PhD from Universidad Autonoma de Madrid in 2019. Jose exploits gravitational-wave data to explore uncharted regions of the Universe. His research lies at the intersection of fundamental physics, cosmology and astrophysics and aims at probing gravity and unveiling the nature of dark energy and dark matter. Jose is member of international collaborations such as LIGO, LISA and Cosmic Explorer.

Zhengwen Liu received his Doctorate from the Université catholique de Louvain in 2019. Before joining the NBIA as an assistant professor in the fall of 2022, Zhengwen was a postdoctoral fellow at the DESY in Hamburg. He is interested in understanding the fundamental interactions in nature, with a particular focus on scattering amplitudes and Feynman integrals in quantum field theory, ranging from their mathematical structures to their applications to collider physics and gravitational-wave observations. He currently works on developing novel computational methods to solve the gravitational two-body problem by importing cutting-edge techniques from high energy physics and mathematics, including effective field theory and iterated integrals.

Junior Faculty

Andres Luna completed his education in Mexico City and then earned his PhD at the University of Glasgow in 2018. He held a postdoctoral position in the Mani L. Bhaumik Institute for Theoretical Physics at UCLA before joining the NBIA as an assistant professor in 2021. His research interests lie at the interface between gravitation and scattering amplitudes in Quantum Field Theory. He is currently working on the generalization of the double copy to black holes and other interesting classical solutions in General Relativity, as well as in the application of these, and other modern scattering amplitudes techniques to the description of the dynamics of binary black holes and its application to the burgeoning field of gravitational-wave physics.

Daniel D'Orazio is a DFF Sapere Aude Research Leader and Assistant Professor at the NBIA. After a Fulbright Fellowship at the University of Zürich, Daniel completed his PhD in 2016 as an NSF Graduate Research Fellow at Columbia University. Before joining the NBIA in 2020 he was a NASA Einstein Fellow and an Institute for Theory and Computation Fellow at Harvard University. Daniel's research lies at the interface of theory and observation and spans a wide range of topics in high energy astrophysics. His primary interests lie in harnessing tools of the burgeoning era of multimessenger astronomy for uncovering the origin of compact-object-binary sources of gravitational radiation, spanning the mass scale from neutron stars up to supermassive black hole binaries.

Weria Pezeshkian is a biophysicist. He received his PhD from the University of Southern Denmark. Before joining NBIA he was a postdoctoral fellow at the University of Groningen. He develops and uses computational microscopes to understand fundamental biological processes at the cellular level. For instance, how cells repair their membranes after injury or how toxic particles hijack cellular machinery for their entry. These mechanisms include many exciting physical phenomena such as fluctuations induced forces, phase transition, phase coexistence, and molecular condensations. His latest works include the first simulation of mitochondrial membranes with realistic size and SARS-CoV-2 virion envelope with a near-atomistic resolution. His current focus is to understand the p molecular mechanisms that control the form of subcellular factories.

Karel Proesmans joined the NBIA as an assistant professor in October 2021. After obtaining his PhD in 2017 at Hasselt University in Belgium, he worked as a post-doctoral researcher in Canada and Luxembourg. During this time, he worked on non-equilibrium statistical mechanics, with particular focus on the development of a general framework, known as stochastic thermodynamics, to study the thermodynamics of mesoscopic systems. Currently, his main research interest is on how thermodynamics puts constraints on biological processes. More specifically, his focus is on questions such as to what extend are biological processes, such as DNA replication, and what are the thermodynamic constraints necessary to create non-equilibrium phenomena motility-induced phase-separation.

Junior Faculty

Natascha Leijnse is an experimental biophysicist working in the Active Intelligent Matter Research group. After she obtained her PhD at University of Copenhagen she worked as a postdoc at Stanford University and returned to Copenhagen. She is studying cell properties and mechanotransduction processes in living cells using optical tweezers combined with fluorescent imaging. Her latest work uncovered an active mechanism that filopodia, "cellular fingers", use to exert forces during embryonic- but also cancer development.

Johan Samsing joined the NBIA as a Louis-Hansen Assistant Professor and Marie Curie Fellow in 2019. In 2020 he received a Villum Young Investigator Grant to establish a group at the NBIA dedicated to gravitational-wave astrophysics. In 2022, Johan also received an ERC Starting Grant from the European Union for the project "Gravitational Wave Astrophysics and Dynamical Formation of Black Hole Mergers". Johan received his PhD from the Niels Bohr Institute (DARK) in 2014, after which he moved to Princeton University, first as an Einstein Fellow and then as a Spitzer Fellow. He currently works on the astrophysical formation of gravitational-wave sources and the origin of black hole mergers.

Maarten Van de Meent joined the NBIA in 2022 as an assistant professor in the "Strong Gravity" group. After obtaining his PhD from Utrecht University under supervision of Gerard 't Hooft, Maarten held an NWO Rubicon Fellowship at the University of Southampton, and a Marie Skłodowska–Curie Fellowship at the Max Planck Institute for Gravitational Physics in Potsdam. He is interested in the relativistic 2-body problem describing the inspiral and merger of black hole binaries. In particular, he is an expert on the gravitational self-force formalism, which solves the 2-body problem as a perturbative expansion in the ratio of the masses. He leverages this knowledge to develop and improve waveform models for gravitational wave observations.

Evert Van Nieuwenburg joined NBIA as an assistant professor in 2019. Evert's research focuses on using machine learning to advance the state-of-the-art in condensed matter physics. Examples are the use of neural networks to predict physical properties of many-body systems, genetic algorithms for quantum error correction, and reinforcement learning for controlling experimental quantum systems. He contributes to the development of quantum games for outreach and education (quantumchess.net and quantumtictactoe.com) and is an organizer for virtualscienceforum.org. In 2022, Evert became an assistant professor in Leiden University.

Junior Faculty

Cristian Vergu graduated from Ecole Normale Superieure (Paris, France) and obtained his PhD in Theoretical Physics from Paris VI University and IPhT Saclay. He held postdoctoral positions at Brown University, USA, ETH Zü-rich, Switzerland and King's College London, UK. He is interested in twistor theory, AdS/CFT, integrability and scattering amplitudes in N=4 super-Yang-Mills theory.

Matt von Hippel received his PhD from Stony Brook. He was a postdoctoral fellow at the Perimeter Institute, before joining NBIA first as a postdoctoral fellow and now as an assistant professor. He researches scattering amplitudes in gauge and gravity theories. In particular, he has developed new methods to calculate multi-loop scattering amplitudes in N=4 super Yang-Mills based on the properties of polylogarithmic functions. Currently, he is interested in extending these techniques, both to more general theories and to elliptic integrals.

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 QMath with a Feodor Lynen Fellowship (a Humboldt Foundation sponsorship). He works within Matthias Christandl's Quantum Information Theory group.

Matthias Willhelm received his PhD from Humboldt University Berlin before joining NBIA in 2015. His research interests lie within the field of quantum field theory and high-energy theory, with a focus on gauge theories, the gauge-gravity duality and exact methods. He works on the number theory behind scattering amplitudes, on form factors and on thermodynamics as well as on the effects of introducing defects.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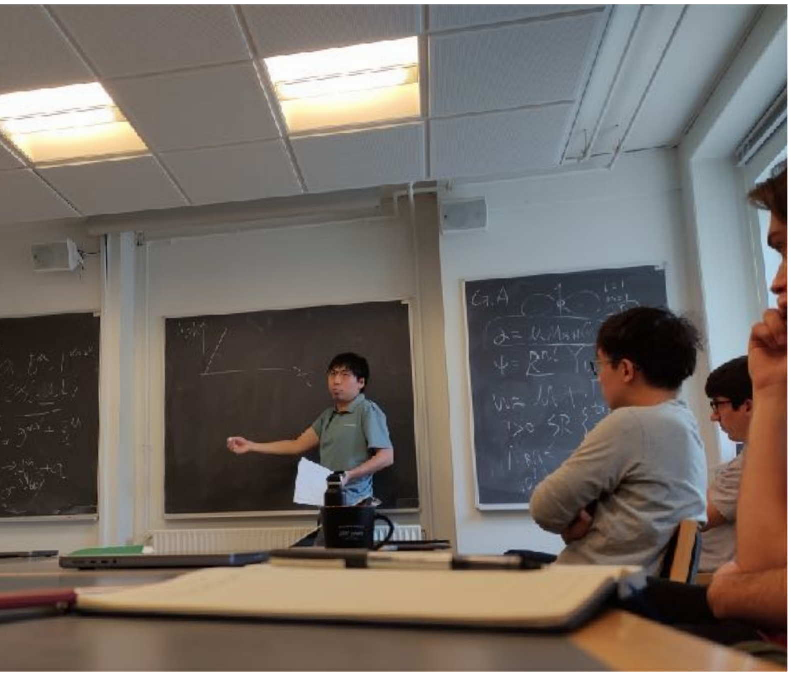
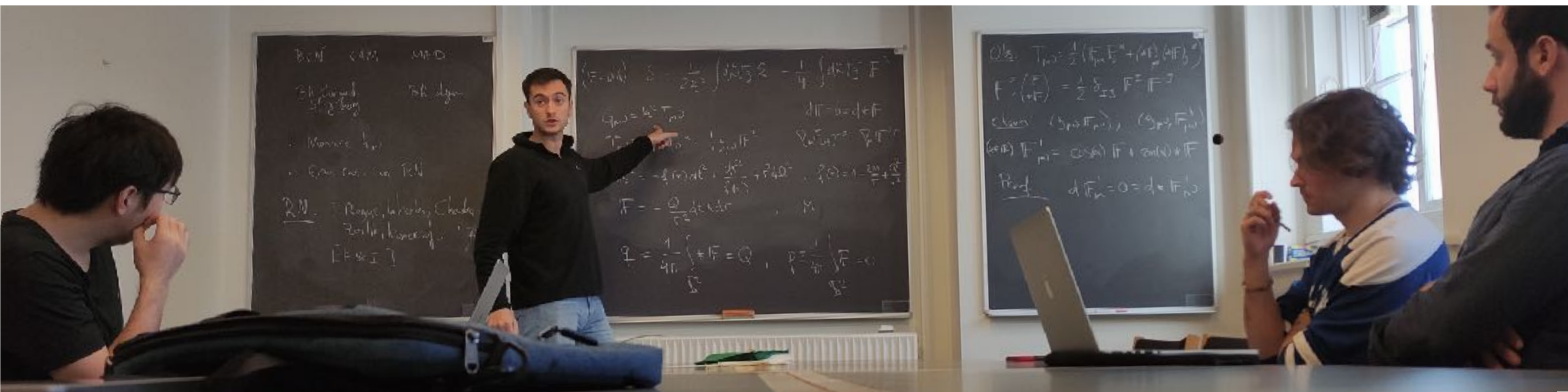
ASTRONOMY





Postdoctoral Fellows

Aleksandra Ardaševa received her DPhil from the Mathematical Institute at the University of Oxford. Her doctoral work focused on studying evolutionary adaptation strategies of cancer cells in dynamic environments using analytical and numerical techniques. She currently studies physico-chemical coupling in active biological matter by utilising phase-field modelling approach and continuum theory of liquid crystals.

Clément Bonnerot joined the NBIA as a Marie Curie fellow in 2021. He obtained his PhD from Leiden Observatory in 2017 and then was a postdoc at the California Institute of Technology. His research concerns tidal disruption events as well as other transient and high-energy phenomena, which he studies theoretically in order to characterize their observational signatures. From February 2023, he will be working as Assistant Professor at the University of Birmingham in the UK.

Gregorio Carullo is a Marie Skłodowska Curie Interactions Fellow in the newly formed Strong gravity group. Before, he received his PhD from the University of Pisa and was a Della Riccia Fellow at the University of Jena. His research focuses on extracting fundamental physics implications from gravitational waves observations and testing the black hole paradigm, mainly using spectroscopy techniques. He is also interested in dynamical captures and measuring black hole horizon effects using LISA.

Adam Chalabi is a postdoc working in theoretical high-energy physics. He joined NBI in 2022 after completing his PhD at the University of Southampton. His research interests include conformal field theory, gauge theory, and supersymmetry. Adam's current work investigates the role of boundaries and defects in conformal field theory, with some inspiration drawn from string theory and condensed matter physics. Boundaries and defects encode crucial information about quantum systems, and they are necessary to describe many realistic physical phenomena.

Gang Chen completed his PhD. in Nanjing University and worked junior faculty in there. Then he moved to Uppsala, Queen Mary University as postdoc. From 2022, he joint in NBI and employed as assistant professor from 2023. Now he works on scattering amplitude, gravitational wave and high spin field theory. He is currently focus on the kinematic algebra and double copy in various theories, and applies them to gravitational-wave and black hole physics.

Postdoctoral Fellows

Yifan Chen obtained his PhD from Sorbonne Universite in 2019. Before joining NBIA as a postdoc, he worked at Institute of Theoretical Physics, Chinese Academy of Science. His research is in the intersection of particle physics, strong gravity, string theory and quantum sensor. Recently, he focuses on detection of ultralight bosons, such as axions and dark photons, by exploiting Event Horizon Telescope observations on supermassive black holes, or a network of sensors like cavities and magnetometers.

Tyler Corbett completed his PhD at Stony Brook University in 2015 and completed a postdoc at Melbourne University before joining NBIA. Tyler's research interests include the Standard Model Effective Field Theory, collider phenomenology and models explaining the baryon asymmetry of the Universe.

Georg Enzian obtained his PhD from the University of Oxford for work in Brillouin cavity optomechanics. He is interested in the preparation and study of non-classical states of mechanical motion. At NBI he currently focuses on the preparation of number states of the motion of silicon-nitride membranes suspended inside an optical cavity. Preparation of exotic quantum states of massive systems can directly test quantum mechanics in thus far unexplored regimes and might shed new light on the foundations of the theory.

Damiano Fiorillo obtained his PhD in late 2021 from the University of Naples and joined the group of Mauricio Bustamante at NBIA in early 2022. His research interests encompass many facets of high-energy multi-messenger astrophysics: he has worked on various topics in dark matter, axions, gamma rays, and high-energy neutrinos. At NBIA, his focus is on how cosmic neutrinos can test both high-energy particle physics and astrophysics, both using present-day observations and forecasting future opportunities with upcoming detectors.

Hjalte Frellesvig's main field of research is scattering amplitudes in particle physics, with a focus on Feynman integrals and their mathematical properties. This includes work on the use of the mathematical disciplines of intersection theory and "symbol" algebra for simplifying and systematizing the manipulation and evaluation of Feynman integrals and associated special functions. He also works on particle scattering phenomenology including a project on the production of the Higgs boson, and one on electro-weak corrections to the production of the Z and W bosons. He has his PhD from the NBI, and has done postdocs in Greece, Germany, and Italy.

Postdoctoral Fellows

Yoann Genolini received his PhD in theoretical phy-sics at LAPTh (Annecy, France) in 2017. He later became a postdoctoral fellow at the Université Libre de Bruxelles. His research focuses on astroparticle physics, cosmic-ray transport and phenomenology. He is also interested in dark matter phenomenology and its indirect probe by astrophysical observables, especially those related to compact objects.

Alejandro Vigna-Gómez received his PhD from the University of Birmingham (UK). He is interested in massive stars, which are the progenitors of gravitational-wave sources and other extremely energetic transients. He uses numerical methods to study multiple-star systems and double compact objects. From 2023, he will join the Max Planck Institute for Astrophysics (MPA) as a Stellar Fellow.

Shilpa Kastha is a postdoctoral researcher in the Strong group at NBIA. She finished her PhD at The Institute of Mathematical Sciences, India in 2019. Before joining NBIA, she was a junior scientist/postdoc at Albert Einstein Institute, Hannover. Her present research efforts span across different areas of tests of general relativity using gravitational wave observations, source modeling, parameter estimation as well as various astrophysical implications of the gravitational wave detections.

Sameer Kumar is a post-doctoral researcher, currently investigating time evolutions and pattern formation in active matter by writting the equations of motion for the density and orientation of living objects of anisotropic shape, coupled to an incompressible fluid. The Naviar-Stokes equation to describe the motion of the flow field (fluid velocity). Numerical solutions to these coupled equations are obtained using the Lattice-Boltzmann method, allowing the study of different pat-

Rajika Kuruwita is an INTERACTIONS fellow at NBI doing numerical simulations of star formation. She obtained her PhD from the Australian National University in July 2019, where she completed both observational and theoretical work on binary star formation. She has a keen interest in the early evolution of young binary and multiple star systems and how their dynamical interactions could affect planet formation. She is also the treasurer of Kvinder I Fysik, and founder of Astronomy on Tap: Copenhagen. Rajika recently became an independent Postdoctoral Fellow at the Heidelberg Institute for Theoretical Studies in Germany.


WINSLØW

Postdoctoral Fellows

Bin Liu received his PhD in China in 2016 and held postdoctoral positions at Shanghai Astronomical Observatory and Cornell University. He joined NBIA in 2020 as an INTERACTIONS fellow and now is a Marie-Curie Fellow. Bin is interested in a wide range of dynamical problems, including exoplanetary systems, dynamical formation of binary black holes, and dynamics and merger of compact objects near super-massive black holes in the disks of active galactic nuclei.

Rasmus Lundkvist received his PhD in Astronomy from Aarhus University in September 2015. Afterwards, he held an Alexander von Humboldt fellowship at Max-Planck-Institut für Kernphysik in Heidelberg before coming to NBIA. His research focuses on neutrino oscillations in the early Universe and in supernova explosions, but he is also interested in related topics such as dark matter and high energy neutrinos.

Lorenzo Maffi received his PhD in 2020 from the University of Florence. The topic of his research has been the edge dynamics of topological states of matter by means of conformal field theory approaches. He focused on the quantum Hall states and topological insulators in 3D. Currently he is working on low temperature phases in nanowire-leads systems, and, in particular, on stability of topological Kondo effect.

Siavash Monfared received his PhD at MIT followed by a postdoc position at Caltech. His research is at the interface of granular physics, statistical mechanics and active matter. He is interested in understanding the link between the physics of force transmission and collective self-organization in biological systems through developing theoretical models and high performance computational tools.

David Pereñiguez obtained his PhD from the Institute of Theoretical Physics, in the Autonomous University of Madrid. He joined NBI in October 2022. His research focuses on black hole physics. At NBI, he works on theoretical aspects of gravitational wave propagation in black hole spacetimes, and studies how these encode information about the black hole structure, with special emphasis on signatures of new physics.

Enrico Peretti obtained his PhD in Astroparticle Physics at the Gran Sasso Science Institute (L'Aquila, Italy) in July 2020 and he joined the Niels Bohr Institute in September 2020. His research interests are in astroparticle physics and focus on the transport of high energy particles and its multimessenger implications in extreme astrophysical environments, most notably starburst galaxies. He is also interested in non-thermal phenomena in relativistic jets such as gamma-ray bursts.

Postdoctoral Fellows

Neda Rahmani was a postdoc in the Computational Material Group at Southern Denmark University. Her research focused on finding new functional materials, specifically multiferroic and half-metallic double perovskites, for photovoltaics and spintronics through density functional theory calculations. Now, as a postdoc at NBIA, she is exploring biomaterials and biological processes using multiscale computer simulation techniques. Currently, Neda is focusing on the design of a nanoscale force sensor to measure interactions between membrane proteins.

Ximena Ramos became a postdoc at the NBIA since 2019. Ximena received her PhD in Planetary Science from the University of Córdoba, Argentina. After her PhD, she was a postdoc at Observatoire de la Côte d'Azur, France. Ximena's research focuses on N-body dynamics and protoplanetary disks. She is particularly interested in planet migration, its connection with the underlying disk-structure, and the associated impact in the final configurations of exoplanetary systems. In 2022, Ximena became a postdoc at the Instituto Milenio de Astrofísica in Chile.

Annika Rudolph obtained her PhD in Mai 2022 from Humboldt University Berlin/DESY and joined the AstroNu group in September 2022. Her work focuses on non-thermal high-energy astrophysical phenomena like Gamma-Ray Bursts an Active Galactic Nuclei. Within these environments she studies the interplay between photons, neutrinos and charged nuclei (called cosmic rays) though numerical modeling, aiming at making multi-messenger predictions testable through observations.

Shashank Shalgar received his PhD from Northwestern University in 2013. He later became a postdoctoral fellow at the University of New Mexico and Los Alamos National Laboratory. His research is focused on neutrino physics in extreme astrophysical environments and the early Universe. He is especially interested in the non-linear evolution of the neutrino flavor that occurs in these astrophysical environments.

Prashant Singh is a postdoctoral researcher at NBIA working with Prof. Karel Proesmans. He obtained his PhD from the ICTS in Bangalore, India in November 2022. The general theme of his research has been non-equilibrium statistical mechanics. More precisely, he has worked on Brownian motion and random walks, active particles, stochastic resetting, extreme-value statistics, single-file motion and functional statistics. At NBIA, he is exploring the field of stochastic thermodynamics with a primary focus on its applications in biological settings.


NIELS BOHR

Postdoctoral Fellows

Anne Spiering received her PhD from Trinity College Dublin. Her research focusses on the interplay between infinite-dimensional symmetries at the core of physical models and their manifestation at the level of the model's observables. This includes the research on how the existence, and absence, of quantum integrability constrains the physical data of superconformal field theories, and in particular the mathematical structure of scattering amplitudes.

Kristian Thijssen is a computational soft matter physicist interested in the dynamics of emergent collective phenomena and how those systems (e.g., bacteria colonies and cellular tissues) interact with reconfigurable surroundings. He obtained his MSc at the Eindhoven University of Technology, after which he did a PhD in physics under the tutelage of Julia Yeomans in Oxford. After holding a postdoctoral position under Robert Jack in Cambridge, he joined the NBI Copenhagen with a Marie-Curie fellowship.

Christopher Tiede received his PhD from New York University in May, 2022 before joining the NBIA as a postdoc in the Fall. His research is in the development and application of high-performance hydrodynamics simulations to astrophysical systems. Chris's primary focus is in the study of gas dynamics around binary black holes and how such accretion phases both alter the life cycles of these binaries and enable their multi-messenger observational prospects.

Inar Timiryasov received his PhD from Moscow State University in 2016. He was a postdoc at EPFL in Lausanne until 2021 when he joined NBI. In 2022 he joined NBIA as an INTERACTION Senior Fellow. Inar's research focuses on the physics of the early Universe (gravity, inflation, dark matter, baryogenesis) and particle physics. He also explores the potential of artificial intelligence as a tool for discoveries in physics and cosmology and the transfer of ideas between deep learning and theoretical physics.

Alessandro Alberto Trani joined the NBIA as an INTERACTION Senior Fellow. He received his PhD from SISSA in 2017, before moving to The University of Tokyo as a JSPS Postdoctoral Fellow. His main research focus is the study of collisional self-gravitating systems, which include star clusters, galactic nuclei, binary stars, and planetary systems. With the advent of gravitational wave astronomy, he is leveraging the few-body problem to unveil the astrophysical origin of gravitational wave events.

Postdoctoral Fellows

Matteo Wauters is interested in a variety of non-equilibrium phenomena in quantum physics, ranging from topological transport properties to reinforcement learning techniques for quantum control and quantum computation. At the moment he focuses on the modeling and numerical analysis of topological Kondo effect in nanowire systems, aiming to a qualitative comparison with experimental results.

Chi Zhang received his PhD in 2020 from the Institute of Theoretical Physics, Chinese Academy of Sciences. He works on scattering amplitudes in gauge theories and string theory. He is interested in studying the underlying mathematical structures of scattering amplitudes as well as developing new techniques for computing amplitudes.

PhD Students

Benjamin Halager Andersen joined the Active Intelligent Matter (AIM) group at NBIA in November as a PhD fellow, where he will be using a combination of numerical and analytical methods to study systems of active matter. Prior to this, Benjamin obtained both his master's and bachelor's degrees from NBI, the former on the topic of complex systems physics and the phenomenon of fully developed turbulence in 2D as well as 3D.

Chun Lung Chan (aka Juno) obtained his MSc degree in Physics from the Chinese University of Hong Kong with a thesis on detecting strongly lensed gravitational waves and the asteroseismology of magnetars. He is now working in the Strong group under the supervision of Jose Maria Ezquiaga and Vitor Cardoso. His research at NBIA focuses on numerical simulations of magnetars and detecting lensed gravitational wave signals.

Marina De Amicis is a PhD student of NBIA, working in the Strong Group under the supervision of Vitor Cardoso and Diego Blas (IFAE). She obtained her Master's Degree at La Sapienza University of Rome with a thesis on black holes evaporation in an alternative theory of gravity, EdGB gravity. Now, her main focus is the stochastic background of gravitational waves. In particular, she is working to find new indirect ways to probe this background for frequencies inaccessible with current detectors.

Conor Dyson obtained his Master's degree from the Department of Applied Maths and Theoretical Physics at the University of Cambridge in 2022. He joined NBIA in October of the same year as a PhD student in the "strong" Gravitational Physics group working under the supervision of Vitor Cardoso and Maarten van de Meent. His research is broadly in the field of black hole perturbation theory with specific focus on applying the self-force approach (a form of singular perturbation theory) to modelling black hole binaries.

Evelyn-Andreea Ester is member of the Strong Gravity group and works under the supervision of Professor Vitor Cardoso on QED effects in curved spacetimes. She completed a Mathematics BSc at Royal Holloway, University of London with a thesis on the Dirac Equation, and a Physics MSc at Royal Holloway and a one-year project on Hawking radiation, dwelling on a solution to the information paradox and an analysis of dark matter produced by decaying primordial black holes. Her research continues to highlight quantum effects in the strong gravity regime.

PhD Students

Gaia Fabj obtained her MSc degree at the University of Heidelberg in 2021. She is currently a PhD student in the gravitational astrophysics group at NBIA. She is working under the supervision of Johan Samsing on the formation and evolution of black-hole binaries in Active Galactic Nuclei (AGN) accretion disks in order to investigate the AGN channel for gravitational-wave detection.

Marcela Grcic received her Master's degree in physics from the University of Copenhagen in 2022 with a thesis on eccentric circumbinary disks. In October 2022, Marcela started working on her PhD with the NBI Astrophysics group. She works under the supervision of Daniel J. D'Orazio and Martin Pessah. Marcela's research at NBIA includes theoretical analysis of the interaction of astrophysical binary systems and surrounding accreting disks, with a focus on the resulting disk eccentricity evolution.

Kathrine Mørch Groth obtained her MSc degree at the NBIA in 2021 working on multi-messenger emission of ultra-high energy cosmic rays. Since October 2021 she has been a PhD student in the astroparticle group under the supervision of Markus Ahlers. Her project aims to clarify the origin of the high-energy cosmic neutrino flux through studies of candidate neutrino sources in the context of multi-messenger observations.

Valeriia Grudtsyna completed her biomedical engineering degree at Lund University and gained research experience as a part of Vinay Swaminathan's group, Laboratory of Cell and Molecular Mechanobiology, at Lund University. Currently, she is pursuing her PhD under Amin Doostmohammadi at the Active Intelligent Matter Research Group. Her focus is on experimental investigations of the underlying physics of collective mechanotransduction in epithelial cells.

Ersilia Guarini is a PhD student working under the supervision of Irene Tamborra. She joined NBI in January 2021, after obtaining her MSc degree from Bari University (Italy) with a thesis on axion-like particles production in photon conversions in large-scale coherent magnetic fields. She is currently working on multi-messenger astrophysics. In particular, her project aims to investigate non-thermal neutrino production in astrophysical transients.

PhD Students

Shanzhong Han obtained his Master's degree in Theoretical Physics from Beijing Normal University in 2019. He is currently pursuing his PhD in Theoretical High Energy, Astroparticle, and Gravitational Physics under the supervision of Professor Niels Obers. His research focuses on the double copy, with a particular emphasis on the Weyl double copy. He is exploring the connection between gravity theory and gauge theory, as well as investigating the applications of double copy on gravitational wave astronomy and astrophysics.

Marie Cornelius Hansen received her MSc degree at the Niels Bohr Institute with a thesis on probing the properties of axion-like dark matter using astrophysical high-energy neutrinos observed in IceCube. She started her PhD in November 2022 under the supervision of Irene Tamborra. Marie's work is within the field of particle astrophysics. Specifically, her PhD project focuses on numerical simulations of the flavor evolution of neutrinos in dense astrophysical environments, such as core-collapse supernovae and neutron star mergers.

Kai Hendriks joined the NBIA as a PhD student in November 2022, to work on the astrophysical formation channels of black hole binaries and imprints on their gravitational wave signals. Kai obtained his BSc and MSc at Maastricht University and Radboud University respectively, with research on neutron star binaries with numerical relativity as well as models of electromagnetic counterparts to gravitational wave sources.

Dana Taylor Kemp obtained her MSc degree at NBI in 2021 contributing to the soliton theory of nerve signalling by combining numerical, theoretical and experimental work. Her PhD-work focuses on theoretical frameworks for non-equilibrium circuits with biological perspectives under the supervision of Karel Proesmans.

Alexander T. Kristensson obtained his MSc degree in theoretical physics from the University of Copenhagen and recently started his PhD in the research group of theoretical high-energy physics at the NBI. His research focuses on understanding the strange behavior of the smallest components of all matter, the quarks, via the maximally supersymmetric Yang-Mills theory.


HAVFRUEN

PhD Students

Roger Morales Espasa joined the NBIA in April 2022 as a PhD student under the supervision of Matthias Wilhelm after obtaining his MSc degree from NBIA too. In his master's thesis, he studied the coalescence of a black hole binary system through the post-Newtonian effective field theory of gravity. Now, his PhD project is devoted to the study of scattering amplitudes and the special mathematical functions that occur in Feynman integrals, focusing on elliptic and higher-dimensional geometries.

Ida E. Nielsen is a PhD student with Prof. Michele Burrello in the Condensed Matter Theory group since October 2019. She works on models of parafermionic modes and proposes experimental realization and verification of these. Parafermionic modes can potentially be exploited to build platforms for error-protected quantum computation.

David O'Neill began his masters in physics at the university of Copenhagen in 2020, before joining the Astrophysics group for his thesis in black hole binary formation. Further pursuing this work, he began his PhD in September 2022 interested in supermassive black hole binaries. His projects aim to investigate the environments and dynamics of the most massive objects in the universe and to explore possible observational signatures they may exhibit.

Ian Padilla-Gay started a position as PhD student at NBIA under the supervision of Irene Tamborra after obtaining his MSc degree from Lund University (Sweden). His PhD project has focused on the development of numerical simulations and analytical methods to understand the flavor evolution of neutrinos in compact astrophysical objects such as neutron star binaries. Ian has successfully defended his PhD thesis on October 13, 2022 and is now a postdoctoral fellow at Stanford University.

Daniele Pica is a PhD student involved in a double PhD program between the Niels Bohr Institute in Copenhagen and the University of Perugia in Italy. He studied Theoretical Physics for both his bachelor and Master's degree at the University of Perugia. He graduated in both cases with honors. He is currently working on black hole physics, specifically in how the presence of a supermassive black hole, or in general a third body, affects the dynamics of a black hole binary system.

PhD Students

Tetyana Pitik is a PhD student working in the Astro-Nu group under the supervision of Irene Tamborra. She obtained her MSc degree in Theoretical Physics from the University of Perugia (Italy) with a thesis on force-free electrodynamics approach to magnetospheres of extremal Kerr black holes. Tetyana's research activity at NBIA focuses mainly on developing a new, self-consistent estimation of particle acceleration in astrophysical transients to compare with observations.

Andrea Placidi obtained a Master's degree in Physics at the University of Perugia in Italy. After this, he started a double degree PhD program between the latter university and the University of Copenhagen. A the moment he is also a research fellow at the Galileo Galilei Institute for Theoretical Physics, in Florence. His work mainly focuses on the theoretical aspects of gravitational wave physics, with particular reference to effective one-body models for coalescing compact binaries.

Xin Qian did his bachelor in Lanzhou, China, followed by a gap year for self-study. He then decided to continue his career in Copenhagen, where there are a number of researchers with similar research interests. Xin joined Prof. Charlotte Kristjansen's group for his master thesis, mainly to work on the field theory side of AdS/CFT correspondence by using the integrability technique. Xin is now a PhD. student supervised by Charlotte Kristjansen's, working on extending the study he carried out in his MSc thesis to ABJM superconformal field theory.

Thomas Spieksma is a PhD student working in the group of Vitor Cardoso since September 2022. He obtained his MSc degree at the University of Amsterdam, where he mainly worked on scalar fields around black holes that are part of a binary system. Currently, he continues to do research on this topic, yet now in an isolated system. In particular, he tries to understand what happens when couplings to other fundamental fields are allowed. This involves analytical work as well as the use of numerical relativity.

Chenliang Su is a PhD student working with Charlotte Kristjansen. He is mainly working in AdS/CFT correspondence, integrability and defect CFTs. He is currently investigating the one-point function in ABJM theory with a domain wall. The intriguing problems include extending the overlap formula between Bethe eigenstates and integrable boundary states, which determines the form of one-point functions, to general values of the bond dimension and to the higher loop orders.

PhD Students

Bernanda Telalovic received her MSc degree in Mathematical Physics from the University of Tübingen in late 2021, with a thesis on the Littlewood-Richardson rule, which has applications in QCD calculations. She joined NBIA as a PhD student in early 2022, under the supervision of Mauricio Bustamante. The work of Bernanda is within particle astrophysics. Her PhD project is on looking for signs of new physics in the distribution of the incoming directions of high-energy neutrinos, and related subjects.

Victor Valera is a PhD student working under the supervision of Mauricio Bustamante. He completed the Postgraduate Diploma Programme in High Energy Physics at the International Centre for Theoretical Physics (Italy) with a thesis on resonance refraction effects on neutrino oscillations due to non-standard neutrino-scalar interactions as an explanation of the MiniBooNE anomaly. Victor's research at NBIA focuses on the study of ultra-high energy neutrinos and their potential to probe new physics using current and future neutrino telescopes.

Matthias Volk obtained his MSc degree from the University of Copenhagen with a project on one-point functions in a defect version of the AdS/CFT correspondence. With his supervisors Charlotte Kristjansen and Jacob Bourjaily he is now working on topics related to integrability and scattering amplitudes in conformal field theories.

Jaime Redondo-Yuste is a PhD student at the Strong group under the supervision of Vitor Cardoso. He obtained his MSc degree at the Perimeter Institute (Canada) with a thesis on the duality between the dynamics of black hole horizons and Carrollian fluids. He combines analytical and numerical techniques in his research to understand the consequences of the non-linear nature of Einstein's equations. This modifies the emission and propagation of gravitational waves, opening a unique window to test General Relativity.

MSc Students

Samuel J. P. Bensted — Astroparticle Physics

Anirudth Bhatnagar — Astroparticle Physics

Anna Liv Bjerregaard — Particle Physics

Alexander John Boccaletti — Particle Physics

Robin Bolsterli —Active Matter

Jonathan Bödewadt — Astroparticle Physics

Johan Møller Christensen — Particle Physics

Thomas Cope — Gravitational Physics

Patrizio Cuglia di Sant'Orsala —

Arun Krishna Ganesan — Astroparticle Physics

Manuel Goimil Garcia — Particle Physics

Elias Roos Hansen — Particle Physics

Katharina Hauer — Particle Physics

Jitze Hoogeveen — Particle Physics

Tobias Barfod Kristiansen — Particle Physics

Zheng Ma — Cosmology

Kjartan Másson — Astroparticle Physics

Yuchan Miao — Particle Physics

Gowtham Rishi Mukkamala —Particle Physics

Jo Nykrem — Particle Physics

Jorge Expósito Patiño — Gravitational Physics

Marcos Skowronek Santos — Particle Physics

Henri Schmidt — Active Matter

Garðar Sigurðarson — Astroparticle Physics

Amit Singh — Astroparticle Physics

Haochun Sun —Active Matter

Toni Teschke — Particle Physics

Patsrikasem Vanitcharenthum — Gravitational Physics

Edwin Vargas — Particle Physics

Anna Louise Juul Willumsen —Particle Physics

Tianyi Zhou — Gravitational Physics

Adjuncts & Associates

Oliver Gressel — Theoretical Astrophysics (AIP, Potsdam, Germany)

Åke Nordlund — Computational Astrophysics (NBI and Rosseland Center, Oslo, Norway)

Igor Novikov — Theoretical Astrophysics (Lebedev Physics Institute, Moscow, Russia)

Jørgen Rasmussen — Mathematical Physics (University of Queensland, Australia)

Meng Ru Wu — Particle Astrophysics (Institute of Physic, Academia Sinica, Taipei, Taiwan)

Visiting Professors

Maria Bergemann joined NBIA during the academic year 2021/2022 as SCIENCE Visiting Scholar at Copenhagen University. Maria Bergemann holds a prestigious position as “Lise Meitner Research Group Leader” at the Max Planck Institute for Astronomy in Heidelberg, Germany and she has recently been awarded an ERC Starting Grant for the project ELEMENTS, which will provide detailed abundances of elements representing all major processes of nucleosynthesis for over 300,000 stars in our galaxy. Maria Bergemann is a world expert in numerous areas of stellar astrophysics, including radiative transfer, spectroscopy, the origins of chemical elements, and Galactic archeology, that overlap with several groups at the Niels Bohr Institute, the Museum of Natural History, and the Globe Institute.


B

Prof. David Gross — KITP, Santa Barbara

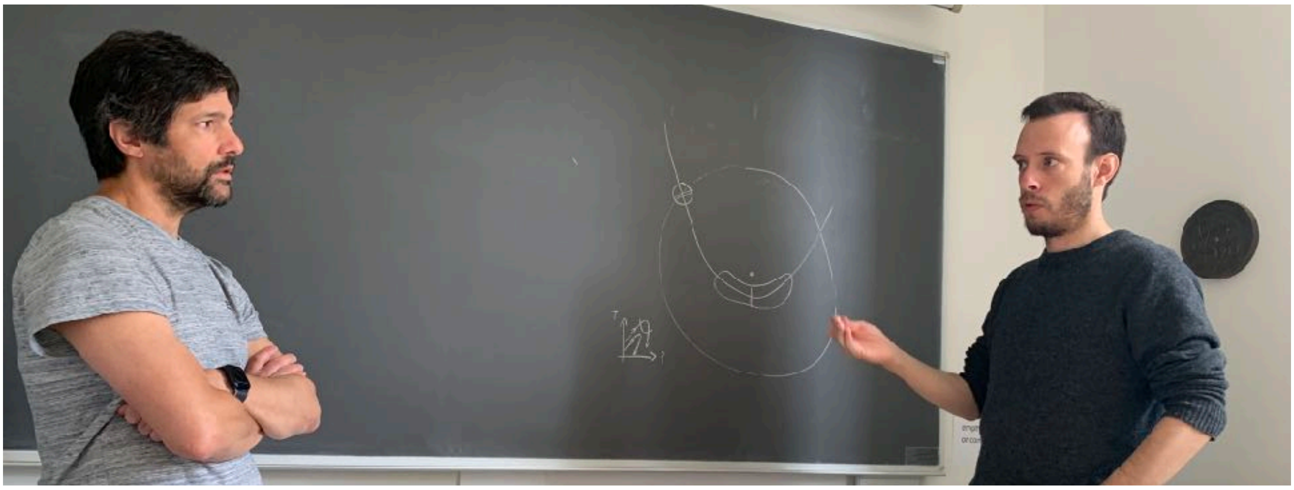
Visitors

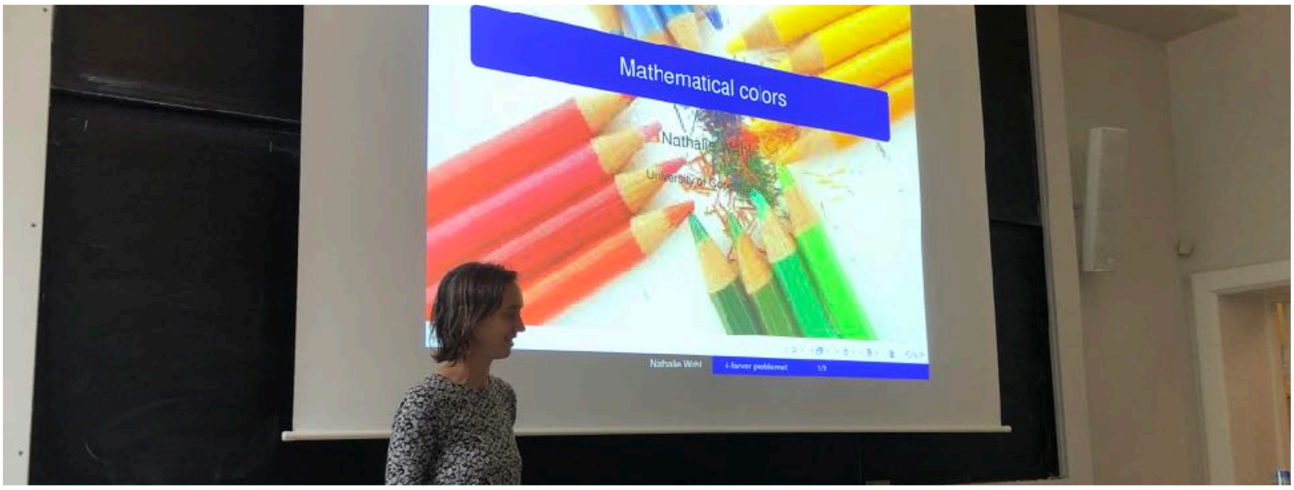
The NBIA maintains a vigorous visitor program, which usually attracts anywhere from 50 to 100 scientists every year. These visitors actively engage in daily activities at the NBIA and the Niels Bohr Institute. The list of visitors for the calendar year 2022 follows below.

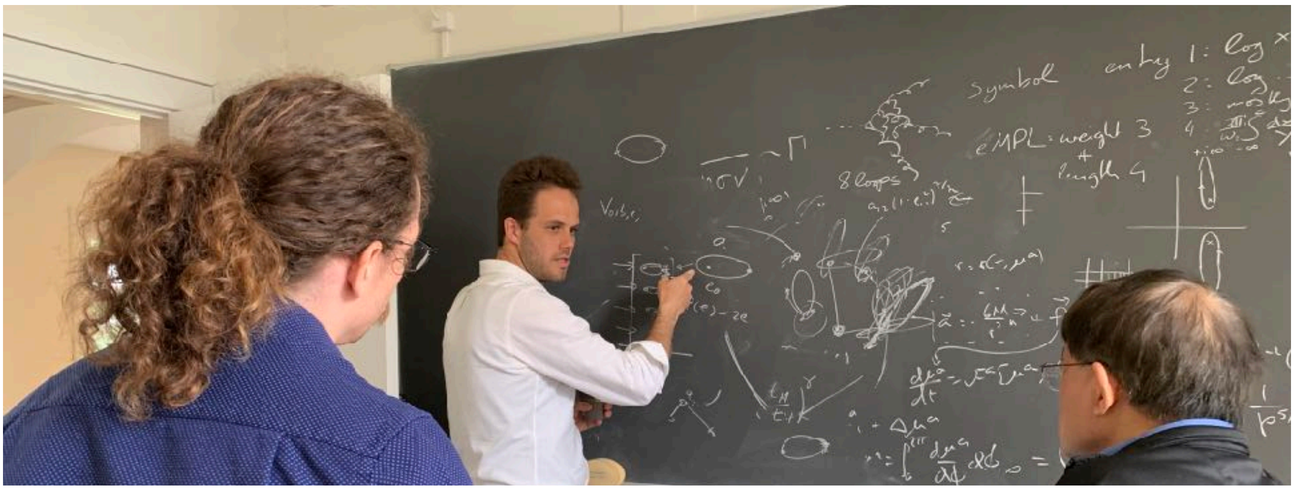
Name	Affiliation	Arrival	Departure
D.F. Zeng	China	17.12.22	16.12.23
N. Song	Liverpol Univ.	12.12.22	14.12.22
N. Cornish	Montana Univ.	12.12.22	14.12.22
I. Esteban	Ohio State Univ.	05.12.22	09.12.22
C. Bartsch	Charles Univ. Prague	05.12.22	08.12.22
K. Kotera	IAP, Paris	04.12.22	07.12.22
A. Amiri	MPI, Dresden	30.12.22	02.12.22
G. Bliard	Humboldt Univ. Berlin	30.11.22	02.12.22
M. Rozner	Israel	28.11.22	15.12.22
J. Steinhoff	AIE Potsdam	28.11.22	01.12.22
E. Lopez	IFT Madrid	23.11.22	25.11.22
P. Cole	Amsterdam	15.11.22	16.11.22
A. Bagchi	Ecole Polytechnique	13.11.22	03.12.22
R. Mbarek	Univ. Maryland	09.11.22	16.11.22
K. Bönish	Univ. Bonn	08.11.22	11.11.22
T. Hinderer	Utrecht Univ.	08.11.22	08.11.22
J. Rønning	Univ. Oslo	04.11.22	11.11.22
P. Dedin	Campinas State Univ.	01.11.22	30.10.23
P. Martínez-Miravé	IFIC (CSIC - U. Valencia)	01.11.22	26.11.22
A. Heinesen	Lyon Obs.	31.10.22	03.12.22
L. Planté	Saclay CRNS	31.10.22	09.11.22

R. Yoshioka	Osaka Univ.	26.10.22	30.11.22
P. Gomez	IST, Lisbon	17.10.22	21.10.22
G. Sigl	Univ. Hamburg	13.10.22.	14.10.22
L. Kelley	Northwestern Univ.	10.10.22	12.10.22
H. Pfeiffer	MPI, Potsdam	10.10.22	11.10.22
S. Manikandan	Nordita	03.10.22	05.10.22
R. Brito	IST Lisbon	02.10.22	15.10.22
X. Xue	Hamburg Univ.	02.10.22	09.10.22
K. Maeda	Tokyo	29.09.22	13.10.22
M. Giroux	McGill Univ.	17.09.22	24.09.22
E. Cannizzaro	Rome, La Sapienza	12.09.22	12.10.22
C. Macedo	Brazil	08.09.22	08.11.22
V. Pozgay	Imperial College	07.09.22	09.09.22
J. Plefka	Humboldt Univ. Berlin	06.09.22	08.09.22
J. Feng	Lisboa Univ.	13.08.22	03.09.22
J. Andersen	Univ. Trondheim	01.08.22	31.12.2022
O. Mena	IFIC, Univ. Valencia	12.07.22	15.07.22
J. Kopp	Johannes Gutenberg Univ.	12.07.22	14.07.22
F. Oikonomou	Norwegian Univ. Tech. & Sci.	12.07.22	14.07.22
F. Vafa	Harvard Univ.	01.07.22	14.07.22
C.H. Shen	UC San Diego	29.06.22	02.07.22
J. Andrews	Univ. of Florida	29.06.22	01.07.22
A. Edison	Uppsala Univ.	27.06.22	02.07.22
P. Heslop	Durham Univ.	27.06.22	29.06.22
M. Parish	Monash Univ.	27.06.22	29.06.22
J. Levinsen	Monash Univ.	27.06.22	29.06.22
B. Basso	ENS Paris	22.06.22	24.06.22


Antonija Oklopčić
University of Amsterdam




Mathematical colors



A. Schwenk	TU Darmstadt	15.06.22	15.06.22
S. Weinzierl	Univ. Mainz	08.06.22	10.06.22
P. Duffell	Purdue Univ.	07.06.22	10.06.22
S. Monfared	Caltech	05.06.22	10.07.22
J. Zanazzi	CITA	05.06.22	18.06.22
J. Yeomans	Univ. Oxford	30.05.22	01.06.22
D. Lai	Cornell Univ.	25.05.22	03.06.22
C. Fiore	Univ. Sao Paulo	16.05.22	27.05.22
P. Steinhardt	Princeton Univ.	09.05.22	21.05.22
S. Pearson	NYU	25.04.22	29.04.22
V. Goncalves	Univ. Porto	24.04.22	29.04.22
A. Georgouids	Nordita	24.04.22	29.04.22
Ö. Gurdogan	Univ. Southampton	20.04.22	23.04.22
S. Chu	Standford Univ.	28.03.22	28.03.22
T. Berlok	AIP, Potsdam	25.03.22	29.03.22
P. Vanhove	Saclay, CRNS	10.03.22	11.03.22
L. Planté	Saclay, CRNS	07.03.22	11.03.22
A. Trani	Univ. Tokyo	01.03.22	03.03.22
V. Cardoso	IST, Lisbon	28.02.22	04.03.22
E. Vitagliano	Univ. California	28.02.22	29.04.22
R. Hoppe	MPIA, Heidelberg	28.02.22	11.03.22
P. Eitner	MPIA, Heidelberg	28.02.22	11.03.22
T. Olander	MPIA, Heidelberg	28.02.22	11.03.22
M. Gent	MPIA, Heidelberg	28.02.22	11.03.22
C. Weniger	UVA	14.02.22	11.03.22

Administrative Staff

Gosia Dekempe is the NBIA administrator. She is responsible for onboarding new employees, coordination of guests and visitors, NBIA office overview and organization of events, workshops, and seminars. She handles HR matters and budget allocation. She holds a master's degree in economics from the Main School of Economics in Warsaw, Poland.

Zofia Merie Kohring is the section secretary for the Theoretical High Energy, Astroparticle and Gravitational Physics section. She is responsible for the daily running of the section, event and workshop coordination, budget, HR, guest handling, onboarding of new employees, and censorship. She is a business language correspondent in English and German from Slagelse Business School.

Iryna Kopachynska is a new part-time Administrative Assistant at NBIA. She assists in all practical matters at NBIA, assists the NBIA Director and Deputy Director, and has duties overlapping with the student assistants. Iryna is a forced migrant from Ukraine, where she was educated as an economist and a lawyer and held administrative positions in State Tax Service of Ukraine. She is currently following intensive courses in Danish outside her working hours at NBIA.

Julie de Molade is the Research Coordinator for the Strong Group at NBIA and PA to Prof. Vitor Cardoso. She is responsible for the daily running of the Strong Group, event coordination, communication, reporting, budget, HR, and general grant administration (DNRF Chair and Villum Foundation). She holds a Master of Arts in English and French from Roskilde University.

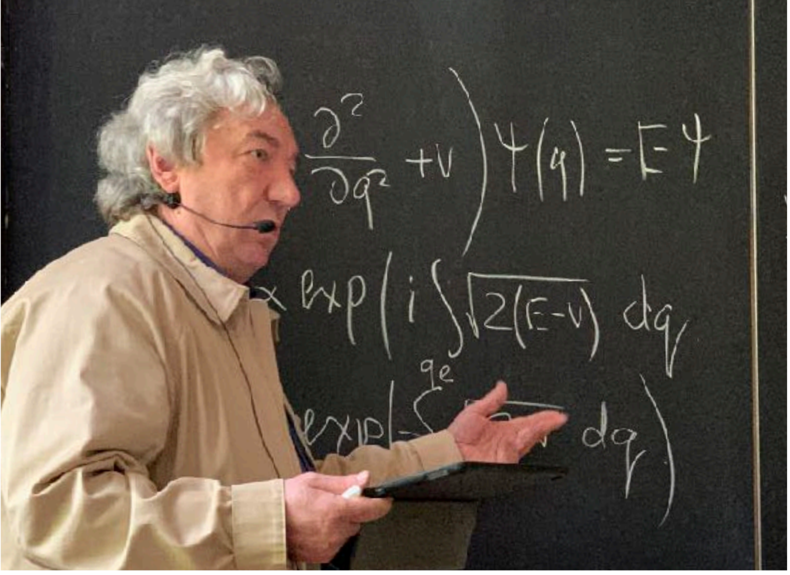
Financial Officers: During 2022, NBIA members received assistance in all matters related to budgets in applications and grants by Aida Coric, Ljiljana Markovic, and Mina Martinez-Diaz in the finance team at the Niels Bohr Institute.

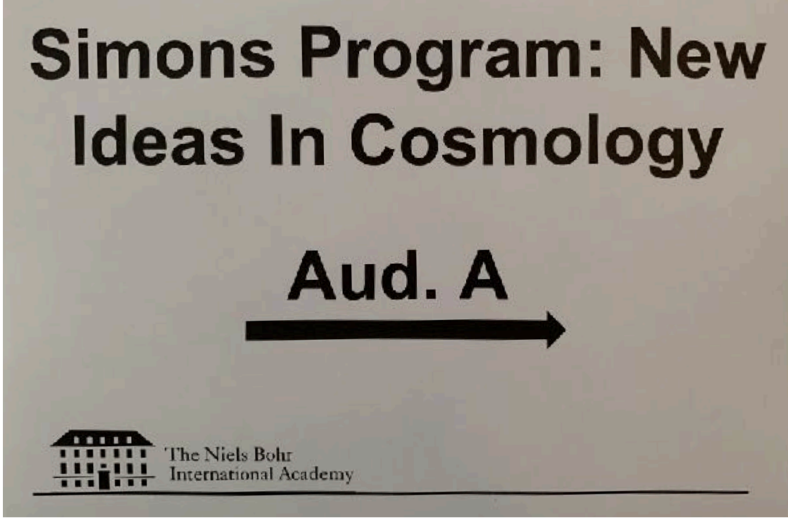
Student Assistants: During 2022, students Marta Bloch Christiansen, Marie Ernø-Møller, Marcos Skowronek Santos and Rasmus Strip assisted the NBIA administrative officers run daily NBIA activities.

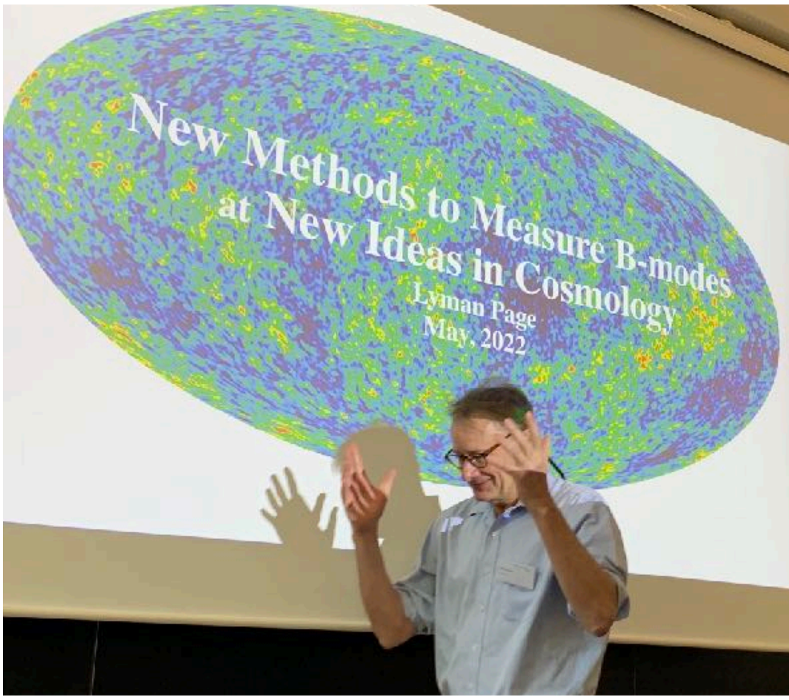

SØNDERJYLLANDS
GENFORENING MED
MODERLANDET
1920


Welcome to NBIA Workshop on Radiation Transfer in Astrophysics
Maria Bergemann & Martin Pessah
The Niels Bohr International Academy
Niels Bohr Institute, Jun 6- Jun 10, 2022

NBIA Activities




Simons Program: New Ideas In Cosmology
Aud. A
The Niels Bohr International Academy


New Methods to Measure B-modes at New Ideas in Cosmology
Lyman Page
May, 2022

NBIA Simons Foundation Program

Based on a generous grant from the Simons Foundation in New York, NBIA has established a highly successful series of Simons Visiting Professorships and associated scientific programs built around these appointments. The program was launched in the fall of 2016 with first Simons Visiting Professor Viatcheslav "Slava" Mukhanov, Chair of Cosmology at the Arnold Sommerfeld Center for Theoretical Physics in Munich. It was in connection with that visiting professorship, and a high-profiled workshop in August 2016, that the NBIA also brought Stephen Hawking to Denmark, for only the second time in Hawking's life. In 2017 the program continued with Simons Visiting Professor Steve Simon from Oxford who stayed at the NBIA in the spring of 2017. The subject concerned new topics in condensed matter physics, and the program included both a series of visiting scientists and two highly successful meetings, one of them organized jointly with Center for Quantum Devices (QDev) at the Niels Bohr Institute. In the fall of 2017 member of NBIA's Scientific Advisory Board Itamar Procaccia Professor of Chemical Physics at the Weizmann Institute) was Simons Visiting Professor, helping to organize two workshops. The first was on hot topics in the theory of turbulence, while the second focused on the physics of new materials and novel states of matter. The Simons Visiting Professors of the spring and fall of 2018 were Charles Bennett (IBM Fellow, IBM Research) and Oxford Professor Alex Schekochihin. Michael B. Green (Professor of Theoretical Physics at Cambridge University and Queen Mary University London) was Simons Visiting Professor during the spring of 2019 with a program largely focusing on amplitude calculations in string theory and field theory. The Simons Visiting Professor for the fall of 2019 was Charles Bennett (IBM Fellow, IBM Research) and it was planned to have Paul Steinhardt (Albert Einstein Professor of Science, Princeton University) as Simons Visiting Professor in the spring of 2020. Because of the pandemic, this latter program was postponed twice, until it finally could take place during the spring of 2022.

NBIA Colloquia

NBIA Colloquia consist of talks on a wide variety of subjects aimed at scientists who are not necessarily experts on the subject matter. Topics are not limited to physics but can cover any subject of interest to the wide spectrum of researchers and students at NBIA. 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. During 2022, the NBIA Colloquia returned to be fully "in-person" in Auditorium A. The list of talks and speakers follows below.

Jan Philip Solovej (Dept. of Mathematics, Univ. of Copenhagen) — 25.11.2022
"Universality in the structure of complex atoms and molecules"

Pia Quist (Department of Nordic Studies and Linguistics, Univ. of Copenhagen) — 11.11.2022
"Method in (socio)linguistics - Do we do different things the same way?"

Nathalie Wahl (Department of Mathematics, Univ. of Copenhagen) — 30.09.2022
"The Four-Colour Theorem"

Serge Belongie (Pioneer Center for Artificial Intelligence, Univ. Copenhagen) — 16.09.2022
"Searching for Structure in Unfalsifiable Claims"

Venkat Venkatasubramanian (Professor at Colombia University) — 12.08.2022
"A unified theory of emergent arbitrage equilibrium phenomena in active and passive matter"

Lyman Page (Princeton University) — 20.05.2022
"The gift that keeps on giving: observing the CMB in the post Planck era"

Rosemary Braun (Northwesteren University) — 22.04.2022
"Time for a Change: how a molecular clock enables life in a changing world"

Johan Rockström (Director of the Potsdam Institute for Climate Impact Research, Professor at the Institute of Earth and Environmental Science at Potsdam University) — 08.04.2022
"Holding the 1.5°C Line - Towards a Sustainable Future"

Michael Douglas (Simons Center, Stony Brook Univ. and CMSA Harvard University) — 25.03.2022
"How will we do mathematics in 2030?"

Geoffrey West (Santa Fe Institute) — 18.02.2022
"Scale: The universal laws of life, growth and death in organisms, cities, and companies"

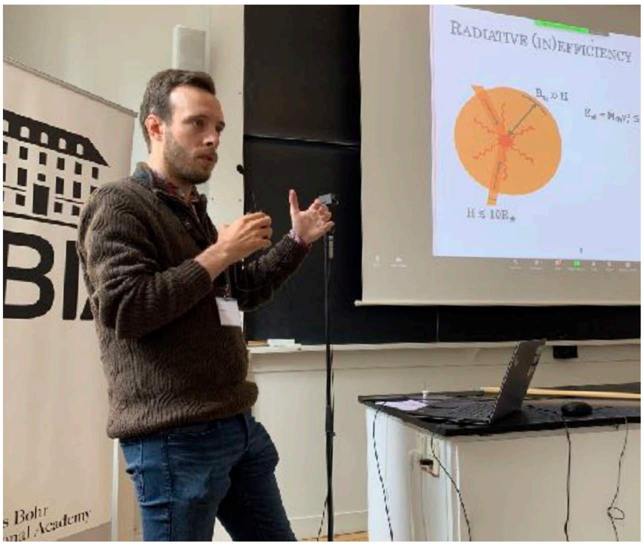
Prof. Serge Belongie — Director, Pioneer Center for AI — NBIA Colloquium

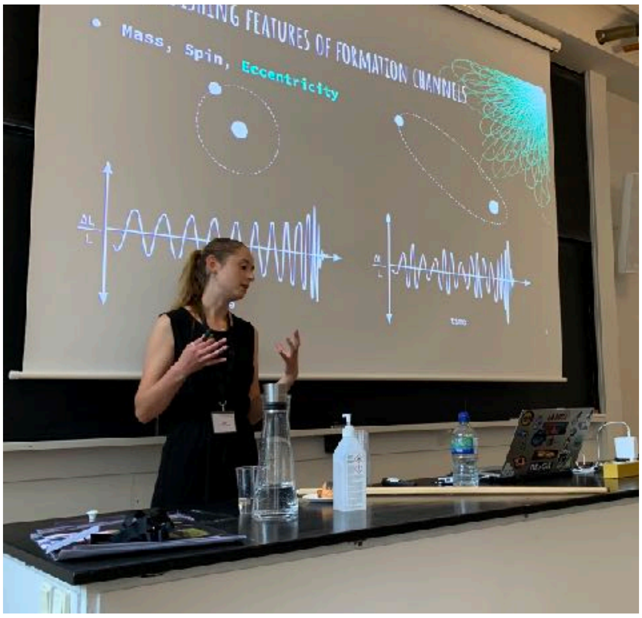
Maria Bergemann — MPIA, Heidelberg —- NBIA Workshop, Radiation Transfer in Astrophysics

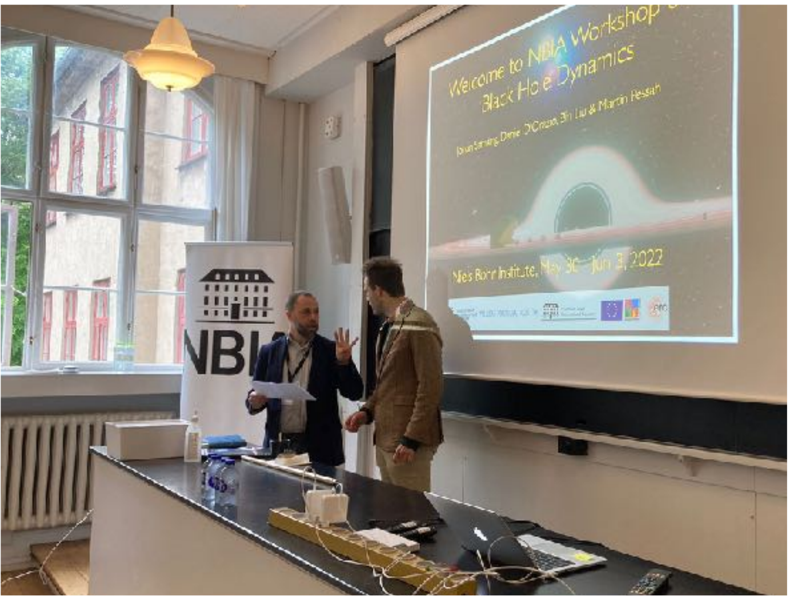
NBIA Seminars & Talks

Apart from the weekly series of NBIA Colloquia, members of the NBIA organize or co-organize numerous more specialized seminars and lectures. Members of the particle theory group at the NBIA co-organize up to two specialized seminars every week, held by visitors to the group. In condensed matter physics there is a flurry of activities and seminars organized through the QDev Center of Excellence, to which NBIA's condensed matter physics group belongs. In astrophysics the talks co-hosted by members of the NBIA are often held together with the Center for Star and Planet Formation. Astroparticle physics talks are customarily held on Mondays, often partially overlapping in topics with both astrophysics and particle physics. On any given week, it will be rare to find a day in which not at least one scientific event is being organized or co-organized by NBIA members. Topics range from gravitational waves emitted from black holes merging to the intricate mathematical structures behind quantum field theory amplitudes at high orders in perturbation theory.

A special opportunity for attracting scientific visitors and thus creating a flow of seminar and colloquium speakers is the NBIA programs for Visiting Professors, which typically open up for the opportunity to focus on a particularly hot subject in an area of interest to the Visiting Professor. The group working on biological physics at the NBIA has its own program of talks and lectures, also in conjunction with the new Novo Nordisk Foundation Visiting Professor program.






Welcome to NBIA Workshop on
Black Hole Dynamics
Niels Bohr Institute, May 30 - Jun 3, 2022
NBI


NBI


ALL BINARY BLACK HOLES MAY
FORM DYNAMICALLY:
THE ECCENTRIC PERSPECTIVE
LIGO
MONASH University

NBIA Workshops & PhD Schools

Building on Niels Bohr's vision, NBIA members engage in several activities aimed at promoting and enhancing the traditions of internationalism, interdisciplinarity and excellence in physics. The NBIA is instrumental in running approximately ten high-profile, international events every year to the benefit of the wider Institute community. The following events were organized by NBIA members during 2022:

"Nordic Winter School on Gravitational Physics" — 05.02 / 10.02.2022

"Scientific Symposium for Andrew Jackson" — 21.04 / 22.04.2022

"Simons Program: Forefronts of Cosmology and Gravitation" — 17.05 / 20.05.2022

"NBIA Workshop on Black Hole Dynamics: From Gaseous Environments to Empty Space" — 30.05 / 03.06.2022

"NBIA Workshop on Radiation Transfer in Astrophysics" — 06.6 / 10.06.2022

"Active & Intelligent Living Matter Conference" — 26.06 / 01.07.2022

"QDev/NBIA Summer School 2022" — 04.07 / 08.07.2022

"NBIA Summer School: Neutrinos: Here, There & Everywhere" — 11.07 / 15.07.2022

"Bohr-100: Current Themes in Theoretical Physics" — 01.08 / 05.08.2022

"6th Intracluster Medium Theory and Computation Workshop" — 15.08 / 19.08.2022

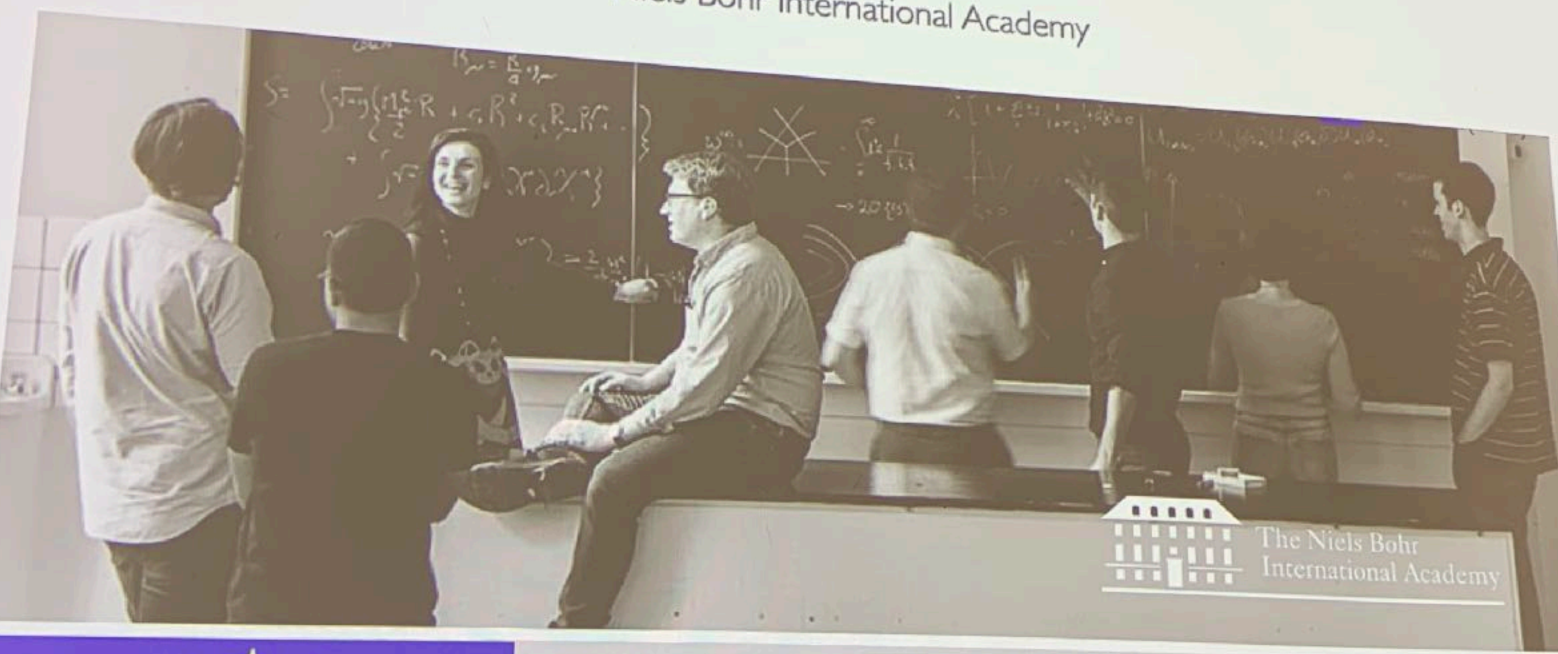
"NBIA Workshop on Jumpstarting Elliptic Bootstrap Methods for Scattering Amplitudes" — 26.09 / 28.09.2022

"Inauguration of the Villum Investigator Project: Illuminating the Dark Universe with Gravitational Waves" — 27.09.2022

INTERACTIONS Fellow's Day

Tips for Staying in Academia

Martin Pessah
March 31, 2022
Niels Bohr International Academy



HORIZON 2020

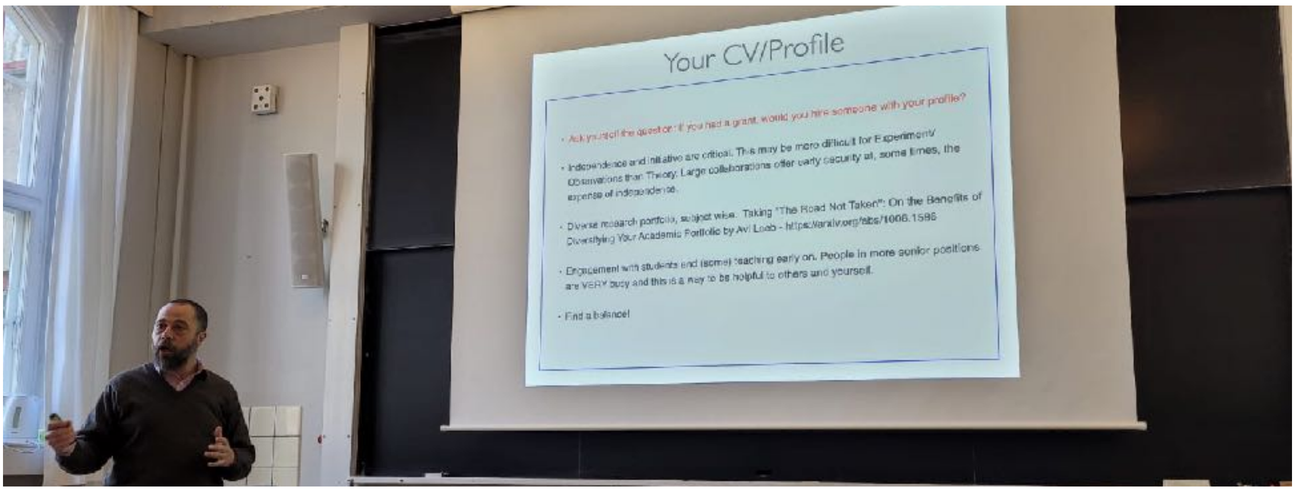
This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 847523.

INTERACTIONS Fellows' Day 2022

On March 31st, 2022, NBIA held the second "INTERACTIONS Fellows' Days''. The meeting took place in the famous Auditorium A on Blegdamsvej 17. Fellows and mentors participated in a stimulating event that included scientific talks and an informative presentations about tips for staying in academia as well as possible paths for careers in the private sector. The Fellows had the opportunity to interact with each other during coffee breaks and a very tasty lunch.







NBIA MSc Day 2022

October 12, 2022
Niels Bohr Institute
Europe/Copenhagen timezone

Enter your search term

- Overview
- Program
- Research
- Registration
- Participant List
- NBIA Brochure
- NBIA Linkedin

Contact

markus.ahlers@nbi.ku.dk

NBIA MSc Day 2022

The Niels Bohr International Academy (NBIA) invites prospective MSc students to an informal event "MSc Projects @ NBIA" on **Wednesday, October 12, 9am-1:30pm**. Join us on that day to learn more about the diverse research program at NBIA. You will have the chance to chat with scientists about their research and the possibilities to carry out your MSc project at NBIA.

The Niels Bohr International Academy (NBIA) is a center of excellence for theoretical physics and neighboring disciplines at the Niels Bohr Institute. Our mission is to attract the best and the brightest to Denmark and provide the environment to enable breakthrough research in theoretical particle physics, gravitational physics and astrophysics, theoretical astrophysics, biophysics and active matter, particle astrophysics, and condensed matter theory.

You can find more information on our NBIA website and brochure.

The NBIA staff includes several Professors, including a Villum Kann Rasmussen Professor and a DNRF Chair. A significant number of NBIA Assistant Professors and Associate Professors have started new research groups in their disciplines by attracting prestigious national and European grants. The NBIA hosts a large number of post-docs, PhD-students, and MSc-students. We have a steady stream of international visitors, who are invited to give seminars or collaborate with NBIA members.

The NBIA hosts around ten workshops, symposia and PhD-schools every year. We also reach out to the public with a number of activities, including an annual series of public lectures in collaboration with the Danish Open University. All in all the NBIA offers an incredible stimulating environment for students!

Starts Oct 12, 2022, 9:00 AM
Ends Oct 12, 2022, 1:30 PM
Europe/Copenhagen

Niels Bohr Institute
Auditorium A
Blegdamsvej 17
DK-2100 Copenhagen

Markus Ahlers
Martin Pessah
N. E. J Bjerrum-Bohr

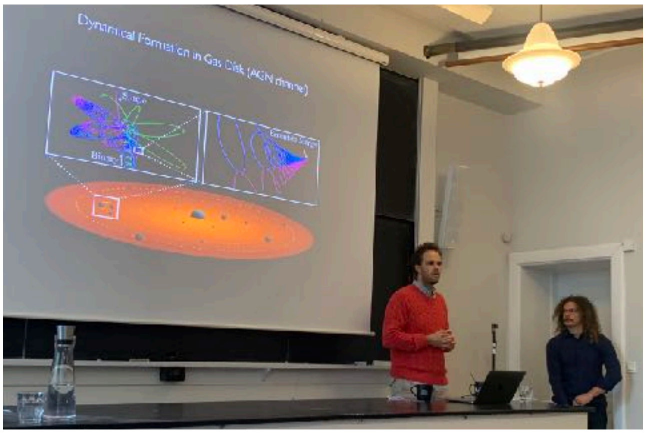
MScDay2022.pdf
nbia-brochure-2022.pdf

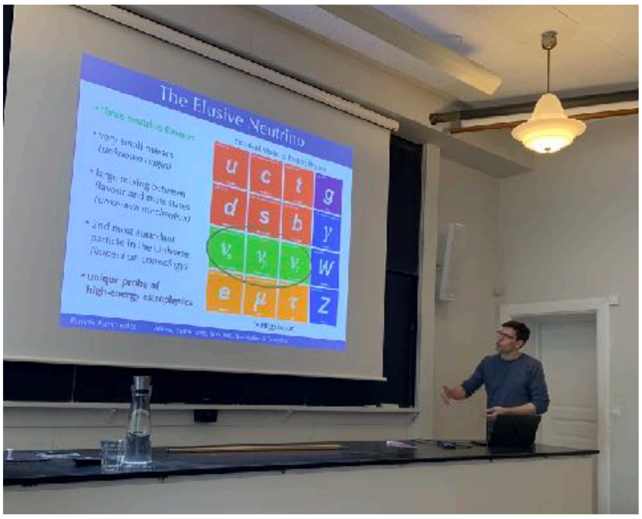
Registration
You are registered for this event.

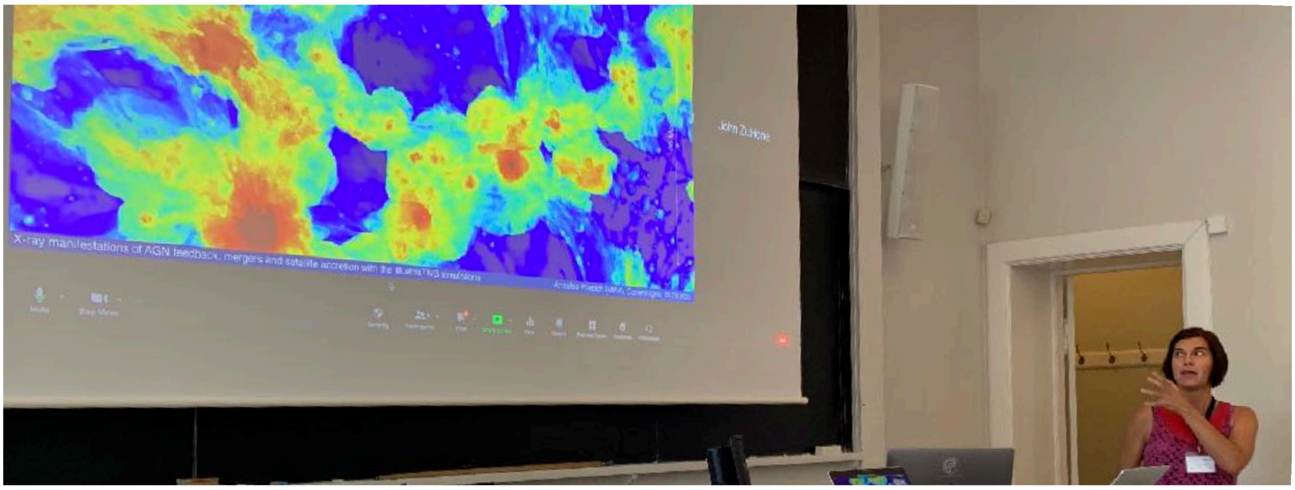
See details

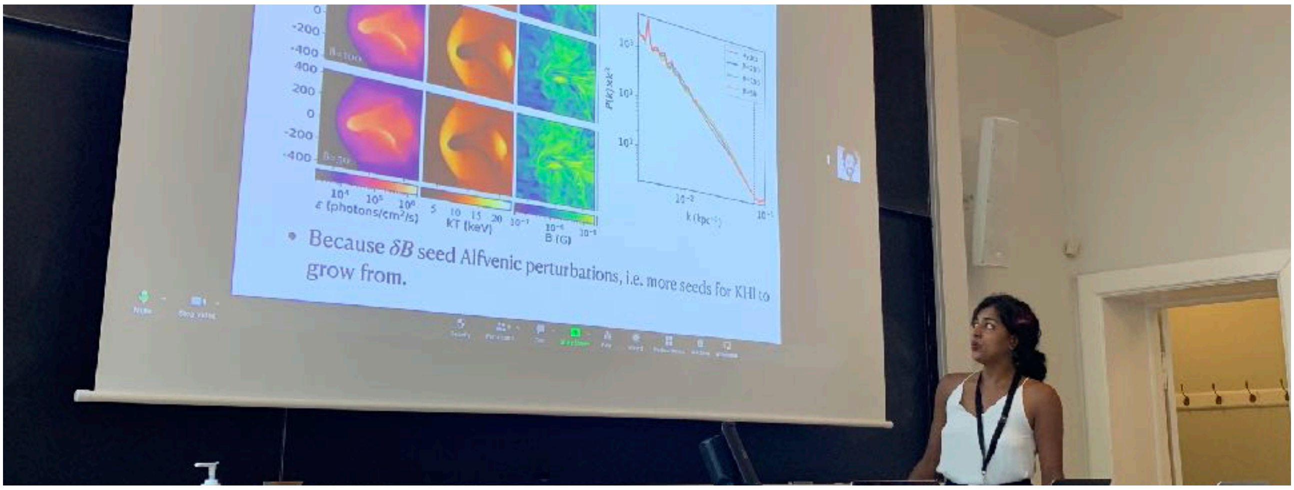
NBIA MSc Day 2022

Starting in 2018, scientists at NBIA began organizing an annual gathering for MSc students for them to learn more about the diversity of research opportunities at NBIA. During this one-day event, the students have the opportunity to attend a series of talks and meet with postdocs and young faculty member in order to discuss their research interests and the possibilities of carrying out Masters projects at NBIA.






X-ray manifestations of AGN feedback, mergers and satellite accretion with the IllustrisTNG simulations
John ZuHone


kT (keV)
B (G)
Because δB seed Alfvenic perturbations, i.e. more seeds for KHI to grow from.

NBIA Public Lectures & Outreach

Since 2011 the NBIA has organized an annual series of public lectures on physics in collaboration with the Danish Open University "Folkeuniversitetet". All lectures take place at the historic Auditorium A. 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.

Noticing that several of the attendees 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. This year's lectures included:

Eugene Simon Polzik (NBI) — 29.03.2022
"Quantum world without quantum uncertainty"

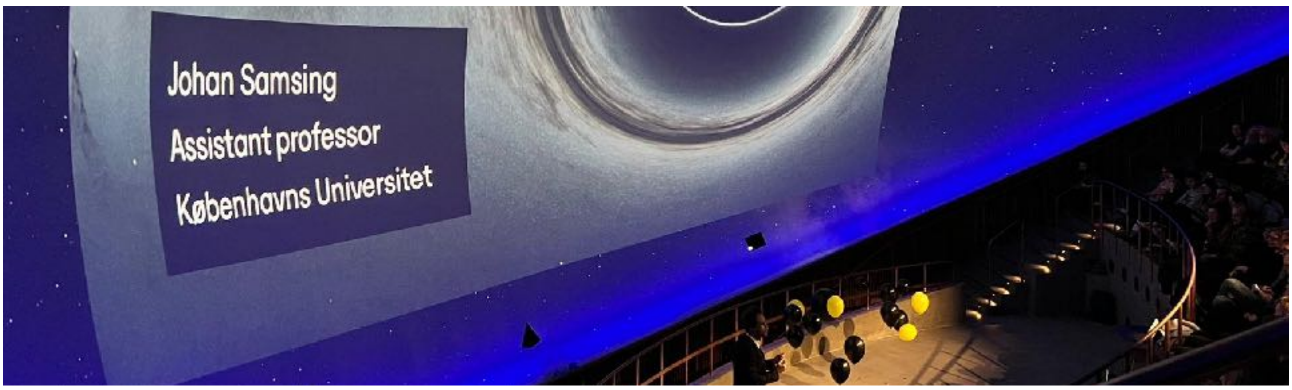
Poul Henrik Damgaard (NBIA) — 05.04.2022
"Shakes in spacetime: Gravitational waves from black holes"

Anja C. Andersen (NBI) — 19.04.2022
"From quanta to quasars: From the smallest to the largest scales"

Uffe Gråe Jørgensen (NBIA) — 26.04.2022
"Life on other planets - does it exist"

Kim Sneppe (NBI) — 03.05.2022
"Life models: From genes to epidemics"

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.




Niels Bohr Institute
Celebrates 100 years
1921 - 2021

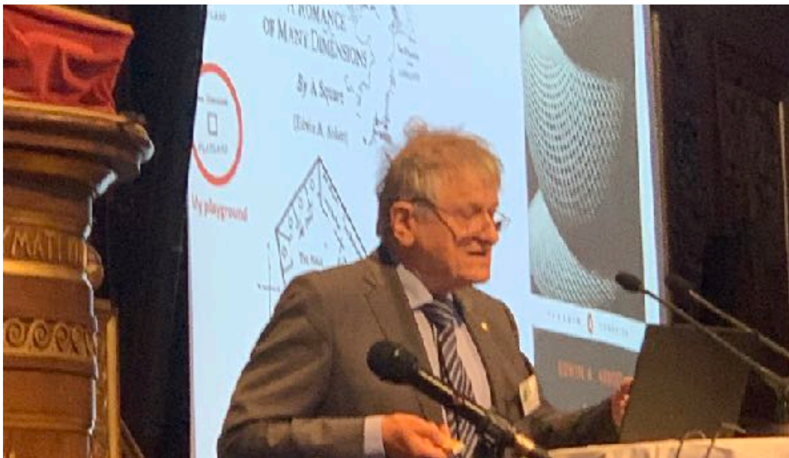

Niels Bohr Institute


Niels Bohr Institute


Medal of Honour 2020
Professor Paul J. Steinhardt
Niels Bohr Institute
1921 - 2021


Nobelpristageren,
professor,
dr. phil. & scient. & techn.
NIELS BOHR
Optaget januar 1952 for
Dansk Kulturfilm
af
A/S Nordisk Film Junior


Niels Bohr Institute


By A Square
My playground

Niels Bohr Institute Centennial

With one year delay due to COVID, the Niels Bohr Institute celebrated its centenary in March 2022. With Emil Bjerrum-Bohr as part of the organizing committee, NBIA contributed to the program and also doubled its number of public lectures during that special year. A number of Nobel Laureates and other luminaries participated in the program that also included a high-profiled celebration at Copenhagen's Town Hall. The venue of the scientific program was the Ceremonial Hall of Copenhagen University. The anniversary continued with a highlighted "Current Themes in Theoretical Physics and Cosmology" workshop in August 2022. The special series of public lectures in the Fall ranged in topics from fundamental physics at the atomic scale to black hole at astrophysical scales.

Charles M. Marcus (NBIA) — 11.10.2022
"Two-Dimensional Superconductor-Semiconductor Arrays"

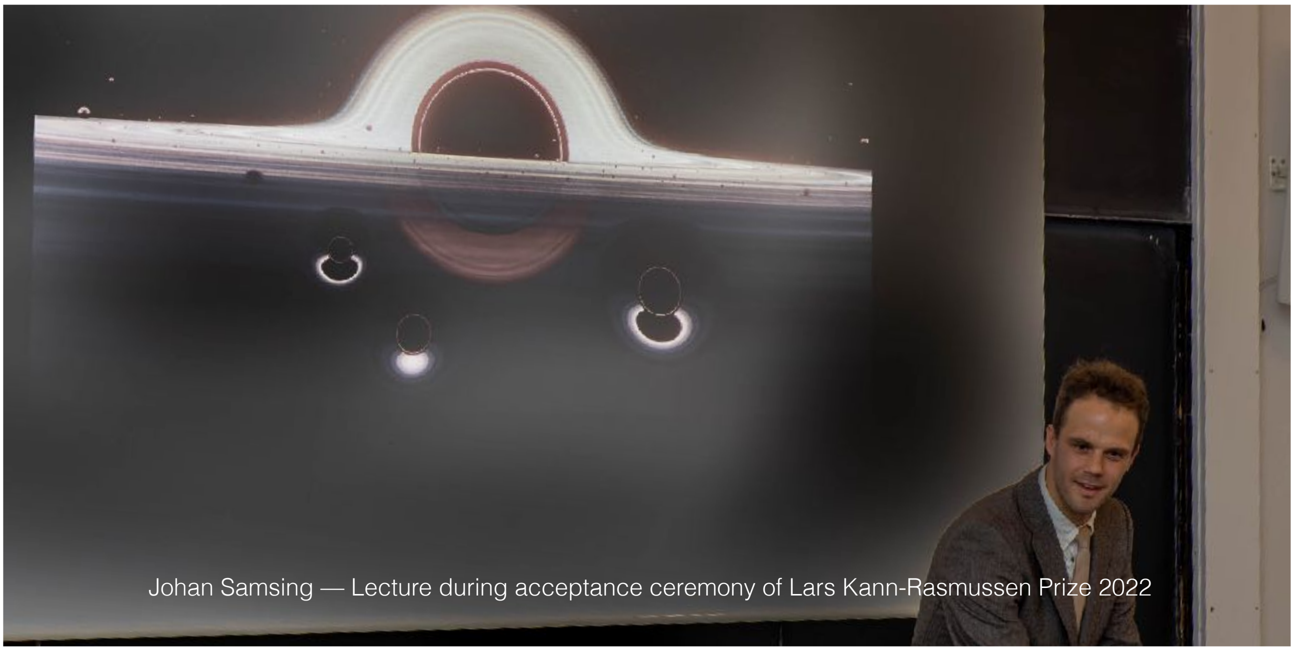
Peter Lodahl (NBI) — 25.10.2022
"From Niels Bohr's atomic model to modern one-photon light sources"

Irene Tamborra (NBIA) — 01.11.2022
"Tales of Cosmic Booms"

Jan W. Thomsen (NBIA) — 08.11.2022
"Modern quantum physics and applications"

Marianne Vestergaard (NBI) — 15.11.2022
"Black holes: from curiosity to an important piece in the evolution of the Universe"

Lene Kann-Rasmussen presents Johan Samsing with the Lars Kann-Rasmussen Prize 2022



Johan Samsing — Lecture during acceptance ceremony of Lars Kann-Rasmussen Prize 2022

Johan Samsing — Acceptance of Lars Kann-Rasmussen Prize 2022

Lars Kann-Rasmussen Prize 2022

In 2021 NBIA inaugurated a new annual science award: the **Lars Kann-Rasmussen Prize**. This prize is given every year to a young scientist who has made unique contributions to the physical sciences and related areas. The award has been established in honor of founding Chairman of NBIA's Director's Advisory Council Lars Kann-Rasmussen.

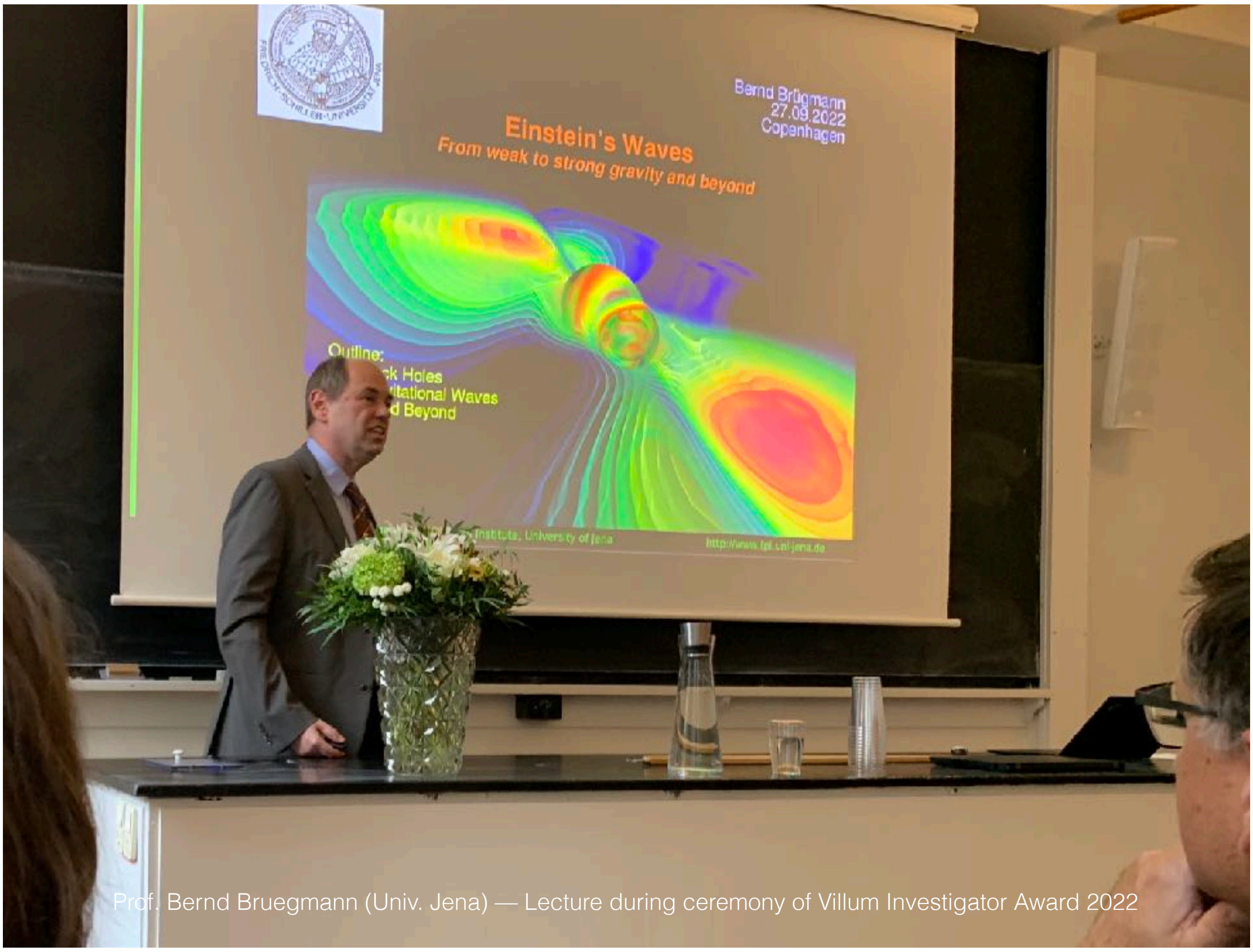
The 2022 award, which comes with a personal prize of 25,000 Kr, was presented by Lene Kann-Rasmussen to Louis-Hansen Foundation Assistant Professor Johan Samsing at an official ceremony in Auditorium A on Blegdamsvej on October 13. Johan Samsing received the award for his pioneering work in gravitational astrophysics, the precise citation being:

"*For his seminal contributions to the understanding of new mechanisms under which compact astrophysical objects can merge under the emission of distinct gravitational wave signals, thus leading to a precise determination of the astrophysical environments in which such binary gravitational mergers can occur.*".

Johan Samsing received his PhD in 2014 from the Niels Bohr Institute. Immediately after his PhD-degree he obtained two of the most prestigious fellowships in astrophysics worldwide: an Einstein Fellowship and a Spitzer Fellowship. This led Johan Samsing to Princeton University where he spent four years and where he also became a Fellow of Mathey College. Johan returned to Denmark in 2019 on an EU Marie Curie Fellowship while also receiving a Louis-Hansen Foundation Assistant Professorship at NBIA. Shortly afterwards Johan Samsing was awarded a Villum Young Investigator grant from the Villum Foundation and in 2022 he has also received an ERC Starting Grant from the EU. Johan Samsing's work has received well-deserved attention and is likely to pave the way for further breakthroughs in the future.


Johan Samsing — Lecture during acceptance ceremony of Lars Kann-Rasmussen Prize 2022

Prof. Lise Arleth, Deputy Dean of Research, Faculty of SCIENCE, University of Copenhagen



Prof. Bernd Bruegmann (Univ. Jena) — Lecture during ceremony of Villum Investigator Award 2022

Villum Investigator Vitor Cardoso

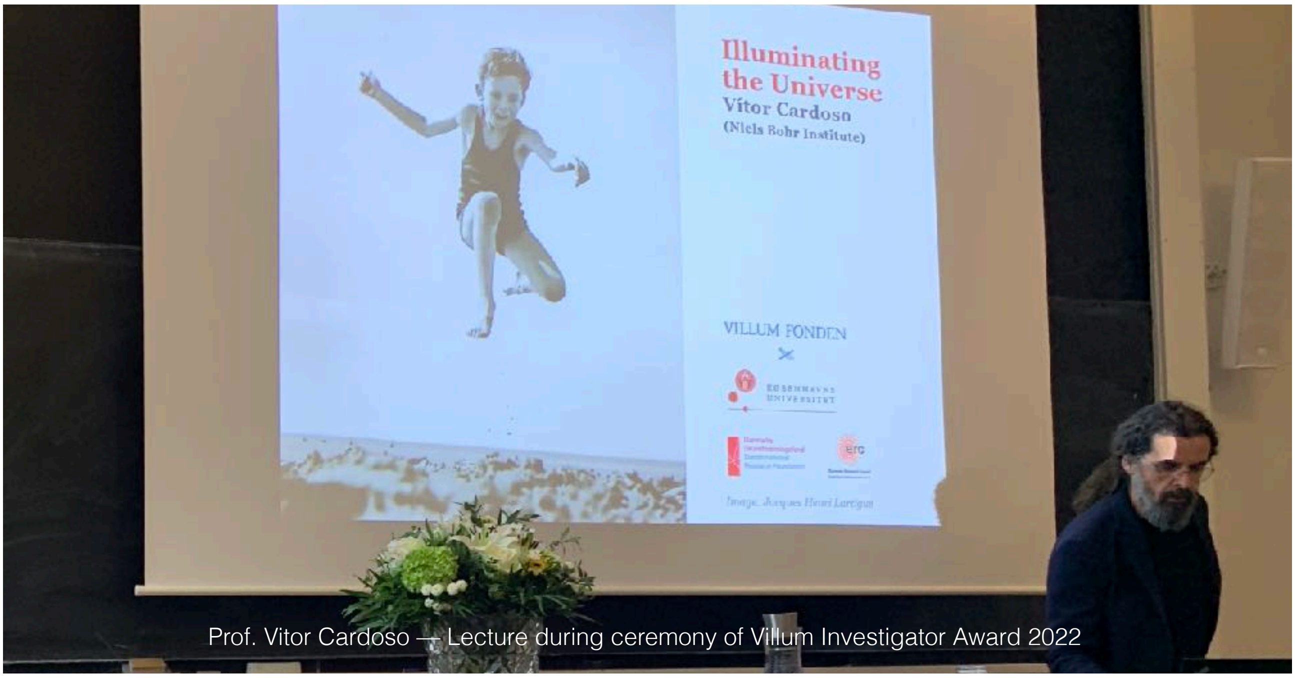
Based on a generous donation from the Villum Foundation, Vitor Cardoso has been recruited to lead a new research group on gravitational wave physics at NBIA. The inauguration took place in a packed Auditorium A on September 27, 2022. Deputy Dean of Research, Lise Arleth, welcomed Vitor Cardoso to the Faculty of Science at Copenhagen University and stressed the importance of bringing stellar talent to Denmark from abroad, a key goal for the Faculty of Science.

Continuing the ceremony, the Chairman of the Villum Foundation, Jens Kann-Rasmussen, expressed the satisfaction in seeing the foundation's Villum Investigator program leading to such strong impact. Finally, before Vitor Cardoso outlined his research strategy, gravitational-wave expert Bernd Bruegmann explained how this positions NBIA at the absolutely forefront in the field of modern gravitational physics. Bernd Bruegmann's opening line to the audience was “You have picked just the right person”.

By the fall of 2022 Vitor Cardoso's group was, remarkably, already in place. Named “Strong”, because it focuses on gravitational interactions in the new and largely unexplored domain where gravitational interactions and curvature of space-time become strong, the group already consists of more than twenty young researchers and PhD-students. From the observational side, gravitational wave data will soon be arriving at a rate no-one could have foreseen just a few years ago. This is part of an ongoing revolution in astrophysics where the gravitational wave detectors provide a new telescope to the Universe that hitherto was entirely hidden.

Jan W. Thomsen, Head of The Niels Bohr Institute, closed the inauguration with warm wishes from the Niels Bohr Institute, expressing the gratitude towards the Villum Foundation that has made this exciting development possible.

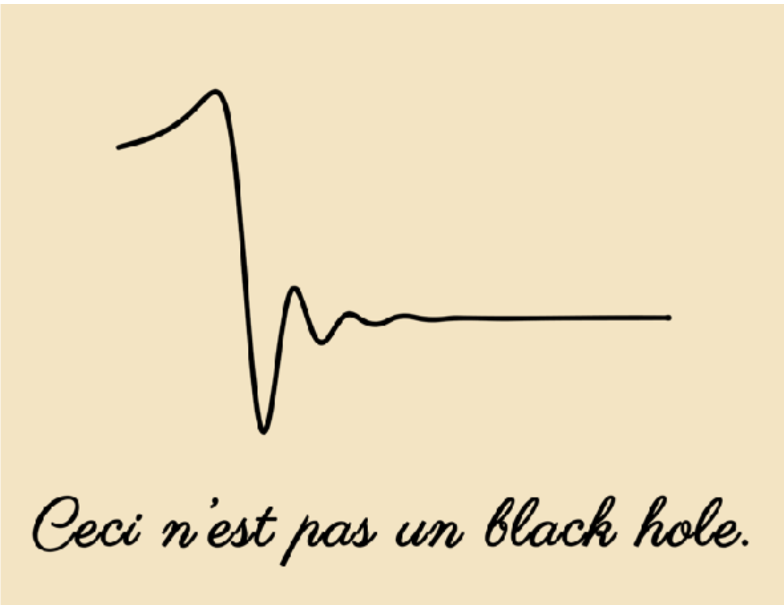
In addition to being Villum Investigator, Vitor Cardoso has also been named DNRF Chair with a grant from the Danish National Research Foundation.



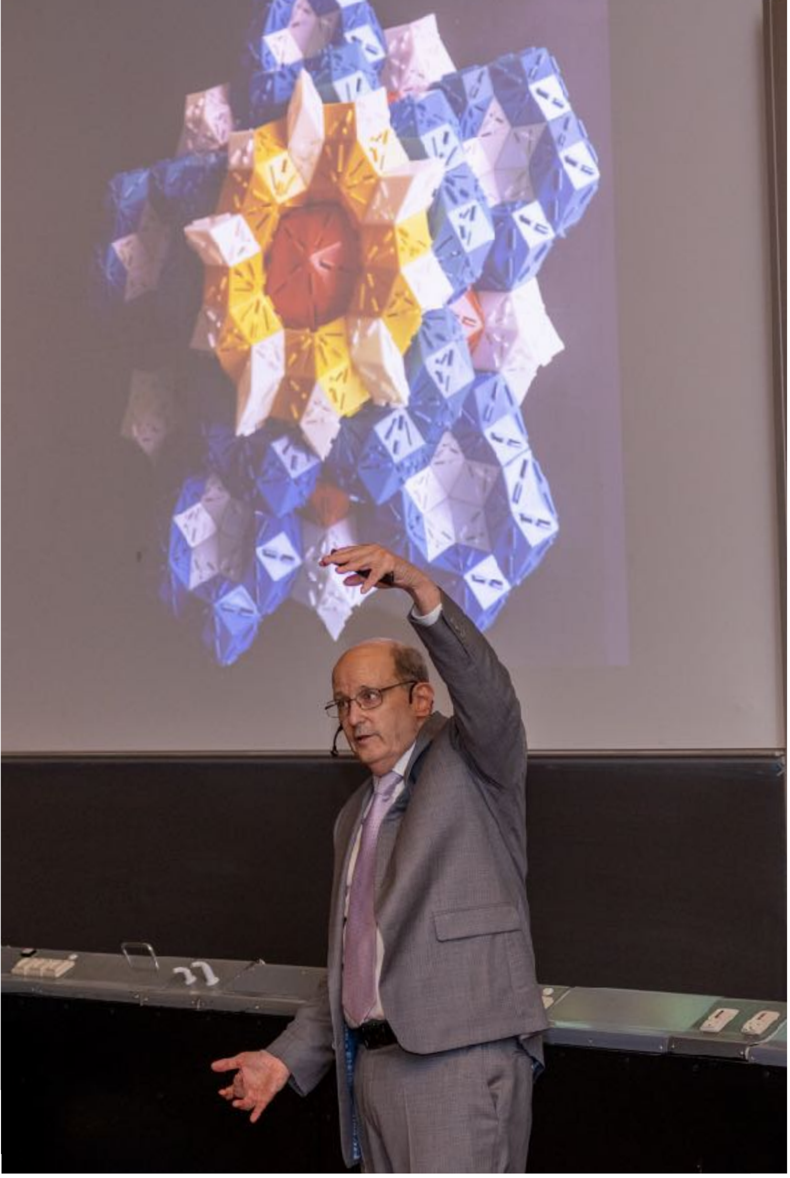
Prof. Vitor Cardoso — Lecture during ceremony of Villum Investigator Award 2022


strong.
niels bohr
institute


Illuminating
the Universe
Vítor Cardoso
(Niels Bohr Institute)
VILLUM FONDEN


Ceci n'est pas un black hole.

Prof. Vitor Cardoso — Strong Group



Profs. Poul H. Damgaard, Katrine K. Andersen, Paul J. Steinhardt, David D. Lassen, and Jan W. Thomsen (left to right)

Niels Bohr Medal - Paul Steinhardt

On August 3rd, 2022, Einstein Professor of Science Paul Steinhardt from Princeton University received the Niels Bohr Institute Medal of Honor.

Established in 2010 to mark the 125th anniversary of the birth of Niels Bohr, the Niels Bohr Institute Model of Honor is awarded every year to a particularly outstanding scientist working in the spirit of Niels Bohr. The medal was awarded to Paul J. Steinhardt

"*For his seminal and creative contributions to a remarkably wide range of subjects within the natural sciences, for his tireless advocacy of the unity of sciences, for his critical reconsideration of every scientific hypothesis that is not backed by experimental evidence, and for his remarkable skills of conveying to the public the excitement of scientific discovery.*"

Paul Steinhardt received his BSc from Caltech in 1974 and his PhD in Physics from Harvard University in 1978. He was Junior Fellow at the Harvard Society of Fellows until 1981 and he was on the faculty of the University of Pennsylvania from 1981 to 1998, at which point he accepted a Professorship at Princeton University. Paul Steinhardt was founding Director of the Princeton Center for Theoretical Science — 2007-2019.

Paul Steinhardt currently devotes most of his research efforts to cosmology where he is a leading figure. Often a visitor to the Niels Bohr Institute, Paul Steinhardt has served for a number of years as a very active and influential member of the International Science Advisory Board of NBIA.

Vice Rector of Copenhagen University David Dreyer Lassen and Dean of the Science Faculty Katrine Krogh Andersen were present at the award ceremony which concluded with a public lecture by Paul Steinhardt on his discovery of what is now known as quasicrystals, a term coined by him and discovered in nature by him.

Prof. Paul J. Steindhardt — Ceremony for Niels Bohr Medal 2022

Prof. Christopher Pethick — Nordita

NBIA Publications

Refereed Papers

1. **On rapid binary mass transfer - I. Physical model**
Lu, Wenbin, Fuller, Jim, Quataert, Eliot et al., 2022, MNRAS - ArXiv: 2204.00847

2. **Uncovering a hidden black hole binary from secular eccentricity variations of a tertiary star**
Liu, Bin, D'Orazio, Daniel J., Vigna-Gómez, Alejandro et al., 2022, Phys. Rev. D, 106, 123010 - ArXiv: 2207.10091

3. **Influence of tidal dissipation on outcomes of binary-single encounters between stars and black holes in stellar clusters**
Hellström, Lucas, Askar, Abbas, Trani, Alessandro et al., 2022, MNRAS, 517, 1695-1708 - ArXiv: 2203.00034

4. **Modeling continuum polarization levels of tidal disruption events based on the collision-induced outflow mode**
Charalampopoulos, Panos, Bulla, Mattia, Bonnerot, Clement et al., 2022, arXiv e-prints, arXiv:2212.05079 - ArXiv: 2212.05079

5. **Lensing or luck? False alarm probabilities for gravitational lensing of gravitational waves**
Çalişkan, Mesut, Ezquiaga, Jose Maria, Hannuksela, Otto A. et al., 2022, preprint - ArXiv: 2201.04619

6. **Measuring the Hubble constant with double gravitational wave sources in pulsar timing**
McGrath, Casey, D'Orazio, Daniel J., Creighton, Jolien et al., 2022, MNRAS, 517, 1242-1263 - ArXiv: 2208.06495

7. **Compact object mergers: exploring uncertainties from stellar and binary evolution with SEVN**
Iorio, Giuliano, Costa, Guglielmo, Mapelli, Michela et al., 2022, arXiv e-prints, arXiv:2211.11774 - ArXiv: 2211.11774

8. **Dynamical Disruption Timescales and Chaotic Behavior of Hierarchical Triple Systems**
Hayashi, Toshinori, Trani, Alessandro A. et al., 2022, ApJ, 939, 81 - ArXiv: 2207.12672

9. **GW190521 as a dynamical capture of two nonspinning black holes**
Gamba, R., Breschi, M., Carullo, G. et al., 2022, Nature Astronomy - ArXiv: 2106.05575

10. **Impact of massive binary star and cosmic evolution on gravitational wave observations - II. Double compact object rates and properties**
Broekgaarden, Floor S., Berger, Edo, Stevenson, Simon et al., 2022, MNRAS, 516, 5737-5761 - ArXiv: 2112.05763

11. **Growing Black Holes through Successive Mergers in Galactic Nuclei: I. Methods and First Results**
Atallah, Dany, Trani, Alessandro A. et al., 2022, arXiv e-prints, arXiv:2211.09670 - ArXiv: 2211.09670

12. **Combining effective-one-body accuracy and reduced-order-quadrature speed for binary neutron star merger parameter estimation with machine learning**
Tissino, Jacopo, Carullo, Gregorio, Breschi, Matteo et al., 2022, preprint - ArXiv: 2210.15684

13. **Electromagnetic emission from axionic boson star collisions**
Sanchis-Gual, Nicolas, Zilhão, Miguel, Cardoso, Vitor et al., 2022, Phys. Rev. D, 106, 064034 - ArXiv: 2207.05494

14. **Eccentric binary black holes: Comparing numerical relativity and small mass-ratio perturbation theory**
Ramos-Buades, Antoni, van de Meent, Maarten, Pfeiffer, Harald P. et al., 2022, preprint - ArXiv: 2209.03390

15. **Magnetic charges and Wald entropy**
Ortin, Tomas, Perẽniguez, David, 2022, JHEP, 11, 081 - ArXiv: 2207.12008

16. **4-OGC: Catalog of gravitational waves from compact-binary mergers**
Nitz, Alex, er H., Kumar, Sumit et al., 2022, preprint - ArXiv: 2112.06878

17. **Kicks in charged black hole binaries**
Luna, Raimon, Bozzola, Gabriele, Cardoso, Vitor et al., 2022, Phys. Rev. D, 106, 084017 - ArXiv: 2207.06429

18. **Model systematics in time domain tests of binary black hole evolution**
Kastha, Shilpa, Capano, Collin D., Westerweck, Julian et al., 2022, Phys. Rev. D, 105, 064042

19. **Linear momentum flux from inspiralling compact binaries in quasielliptical orbits at 2.5 post-Newtonian order**
Kastha, Shilpa, 2022, Phys. Rev. D, 105, 064039

20. **Carrollian Motion in Magnetized Black Hole Horizons**
Gray, Finnian, Kubiznak, David, Perche, T. Rick et al., 2022, preprint - ArXiv: 2211.13695

21. **Modified gravitational wave propagation with higher modes and its degeneracies with lensing**
Ezquiaga, Jose Maria, Hu, Wayne, Lagos, Macarena et al., 2022, JCAP, 08, 016 - ArXiv: 2203.13252

22. **Spectral Sirens: Cosmology from the Full Mass Distribution of Compact Binaries**
Ezquiaga, Jose Maria, Holz, Daniel E., 2022, Phys. Rev. Lett., 129, 061102 - ArXiv: 2202.08240

23. **Eigenvalue repulsions in the quasinormal spectra of the Kerr-Newman black hole**
Dias, Oscar J. C., Godazgar, Mahdi, Santos, Jorge E. et al., 2022, Phys. Rev. D, 105, 084044 - ArXiv: 2109.13949

24. **Nonperturbative gedanken experiments in Einstein-dilaton-Gauss-Bonnet gravity: nonlinear transitions and tests of the cosmic censorship beyond General Relativity**
Corelli, Fabrizio, De Amicis, Marina, Ikeda, Taishi et al., 2022, preprint - ArXiv: 2205.13007

25. **Disks, spikes, and clouds: distinguishing environmental effects on BBH gravitational waveforms**
Cole, Philippa S., Bertone, Gianfranco, Coogan, Adam et al., 2022, preprint - ArXiv: 2211.01362

26. **Nonlinear effects in black hole ringdown**
Cheung, Mark Ho-Yeuk et al., 2022, preprint - ArXiv: 2208.07374

27. **Photon Ring Astrometry for Superradiant Clouds**
Chen, Yifan, Xue, Xiao, Brito, Richard et al., 2022, preprint - ArXiv: 2211.03794

28. **Superradiant evolution of the shadow and photon ring of Sgr A***
Chen, Yifan, Roy, Rittick, Vagnozzi, Sunny et al., 2022, Phys. Rev. D, 106, 043021 - ArXiv: 2205.06238

29. **Stringent axion constraints with Event Horizon Telescope polarimetric measurements of M87**
Chen, Yifan, Liu, Yuxin, Lu, Ru-Sen et al., 2022, Nature Astron., 6, 592--598 - ArXiv: 2105.04572

30. **Birefringence tomography for axion cloud**
Chen, Yifan, Li, Chunlong, Mizuno, Yosuke et al., 2022, JCAP, 09, 073 - ArXiv: 2208.05724

31. **Axion haloscope array with PT symmetry**
Chen, Yifan, Jiang, Minyuan, Ma, Yiqiu et al., 2022, Phys. Rev. Res., 4, 023015 - ArXiv: 2103.12085

32. **Dissecting axion and dark photon with a network of vector sensors**
Chen, Yifan, Jiang, Min, Shu, Jing et al., 2022, Phys. Rev. Res., 4, 033080 - ArXiv: 2111.06732

33. **Constraints on Kerr-Newman black holes from merger-ringdown gravitational-wave observations**
Carullo, Gregorio, Laghi, Danny, Johnson-McDaniel, Nathan K. et al., 2022, Phys. Rev. D, 105, 062009 - ArXiv: 2109.13961

34. **Piercing of a boson star by a black hole**
Cardoso, Vitor, Ikeda, Taishi, Zhong, Zhen et al., 2022, Phys. Rev. D, 106, 044030 - ArXiv: 2206.00021

35. **Toward very large baseline interferometry observations of black hole structure**
Carballo-Rubio, Raúl, Cardoso, Vitor, Younsi, Ziri et al., 2022, Phys. Rev. D, 106, 084038 - ArXiv: 2208.00704

36. **Statistical validation of the detection of a sub-dominant quasi-normal mode in GW190521**
Capano, Collin D., Abedi, Jahed, Kastha, Shilpa et al., 2022, preprint - ArXiv: 2209.00640

37. **Kilohertz Gravitational Waves from Binary Neutron Star Mergers: Inference of Postmerger Signals with the Einstein Telescope**
Breschi, Matteo, Gamba, Rossella, Borhanian, Ssohrab et al., 2022, preprint - ArXiv: 2205.09979

38. **Cosmology with the Laser Interferometer Space Antenna**
Auclair, Pierre et al., 2022, preprint - ArXiv: 2204.05434

39. **New horizons for fundamental physics with LISA**
Arun, K. G. et al., 2022, Living Rev. Rel., 25, 4 - ArXiv: 2205.01597

40. **Virgo Detector Characterization and Data Quality: tools**
Acernese, F. et al., 2022, preprint - ArXiv: 2210.15634

41. **Virgo Detector Characterization and Data Quality: results from the O3 run**
Acernese, F. et al., 2022, preprint - ArXiv: 2210.15633

42. **Virgo Detector Characterization and Data Quality during the O3 run**
Acernese, F. et al., 2022, preprint - ArXiv: 2205.01555

43. **Model-based cross-correlation search for gravitational waves from the low-mass X-ray binary Scorpius X-1 in LIGO O3 data**
Abbott, R. et al., 2022, preprint - ArXiv: 2209.02863

44. **Search for continuous gravitational wave emission from the Milky Way center in O3 LIGO—Virgo data**
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45. **First joint observation by the underground gravitational-wave detector KAGRA with GEO 600**
Abbott, R. et al., 2022, PTEP, 2022, 063F01 - ArXiv: 2203.01270

46. **Search for gravitational waves from Scorpius X-1 with a hidden Markov model in O3 LIGO data**
Abbott, R. et al., 2022, preprint - ArXiv: 2201.10104

47. **All-sky search for continuous gravitational waves from isolated neutron stars using Advanced LIGO and Advanced Virgo O3 data**
Abbott, R. et al., 2022, preprint - ArXiv: 2201.00697

48. **Narrowband Searches for Continuous and Long-duration Transient Gravitational Waves from Known Pulsars in the LIGO-Virgo Third Observing Run**
Abbott, R. et al., 2022, Astrophys. J., 932, 133 - ArXiv: 2112.10990

49. **Search of the early O3 LIGO data for continuous gravitational waves from the Cassiopeia A and Vela Jr. supernova remnants**
Abbott, R. et al., 2022, Phys. Rev. D, 105, 082005 - ArXiv: 2111.15116

50. **Searches for Gravitational Waves from Known Pulsars at Two Harmonics in the Second and Third LIGO-Virgo Observing Runs**
Abbott, R. et al., 2022, Astrophys. J., 935, 1 - ArXiv: 2111.13106

51. **Search for Gravitational Waves Associated with Gamma-Ray Bursts Detected by Fermi and Swift during the LIGO—Virgo Run O3b**
Abbott, R. et al., 2022, Astrophys. J., 928, 186 - ArXiv: 2111.03608

52. **Predicting the Stability of Hierarchical Triple Systems with Convolutional Neural Networks**
Lal, e, Florian, Trani, Alessandro A. et al., 2022, ApJ, 938, 18 - ArXiv: 2206.12402

53. **Mergers prompted by dynamics in compact, multiple-star systems: a stellar-reduction case for the massive triple TIC 470710327**
Vigna-Gómez, Alejandro, Liu, Bin et al., 2022, MNRAS, 515, L50-L55 - ArXiv: 2204.10600

54. **Tidal disruption events by compact supermassive black hole binaries**
Ryu, Taeho, Trani, Alessandro A. et al., 2022, MNRAS, 515, 2430-2444 - ArXiv: 2202.07668

55. **Lagrange vs. Liapunov stability of hierarchical triple systems: dependence on the mutual inclination between inner and outer orbits**
Hayashi, Toshinori, Trani, Alessandro A. et al., 2022, arXiv e-prints, arXiv:2209.08487 - ArXiv: 2209.08487

56. **Revisiting the common envelope evolution in binary stars: A new semianalytic model for N -body and population synthesis codes**
Trani, Alessandro Alberto, Rieder, Steven et al., 2022, Phys. Rev. D, 106, 043014 - ArXiv: 2205.13537

57. **Wide binary pulsars from electron-capture supernovae**
Stevenson, Simon, Willcox, Reinhold, Vigna-Gómez, Alejandro et al., 2022, MNRAS, 513, 6105-6110 - ArXiv: 2205.03989

58. **Extreme Eccentricities of Triple Systems: Analytic Results**
Mangipudi, Abhi, Grishin, Evgeni, Trani, Alessandro et al., 2022, ApJ, 934, 44 - ArXiv: 2205.08703

59. **Evolution of stellar orbits around merging massive black hole binary**
Liu, Bin, Lai, Dong, 2022, MNRAS, 513, 4657-4668 - ArXiv: 2201.08399

60. **Multiciliated cells use filopodia to probe tissue mechanics during epithelial integration in vivo**
Ventura, Guilherme, Amiri, Aboutaleb, Thiagarajan, Raghavan et al., 2022, Nature Communications, 13, 1--15

61. **Distinct impacts of polar and nematic self-propulsion on active unjamming**
Venkatesh, Varun, Mondal, Ch, ana et al., 2022, The Journal of Chemical Physics, 157, 164901

62. **Quadrupolar active stress induces exotic patterns of defect motion in compressible active nematics**
Sultan, Salik A, Nejad, Mehrana R, Doostmohammadi, Amin et al., 2022, Soft Matter, 18, 4118--4126

63. **Strength in numbers: effect of protein crowding on the shape of cell membranes**
Ruhoff, Victoria Thusgaard, Moreno-Pescador, Guillermo, Pezeshkian, Weria et al., 2022, Biochemical Society Transactions, 50, 1257-1267 - ArXiv: https://portlandpress.com/biochemsoctrans/article-pdf/50/5/1257/939031bst-2021-0883c.pdf

64. **Nematic order condensation and topological defects in inertial active nematics**
Roozbeh Saghatchi, Mehmet Yildiz, Amin Doostmohammadi et al., 2022, Physical Review E, 106

65. **Molecular architecture and dynamics of SARS-CoV-2 envelope by integrative modeling**
Pezeshkian, Weria, Grünewald, Fabian, Narykov, Oleks et al., 2022, bioRxiv

66. **Obtaining efficient thermal engines from interacting Brownian particles under time-periodic drivings**
Mamede, Iago N, Harunari, Pedro E, Akasaki, Bruno AN et al., 2022, Physical Review E, 105, 024106

67. **Wrinkle force microscopy: a machine learning based approach to predict cell mechanics from images**
Li, Honghan, Matsunaga, Daiki, Matsui, Tsubasa S et al., 2022, Communications biology, 5, 1--9

68. **Filopodia rotate and coil by actively generating twist in their actin shaft**
Leijnse, Natascha, Barooji, Younes Farhangi, Arastoo, Mohammad Reza et al., 2022, Nature communications, 13, 1--16

69. **Martini 3 Coarse-Grained Force Field for Carbohydrates**
Grünewald, Fabian, Punt, Mats H., Jefferys, Elizabeth E. et al., 2022, Journal of Chemical Theory and Computation, 18, 7555-7569

70. **Reliability and entropy production in nonequilibrium electronic memories**
Freitas, Nahuel, Proesmans, Karel, Esposito, Massimiliano et al., 2022, Physical Review E, 105, 034107

71. **Self-sustained oscillations of active viscoelastic matter**
Emmanuel, LC, Le Thi, Huong, Yeomans, Julia M et al., 2022, Journal of Physics A: Mathematical and Theoretical, 55, 275601

72. **Synthetic Membrane Shaper for Controlled Liposome Deformation**
De Franceschi, Nicola, Pezeshkian, Weria, Fragasso, Alessio et al., 2022, ACS Nano

73. **Fluctuation-induced dynamics of nematic topological defects**
Bonn, Lasse, Ardaševa, Aleksandra et al., 2022, Physical Review E, 106, 044706

74. **Topological defects in biological matter**
Ardaševa, Aleksandra, Doostmohammadi, Amin et al., 2022, Nature Reviews Physics, 4, 354--356

75. **Unifying polar and nematic active matter: emergence and co-existence of half-integer and full-integer topological defects**
Amiri, Aboutaleb, Mueller, Romain, Doostmohammadi, Amin et al., 2022, Journal of Physics A: Mathematical and Theoretical, 55, 094002

76. **Bridging microscopic cell dynamics to nematohydrodynamics of cell monolayers**
Ardaševa, Aleksandra, Romain Mueller et al., 2022, Soft Matter, 18, 4737--4746

77. **Modeling gravitational few-body problems with TSUNAMI and OKINAMI**
Trani, Alessandro Alberto, Spera, Mario et al., 2022, arXiv e-prints, arXiv:2206.10583 - ArXiv: 2206.10583

78. **How Binaries Accrete: Hydrodynamic Simulations with Passive Tracer Particles**
Tiede, Christopher, Zrake, Jonathan, MacFadyen, Andrew et al., 2022, ApJ, 932, 24 - ArXiv: 2111.04721

79. **Compact Binary Coalescences: Astrophysical Processes and Lessons Learned**
Spera, Mario, Trani, Alessandro Alberto et al., 2022, Galaxies, 10, 76 - ArXiv: 2206.15392

80. **Reusability report: Comparing gradient descent and Monte Carlo tree search optimization of quantum annealing schedules**
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The Niels Bohr International Academy
Blegdamsvej 17
DK – 2100 Copenhagen Ø
www.nbia.dk