The Niels Bohr International Academy

Annual Report 2025

The Niels Bohr International Academy

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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.

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- **Martin E. Pessah,** Niels Bohr Institute (Deputy Director)
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- **Michael K. Rasmussen**
  Former Vice President, Brand in VELUX Group, private consultant

The Niels Bohr International Academy

From the Director

It is a remarkable fact that the first Endowed Chairs in academia date back to Rome's philosopher-emperor Marcus Aurelius. In 176 AD he established four such professorships in Athens, then recognized as the leading center of higher learning. The model he invented for these four Endowed Chairs has carried through essentially without change ever since: the Chairs should guarantee the continued existence of schools that in today's language would engage in research and in the teaching of young generations. The scope was perpetuity. These Chairs should also ensure independence of shifting fashions and rulers, and it is striking that three of the Endowed Chairs were designated to be in different philosophical directions than Marcus Aurelius's preferred Stoic school. To some degree even in direct opposition to it. Tellingly, Marcus Aurelius delegated the selection of the chosen professors to a committee in Athens over which he had no saying. Funds for the salaries, to be given for life, came from him. In not accepting that any one school might have found the final answers to all questions, he brushed aside both dogmatism and politically motivated agendas. Marcus Aurelius understood that criticism, open discussions, and sharpened arguments only lead to better understanding.

In Britain, donations by wealthy individuals to colleges (and later universities) began in the middle ages. The names of many of the oldest colleges at Oxford University and Cambridge University are linked to generous donations from wealthy patrons. To give just one example: Merton College at Oxford, whose name honors the patron Walter de Merton, was founded it in 1254 as the first entirely self-governed college at Oxford. The respect surrounding it has held up to this day! Among today's prominent scientists and scholars at Merton College is the mathematician Andrew Wiles who famously proved Fermat's Last Theorem not long ago. Andrew Wiles is Regius Professor in Mathematics at Merton College. From what does “Regius” in this named professorship derive? Readers with a flair for etymology will guess that it is related to royal, *i.e.* as originating with the crown of England, as it indeed does: Regius Professorships were invented by King Henry the 8th! The King founded no less than ten such named Chairs, first five for Cambridge University, and soon thereafter five for Oxford University as well. The first Regius Professorship in Mathematics had to wait for another king two hundred years later, and Andrew Wiles holds the first such Endowed Chair in Mathematics at Oxford University. These examples continue almost endlessly at Cambridge and Oxford Universities. Endowed Chairs, whole colleges, or university halls originating from generous private donors bring these two universities a robustness, continuity, and prestige that other universities struggle to match.

The tradition of Endowment Funds was quickly established in the US as well. Harvard University was not founded by John Harvard but his name has been honored by first changing the name from New College to Harvard College (and later to Harvard University) due to his large private donation in 1638. Similarly, the Collegiate School of Connecticut was renamed after Elihu Yale made a very significant donation in 1718. Most other prestigious named American universities originate in similar circumstances, and the tradition of private donations to academic institutions is at least as strong in the US as it is in Britain. The latest available figures for a stellar institution such as Institute for Advanced Study (IAS) at Princeton, which has around 25 permanent academic members distributed across areas of Historical Studies, Mathematics, Natural Sciences (currently Astrophysics, Particle Physics, and Systems Biology), and Social Science, lists an Endowment Fund in 2020 of close to roughly $800 million. The figure for 2025 is with certainty significantly higher. Interestingly, the original donation in 1930 by the benefactors Louis Bamberger and Caroline Bamberger Fuld amounted to $5 million, in current value less than one-tenth the total assets of today's Endowment Fund for IAS. Similar success stories are associated with all prestigious American academic institutions. Such growth in Endowment Funds in both Britain and the US comes from both good investments (reflecting general growth of wealth in society) and an increasing interest from wealthy individuals to act as benefactors for academic institutions.

It is notable that there exist very, very few examples of Endowment Funds in continental Europe. When the Villum Foundation offered NBIA to identify a stellar scientist whose salary would be paid by the foundation for the duration of the tenure, *this was Denmark's first Endowed Chair*. It became named after the founder of the Villum Foundation, Villum Kann Rasmussen. Charles Marcus, currently also member of NBIA's International Science Advisory Board, is Denmark's first Villum Kann Rasmussen Professor. The same Advisory Board has repeatedly urged NBIA to try to establish an Endowment Fund. As with all actions spearheading in new and unexplored territory (in our Danish context) this is not a simple task. But the dream to achieve this goal has never left us. For NBIA, accustomed to functioning with essentially no basic funding, it would be nothing less than a revolution. With stable annual income, even if it be in very modest amounts compared to the figures mentioned above, we would finally be able to realize the full potential that is just waiting to be released. The difference between jumping from one individual grant to the next and having known resources many years into the future is simply not possible to describe. With most valuable help from our Director's Advisory Council we aimed for an Endowment Fund more than five years ago, and although it did not pan out in the way we had envisioned (but nevertheless led to important institutional grants to NBIA), it was a most valuable experience. With firm hearts we now enter the field again, ready and prepared. More cannot be stated at this stage but we are warmed by all the goodwill around us. We need also quite some good luck, and here we are comforted by one of my favorite Latin proverbs: *audentes Fortuna iuvat* - fortune favors the bold.

For now, I offer you this Annual Report that illustrates the scientific activities at NBIA during 2025. The cover photo is a new tradition: from now on we will have a collective picture taken of all NBIA members in the fall when most new arrivals are joining us (Brooklyn, the dog, is considered an honorary member). In the following pages you will get an overview of the wide array of topics we currently focus on, an interdisciplinary combination of some of the hottest and most urgent research questions in theoretical physics today.

Poul Henrik Damgaard

From the Chair of the Council

The Unreasonable Effectiveness of Mathematics in the Natural Sciences

Over millennia, scientists have observed fundamental general facts about the universe, and new ones or refinements of old ones keep being discovered. We call them laws of nature, universal principles describing consistent observable patterns representing inherent regular order, such as gravity, Maxwell's equations, relativity and quantum mechanics.

The greeks were using math to figure out which natural law applied to the movement of planets, and Galileo Galilei famously stated that the universe is "written in the language of mathematics" thus arguing that math is the way to precisely model physical reality. In 1960, Eugene Wigner wrote a well-known paper under the title quoted above, in which he stated that "the enormous usefulness of mathematics in the natural sciences is something bordering on the mysterious" and "there is no rational explanation for it."

However, a fundamental property of the universe is that logic cannot be violated. Surely logic was invented by philosophers, but the inspiration came from observations of the universe. And logic is the parent of math, so math is a potential key to provide a framework that not only remains consistent, but allows us to make predictions such as the existence of the Higg's Boson decades before it was detected.

An early beautiful example of math leading the way was the observation that Uranus did not follow the path around the Sun predicted by the math developed based on Newton's law of gravity. A mathematician, Urbain Le Verrier assumed this was caused by an unobserved eighth planet, and calculated the exact coordinates where this phantom planet should be on Sept 23, 1846 and sent a letter to the Berlin Observatory with the coordinates, which led to the discovery of Neptune by the astronomer J. Galle within one degree of the predicted location.

Other fundamental predictions by math include Black Holes and Gravitational Waves, both finally confirmed recently - about 100 years after they were predicted by Einstein. Let's take a closer look at the math behind black holes. We all live in a 4-dimensional space, the 4th dimension being time. In 1915, Einstein published his "Field Equations", which basically describes the relationship between Matter and how it moves and Space and how it curves. Shortly after the physicist Karl Schwarzschild used the equations to describe what happens to the curvature of space around a perfectly spherical mass, and discovered if you crush a mass into a small enough radius (now called the Schwarzschild Radius R_s), and the escape velocity required for matter to leave would exceed the speed of light (even though the curvature of spacetime remains finite). So R_s is the "point of no return".

For decades, Black Holes remained "mathematical ghosts" - we could see their effects on nearby stars, but we could not see them. That changed in 2019 when the Event Horizon Telescope captured the first image of the M87* Black Hole. The image looked exactly like the math model predicted. It is fascinating that a place where gravity is so strong that even light cannot escape is governed by a very simple equation derived from the balance between an object's mass and the speed of light: $R_s = 2GM/c^2$, where G, is the Universal Gravitational Constant $6.674 \times 10^{-11} m^3 kg^{-1} s^2$, M is the mass, and c is th speed of light. If you double the mass, you double the radius. To illustrate how much "empty space" is actually inside atoms, which radius would it take to turn the Earth into a black hole? About 9 mm!

We now switch to quantum mechanics, an instance where Bohr's pioneering work on the electronic orbits around the atomic kernel was a discovery ahead of the math that eventually described the entire framework. The tool is known as matrix groups and how they act on vector spaces.

To illustrate, consider the 3-dimensional space we move in spanned by the 3 unit vectors $e_1 = (1{,}0{,}0), e_2 = (0{,}1{,}0), e_3 = (0{,}0{,}1)$. So the point, or vector, (x, y, z) is $xe_1 + ye_2 + ze_3$. Now consider the group S of permutations on 3 elements, of which there obviously are 6 altogether, and let it permute the set $\{e_1, e_2, e_3\}$. For each g in S, g acts on any point (x, y, z) by $g(x, y, z) = xg(e_1) + yg(e_2) + zg(e_3)$. Now consider 2 subspaces, one of dimension 1, say U, and one, say V, as follows: U of dimension 1 consists of all points $(x, x, x) = x(e_1 + e_2 + e_3)$ and V of all points $x(e_1 - e_2) + y(e_2 - e_3)$ of dimension 2. Notice that $z(e_1 - e_3) = z(e_1 - e_2) + z(e_2 - e_3)$ is in V as well. It immediately follows that S(U) = U. As for V notice that the 6 vectors $\pm(e_1 - e_2), \pm(e_1 - e_3), \pm(e_2 - e_3)$ form an orbit under the action of S, and S(V) = V as well. Each element of U is a fixed point of the entire S, whereas in V there are no general fixed points except (0,0,0), and no subspace of V is mapped to itself under S except (0,0,0), which is what is called an irreducible representation of S.

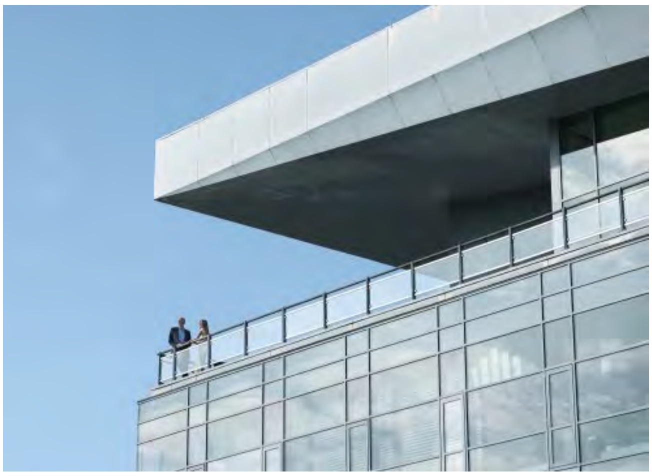
Back to quantum mechanics: A fundamental approach is to consider an atom as a system with spherical symmetry. As a consequence the group of rotations in 3 dimensions leaves the centered atom invariant under this action, whereas the various orbits – or shells – of electrons are acted upon and in fact becomes irreducible representations of the group, well understood and described by pure math just as we saw above, and out drops the the number of available seats for electrons in each shell as a dimension of an irreducible representation. Pure math.

We could go on, but in conclusion, there is overwhelming evidence that as we live in a "logical" universe, math is a universal language fit perfectly to describe physical laws and make predictions with infallible certainty. Wigner closed his paper by stating that this "miracle" as he calls it "is a wonderful gift which we neither understand nor deserve. We should be grateful for it and hope that it will remain valid in future research." We have tried to argue it is not a miracle at all, on the contrary.

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 only condition was that 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 supports research at NBIA that may potentially have large impact on the life sciences. These are research 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, mathematicians, biologists and medical scientists adds to 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, more recently, an ERC Starting Grant, he has already established a large junior research group. Amin Doostmohammadi received tenure at the Niels Bohr Institute in 2023. In 2021 the NBIA life-science program extended further by the simultaneous hire of Weria Pezeshkian (who works on computational biophysics) and Karel Proesmanns (who applied thermodynamics and statistical mechanics methods to biological systems). Weria Pezeshkian, who has also received an EU Marie Curie Fellowship, 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 also received an EU Marie Curie Fellowship and established a junior research group based on a project grant from the Novo Nordisk Foundation. In the fall of 2023 the NBIA bio-group extended further in new directions through the hire of Mary Wood who has a background in chemistry and who is pushing for new understanding of bio-electronic materials. Derived effects of this important grant can also be felt: Kristian Theissen, who originally came to NBIA on an EU Marie Curie Fellowship and who is now Assistant Professor here, has since received a large grant from the Novo Nordisk Foundation that has allowed him to establish his own junior research group on data science in biological physics. After a mid-term review of the grant in 2024 NBIA was given the go-ahead to complete the program within the total time-frame of twelve years.



Hoffmann and Husmans Fond

A large donation from the Hoffmann and Husman Foundation given to NBIA allows us to attract top talent from around the world as Hoffmann and Husman Foundation Visiting Scholars. Stays at 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. An important addition is Hoffmann and Husman Foundation Visiting Professorships which can support visiting professors on sabbaticals 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.

HOFFMANN & HUSMANS FOND

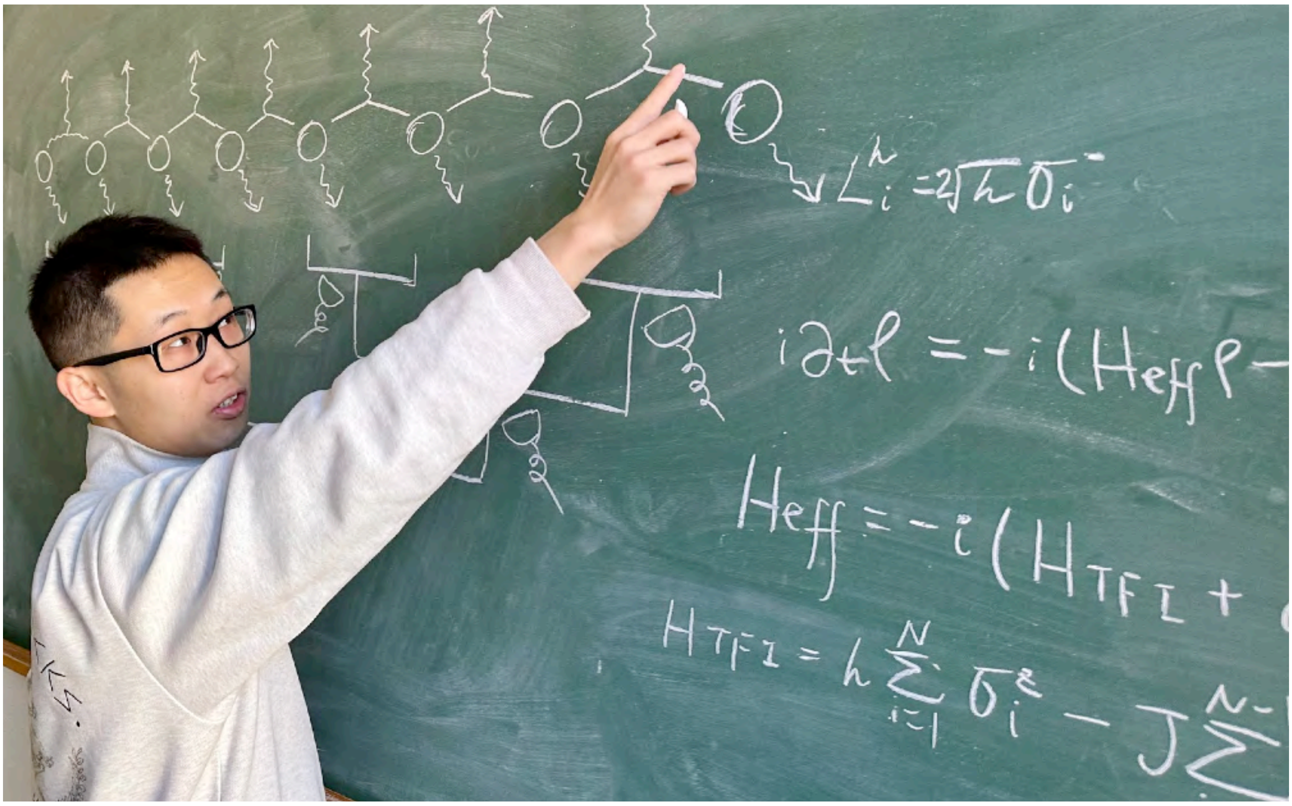
Hoffmann and Husman Foundation Scholarships are also available for invitations of collaboration partners for NBIA scientists and funds from the grant can be used to organize specialized smaller workshops. During 2025 this grant has in particular supported Hoffmann and Husman Foundation Visiting Professor James Cline from McGill University, as well as a number of visiting scientists on shorter stays at NBIA.

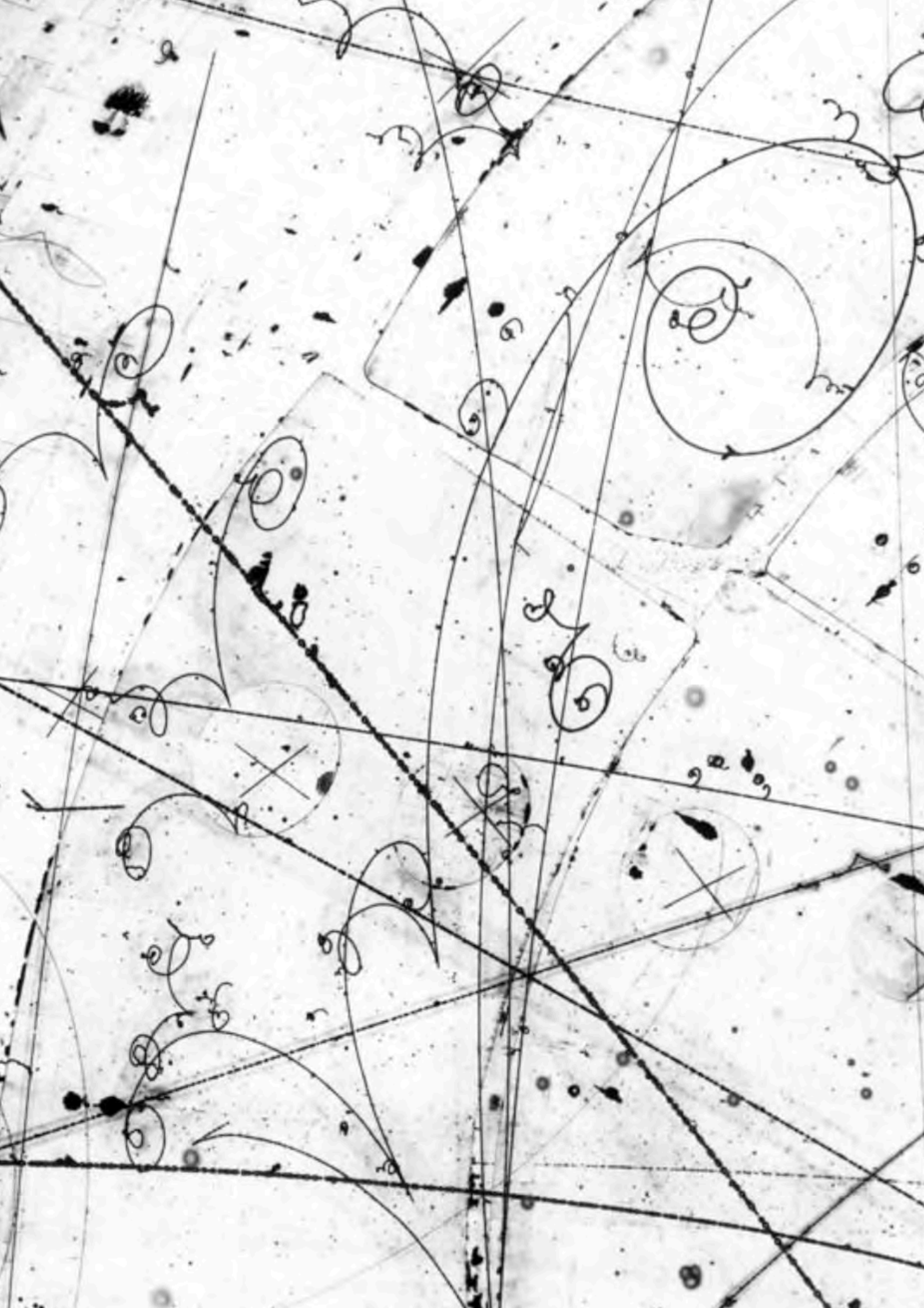
Louis-Hansen Foundation Grant

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 has allowed 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 has opened 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 postdoctoral years where they have been able to liberate themselves from their thesis topics and thus define their own research directions. These are scientists who can drive the NBIA in the coming years and who we now have invited 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. In 2023 NBIA appointed Apoorv Tiwari as new Louis-Hansen Foundation Assistant Professor. Apoorv Tiwari, who received a Villum Young Investigator grant in 2024, works in the new and rapidly growing field of non-invertible or so-called categorical symmetries which bridges between condensed matter physics and quantum sciences to high energy physics. From Princeton University comes Andrew Chael who takes up his position as Louis-Hansen Foundation Assistant Professor in 2026. Andrew Chael has also received a Villum Young Investigator grant that will allow him to establish his own junior research group.

Firuza Foundation Grant

In 2025 Firuza Foundation established a Firuza Foundation Fellowship for NBIA. The Firuza Foundation supports strategic philanthropic goals that address global challenges and foster scientific inquiry. As part of its commitment to advancing frontier scientific research, the foundation supports groundbreaking work in quantum sciences, and this has allowed NBIA to launch a new theoretical direction into the development of novel pathways for quantum computing, which promises to greatly outperform conventional classical supercomputing for specific complex tasks. First recipient of the Firuza Foundation Fellowship is Fan Yang who received his PhD from Tsinghua University in 2020 and subsequently held post-doctoral positions at Aarhus University, Niels Bohr Institute, and, most recently, University of Innsbruck. At NBIA Fan Yang works on the interface of quantum optics, quantum computing, and condensed matter physics. His work includes discovery of a successful scheme to manipulate interactions in atomic arrays in order to realize exotic phases of matter that have been predicted to exist but which so far have not been observed in experiments. Fan Yang works in close collaboration with the quantum optics group at the Niels Bohr Institute and with a large network of international collaborators around the globe. Specifically, the collaboration with Niels Bohr Institute scientists at the quantum optics group focuses on quantum correlations between photons which can serve as ideal media for distributing quantum information, a challenging but exciting task.





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 a 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 in theoretical physics.

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. The last call for new INTERACTIONS fellows closed in 2022 but towards the end of 2023 NBIA was given permission to extend some of the current contracts beyond the original end-date of 2024 so that some INTERACTIONS Fellows will now continue longer, some all the way to the end of 2026. More information on this program can be found at the INTERACTIONS website https://nbia.nbi.ku.dk/programs/nbia-interactions/.

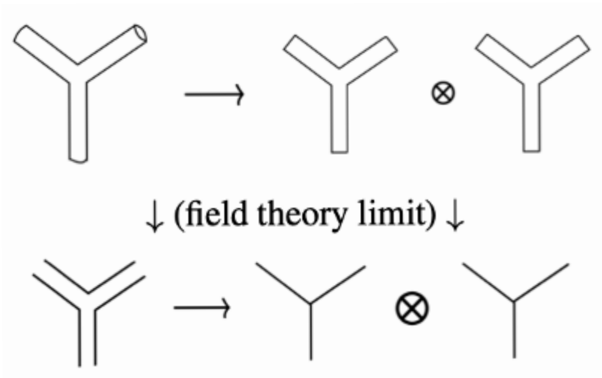
NBIA Research

Theoretical Particle Physics & Gravity

The theoretical particle physics group at NBIA studies the fundamental interactions of Nature, thus making contributions to the understanding of physics of the shortest length-scales probed by experiments such as that of the Large Hadron Collider at CERN. Remarkably, the same methods that are used to predict processes in the Standard Model of particle physics can with success also be used to solve the Einstein equations of classical gravity. This has given rise to great strides taken towards accurate analytical predictions for black hole interactions and associated gravitational wave emission, work that is needed for rapid match between incoming gravitational wave data and theory. By connecting those extremes, the group has been instrumental in describing how these seemingly different areas of physics are deeply related.

When protons interact at the Large Hadron Collider we are in fact dealing with individual scatterings not only among the proton constituents (quarks and gluons) but also among a host of other elementary constituents of matter and force-mediators between them. Described by relativistic quantum field theory, all these different interactions are used to compute physical observables such as cross sections and decay rates. In contrast to predictions of classical physics this requires highly sophisticated methods in quantum field theory that sums up all possible paths towards which a given observation can be reached. In technical terms this requires so-called loop integrations, high-dimensional integrals that cannot be tackled analytically by standard means. New methods are constantly being developed, and at NBIA a strong focus in recent years has been on providing a suitable basis of integrals from which physical observables can be computed. A group at NBIA has been at the forefront of developing a new approach based on so-called intersection theory from mathematics. This new method holds the promise of being superior to other methods at high orders in perturbation theory. By a stroke of luck, the same technique can also hold the key to identifying which mathematical functions are required at each new order of perturbation theory in Einstein's theory of gravity. We shall return to this below.

While quantum field theory is required to describe the intricate particle physics processes at CERN, Einstein's classical theory of gravity may appear superficially far simpler. For each physical process involving classical gravity there is only one path involved in its solution. Objects follow orbits determined by a set of differential equations, Einstein equations of motion. There is no quantum uncertainty here, and yet, to much surprise, quantum field theoretical techniques can with advantage be used to determine the orbits of two (or more) massive objects interacting gravitationally. The discovery of this has sparked numerous new approaches to classical general relativity, and the group at NBIA has played leading roles in several of these novel methods. Central is a translation from a quantum mechanical scattering amplitude (as described by the gravitational S-matrix) describing gravitational scattering to the computation of purely classical observables (for the corresponding classical scattering process) in Einstein gravity. This describes in a systematic manner the classical scattering dynamics of two non-spinning black holes. In matching data with theory it is in a first



approximation quite sufficient to consider the interactions of two such non-spinning black holes. But in reality black holes are almost invariably bound to also carry intrinsic spin. It is therefore urgent to understand how the formalism extends in such a way as to include spin, and much work at NBIA has recently been focused on this extension.

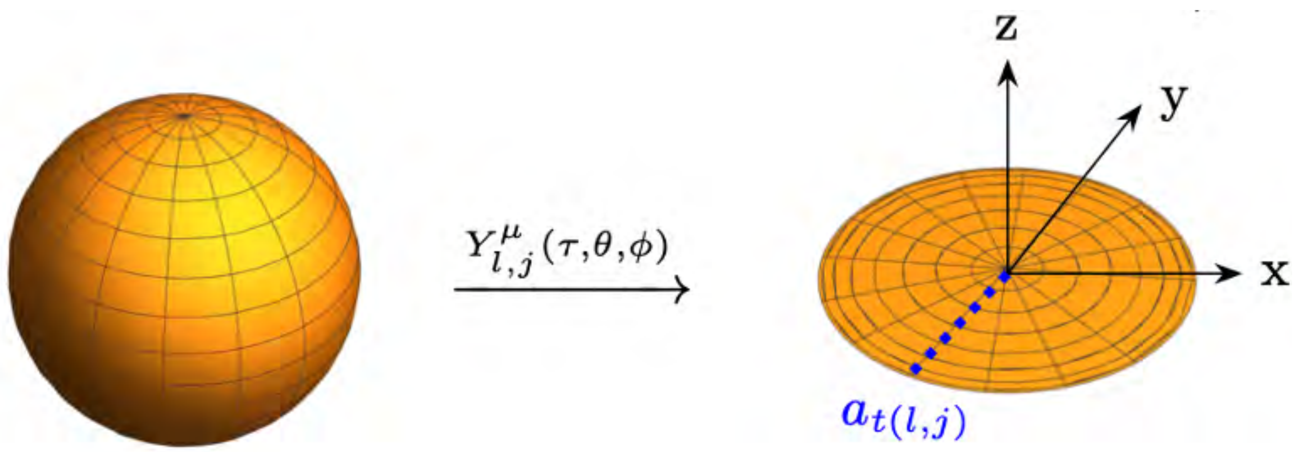
Once the relation to quantum mechanical scattering amplitudes has been established, an immediate bottleneck for computations will be the evaluation of loop integrals just as for evaluation of scattering amplitudes. Members of the NBIA group have applied the same techniques that allow for a determination of the space of functions needed for processes at the Large Hadron Collider to the gravitational case. Not unexpectedly, the space of functions needed for the classical evaluations is significantly smaller than the full space, and the potentially appearing functions can be determined order by order in perturbation theory. This list of possible functions forms an important check on the final calculations.

When calculating scatterings in classical general relativity, it can be advantageous to employ a beautiful link between tree-level amplitudes in gravity with corresponding tree-level amplitudes of gluons. Such relations are most easily understood from the point of view of string theory (although string theory is not needed to prove them). Diagrammatically, one can illustrate such relations for three-point functions as shown in the figure below in the previous page. A closed-string amplitude contains a graviton component, and when written in terms of open strings its field theory limit relates graviton amplitudes to gluon amplitudes as shown.

Similar relations hold when gravitons couple to matter, yielding so-called double copy relations for amplitudes. In this abstract way, the scattering of two black holes can be mapped to the scattering based on interactions with gluons, a remarkable dual description of weakly-coupled gravity.

The puzzle of how to describe the quantized version of gravity is not relevant for the above scattering processes. Nevertheless with observational confirmation of the existence of black holes, the issue of a consistent theory of quantum gravity has become more urgent. NBIA scientists are working on a variety of different directions and are playing an important role in bringing scientists in this field to Copenhagen.

Eventually, major research goals include precise analytical descriptions of gravitational wave emission from events that also involve neutron stars, thus directly merging the field of gravitational wave physics with astrophysics and in particular the physics of these extremely massive objects that also has links to nuclear astrophysics. Novel approaches are still needed to describe spinning black holes and perhaps ideas from mathematical physics-inspired models can lead to an understanding of the classical dynamics of spinning black holes, as illustrated below.



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 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.

One of the most burning questions in Particle Astrophysics revolves around the role of neutrinos in compact astrophysical sources. In particular, neutron star 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 relying on hydrodynamical simulations of core-collapse supernovae. To this purpose, we have developed numerical simulations that track the neutrino flavor conversion in the core of compact sources. In parallel, we worked to find a simple analytical recipe that can predict the final flavor configuration without solving the kinetic equations numerically to account for this physics in large-scale hydrodynamic simulations.

Neutrinos could be powerful probes of unexplored astrophysical sources. This is the case of Thorne-Zytkow Objects. We have shown that existing neutrino telescopes can inform us about the existence of such fascinating sources, which are easy to confuse with red supergiants, if one were to rely on electromagnetic radiation only; current generation of gravitational wave detectors is not yet sensitive to such sources. Moreover, we have computed the flux of neutrinos produced from all stars in the Milky Way throughout their lifetime. Using data from Gaia, a space observatory of the European Space Agency, we explored which Galactic regions send the most neutrinos. We found that a large neutrino flux should be expected from stars populating the Galactic Center. Hence, the detection of such a signal could provide powerful insight on the inner workings of our Milky Way.

In 2025, we have modeled the production of neutrinos and electromagnetic radiation from short gamma-ray bursts, pinpointing the efficient sites of particle acceleration. In order to do that, we have solved the particle transport equations relying on general relativistic magnetohydrodynamic simulations. Moreover, we have computed the impact of radiation on the structure of a magnetized shock, highlighting the importance of accounting for the feedback of particles on the source physics--something currently neglected. Our work clearly shows that it is crucial to move beyond naive models of particle production and take into account the non-linear mixing of matter in the source to model the electromagnetic and neutrino signals.

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, and participates in the planning of future neutrino telescopes. Moreover, members in our group were heavily involved in the deployment of a new neutrino telescope, the Giant Radio Array for Neutrino Detection (GRAND) in the Gobi Desert, in China, whose goal is to eventually observe ultra-high-energy cosmic neutrinos, first predicted in 1969. The experiment consists of an array of antennas that target the radio emission that is expected when these neutrinos collide with the Earth's atmosphere, triggering large particle showers that travel in the air and that emit short-lived radio pulses that travel for up to 100 km before hitting the ground. In 2025, we reported the first candidates cosmic rays observed by the prototype array, consisting of 65 antennas. Members of our group are part of the Executive Board of the experiment, coordinate its publications, and guide its science output.

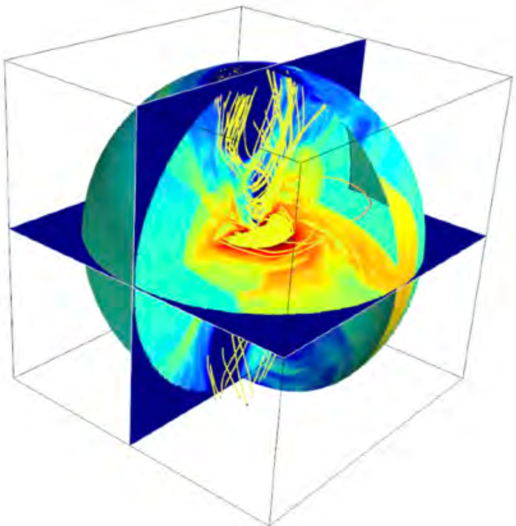
In 2025, scientists in our group have maintained strong ties with researchers at the Max Planck Institutes in Garching through the Collaborative Research Center sponsored by the Deutsche Forschungsgemeinschaft and we have been active in a number of outreach activities. Moreover, we have hosted a very successful series of seminars on a broad range of topics in Astrophysics and Astroparticle Physics, attracting visitors from around the world.

In July of 2025, we organized the fourth edition of the NBIA Neutrino School “Here, There & Everywhere”, directed at PhD students and advanced MSc students. The school was a resounding success. Over the course of a week, around 50 students from around the world received lectures on neutrino phenomenology, astrophysics, and cosmology from world experts, and presented their work to their peers.

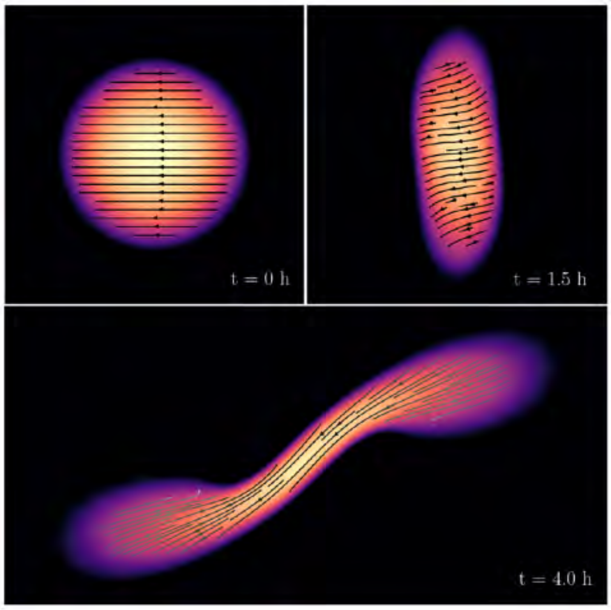
Theoretical Astrophysics

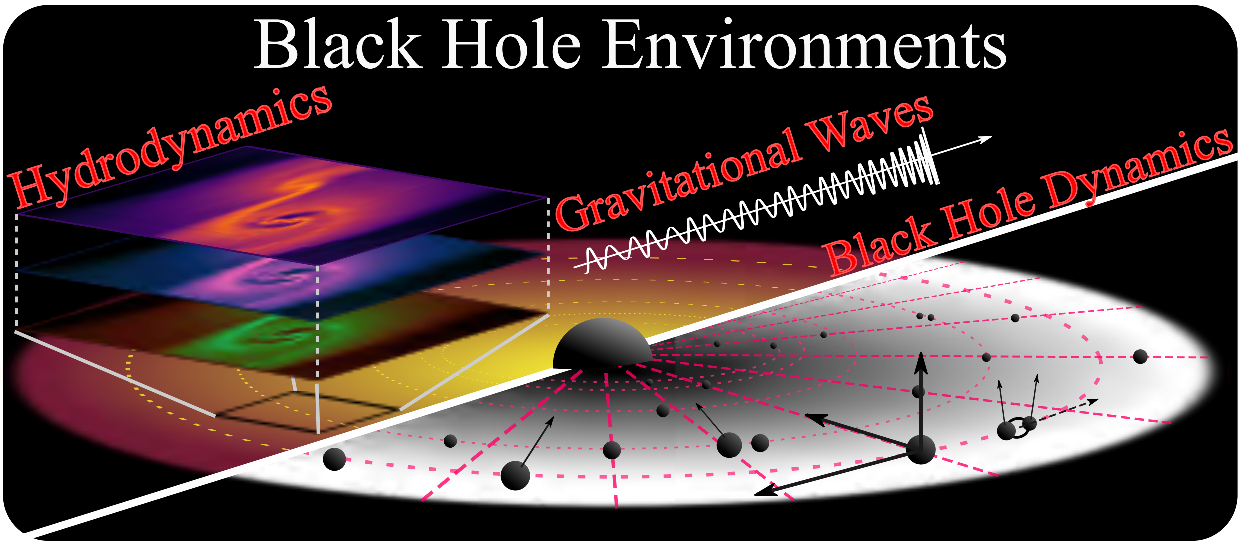
The Theoretical Astrophysics Group at NBIA strives for a comprehensive approach to astrophysics. Current research areas encompass protoplanetary disks and planet formation, accretion phenomena related to various types of compact objects, galaxy clusters, and the physics of gravitational-wave sources. All problems are tackled with a wide perspective, ranging from fundamental theoretical aspects to state-of-the-art simulations with the aim of linking theory and models with observations. A summary of research activities during 2025 follows below.

Understanding the dynamical evolution of satellites embedded in disks around a more massive object is a fundamental problem that connects with many branches of astrophysics. These range from planetesimals in cicumplanetary disks to planets in circumstellar disks to stellar-mass black holes in disks around massive black holes in active galaxies. In collaboration with scientists in the Czech Republic and Mexico, our group has initiated a program to study this problem across a wide range of scales. As a first important step, we have carried out global simulations of an embedded satellite in a turbulent magnetized disk and showed that this leads a bipolar outflow on scales comparable to the satellite's Hill sphere. Beyond establishing the physical mechanism for outflow launching, this first set of simulations provides a foundation for more elaborate physical models.

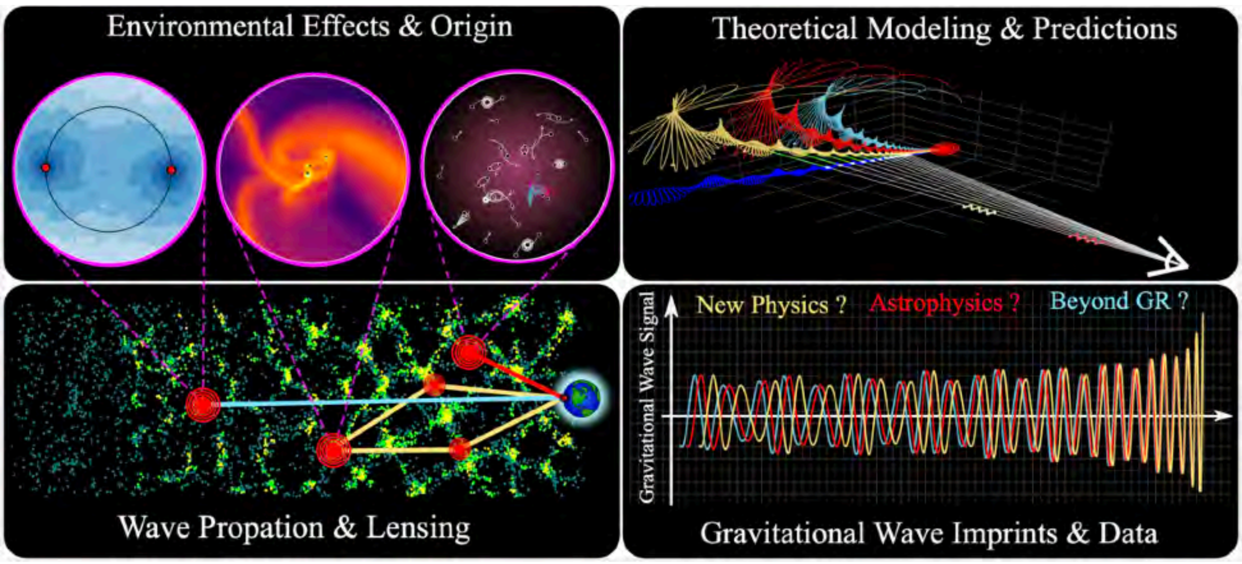


When a star passes too close to a supermassive black hole, it gets tidally disrupted by strong tidal forces. The stellar debris then evolves into an elongated stream of gas that partly falls back towards the black hole, which accretes part of it. The flash of electromagnetic radiation produced during tidal disruption events is a unique probe of the central supermassive black holes in distant galaxies. Several tens of tidal disruptions have already been detected and their number is about to skyrocket with the advent of observational facilities such as the Rubin Observatory. Fully exploiting these observations demands a precise characterization of the detectable signatures from tidal disruptions that can be used to interpret the wealth of upcoming data in an optimal way. In collaboration with researchers at the University of Birmingham, we have developed the first models that enable us to understand the role played by magnetic fields when a star is tidally disrupted. We have shown that magnetic pressure can become important in a significant fraction of the mass of the stream, leading to a fast increase in its thickness. Our long term goal is to shed light on the role of magnetic fields in enabling angular momentum transport in the ensuing accretion disk, thereby determining the observable signatures associated with tidal disruption events such as X-ray radiation and relativistic outflows.





Gravitational wave astrophysics continues developing vigorously at NBIA. We have now seen ~200 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. Our 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.



Quantum Sciences

A notable recent development is the convergence of condensed matter physics, quantum optics, and high-energy physics, largely driven by excitement surrounding new advances in quantum computing—an area now broadly referred to as Quantum Sciences.

One of the new fields being studied at NBIA is the application of techniques from integrable spin models to the study of quantum systems subjected to non-trivial boundary conditions or abrupt changes due to interactions with the environment. In particular, we may ask: What happens when a quantum system is exposed to a sudden disturbance, known as a quantum quench?

This question is of interest for the entire quantum community from condensed matter experimentalists working with cold atoms to theorists operating in the realm of quantum information theory. In the Villum Investigator group we apply methods from theoretical high energy physics to answer questions about the post-quench behavior of specific quantum systems outside the traditional realm of condensed matter physics.

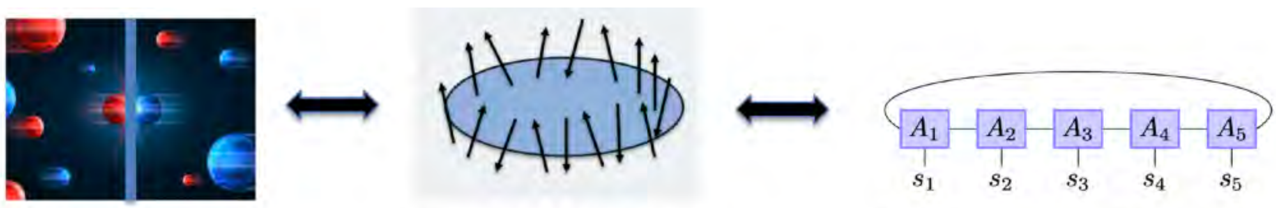
In quantum mechanics one has a duality between particles and waves which constitutes a cornerstone of the theory. In the same way, one of the pillars of modern theoretical high energy physics takes the form of a duality, namely a duality between quantum field theory and string theory, known as the Maldacena duality.

In quantum field theory one describes the smallest constituents of matter as particles whereas in string theory one describes these as one-dimensional objects known as strings. A special feature of the duality is that the preferred states of the two theories can be identified with the preferred states of a much simpler system, a so-called spin chain which is exactly a quantum many body system of the type that one can use to model the systems of cold atoms that one uses for quantum quench experiments.

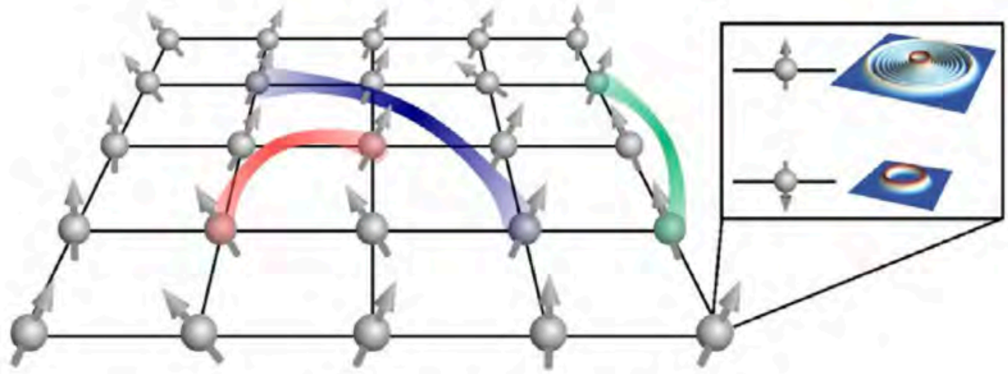
In the Villum Investigator group we work on the connection between quantum field theory and quantum many body systems. On the quantum field theory side we are considering systems with defects or boundaries. Defects and boundaries are ubiquitous in physics since realistic physical systems are not perfect and they typically have boundaries. We are particularly interested in defects which arise as a consequence of the field theory in question having a non-trivial vacuum. A famous example of a quantum field theory with a non-trivial vacuum is the Standard Model of Particle Physics where the Higgs particle arises precisely as a consequence of the non-trivial vacuum. An example of a defect of the above type could be a domain wall which separates two regions of space where the quantum field theory is in different vacua.

It turns out that considering such a defect in the quantum field theory entering the Maldacena duality corresponds to performing a quench (a disturbance) of the underlying quantum many body system (spin chain) as illustrated the figure

In the Villum investigator group we work on developing exact methods to describe the behavior of the quantum many body system after a quench using the language of quantum information theory.



Defect — Quench Initial State — Matrix Product State



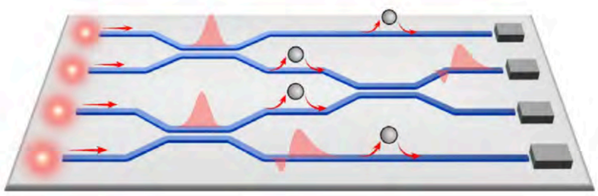
For instance, domain wall defects and their corresponding quench initial states are described as matrix product states which are known in quantum information theory for their ability to encode a specific (limited) amount of quantum entanglement. Furthermore, we are working on giving a quench description of specific defects which play a central role in theoretical high energy physics.

Examples are one-dimensional defects known as Wilson and 't Hooft lines, the behavior of which can signal phase transitions in a quantum field theory. Most recently, we have identified the equivalent of a black hole in the quantum many body system. Such a state is described in terms of a random matrix product state and has an unlimited amount of quantum entanglement.

Another active area in Quantum Sciences relates to the manipulation of quantum many-body phenomena and quantum states in atomic, molecular, and optical systems. We are examining many-body quantum optics. Real-world physical problems often concern complex many-body systems governed by the laws of quantum mechanics. As highlighted by Nobel laureate Philip Anderson's famous notion "more is different", completely new physics phenomena would emerge in such a quantum many-body system even if the elementary interactions are well understood. Atomic, molecular, and optical (AMO) system has recently emerged as a promising platform for constructing many-body setups through bottom-up approaches, facilitating a number of quantum information processing tasks, such as efficient quantum simulators and secure communication channels.

At NBIA, we are focusing on theoretical descriptions of such AMO many-body systems, including development of theoretical approaches for efficiently describing the manybody dynamics, exploration of new many-body phenomena in a hybrid setup, and construction of novel schemes for quantum information processing. We are currently studying many-body spin dynamics in a Rydberg atom array and multiphoton scattering in a strongly coupled system with quantum nonlinearity. Here, Rydberg atoms serve as stationary matter qubits for storing and processing quantum information, while propagating photons are ideal to transfer and distribute it. The interplay between stationary and flying qubits can further improve the performance of both systems and leads to a hybrid quantum network.

As a near-term goal, we are trying to develop a unified, tensor-network based framework for describing the many-body dynamics in such a hybrid system, going beyond existing methods that can only treat the dynamics semi-classically or in the few-particle regime. In addition to pure theoretical contributions, we will design novel protocols for quantum information processing and aim to realize our theoretical proposals experimentally. Theory-experiment collaborations with world-leading laboratories at NBI, Max Planck Institute of Quantum Optics, and ETH Zurich are already planned.



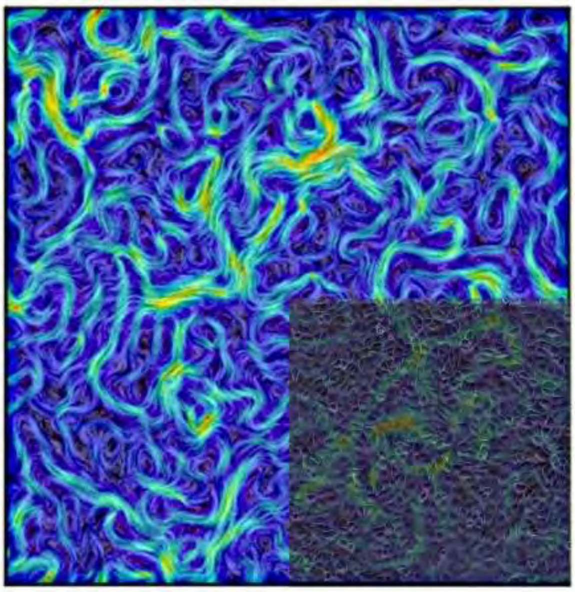
Soft Matter Physics & Active Matter

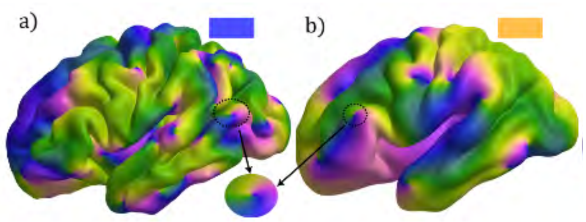
Soft matter physics lies at the heart of a quantitative understanding of many biological processes. From subcellular protein-driven flows to multicellular organ formation, biological matter continuously drives itself away from thermodynamic equilibrium using internal biochemical processes. In addition 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 expanded 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.

The core idea is to design a novel class of Living Matter, comprised of a viscoelastic and adaptive phase freely embedded within spontaneously flowing biofluids. 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.

Mechanostransduction: 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, our group will combine 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.

Topological analyses of biological data — The group also works on developing and applying methods from computational and applied geometry and topology to characterize and understand the emergence of order and self-assembled structures in a variety of soft matter and biophysical systems. This work takes place at the interfaces between theory, simulation, and experiments, with the aim of providing clear ways to interpret and relate results from various sources directly to one another.

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 such 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 applications.

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 FreeDTS, a software package to simulate a biological membranes at the mesoscale. Our current focus is to understand how biomolecules come together and form the architecture of the cellular powerhouse.

A new toolbox to reveal bioelectronic interfaces — We aim to unravel and rewire the complex biointerfaces between photosynthetic biofilms and electrode surfaces, which lie at the heart of the rapidly growing field of bioelectronic devices that use photosynthetic organisms such as cyanobacteria wired to electrodes to renewably generate electrical energy, fuels and chemical feedstocks. These technologies are extremely promising, but remain limited by slow electron transfer at the biofilm/electrode interface, which has proven particularly challenging to surmount, due to poor understanding of the key mechanisms at these interfaces. Of particular interest is the thylakoid membrane, which is the site of photosynthesis in plants and cyanobacteria. These thylakoid membranes can be extracted and deposited directly onto the electrode for improved light harvesting, but are still limited by our poor understanding of their electron transport mechanisms.

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 Curie Institute) and Japan (Osaka University), as well as with the Novo Nordisk Foundation Center for Stem Cell Medicine and Novo Nordisk Foundation Center for Protein Research to profile NBIA as one of the leading institutions in these rapidly growing areas of research.

NBIA Staff

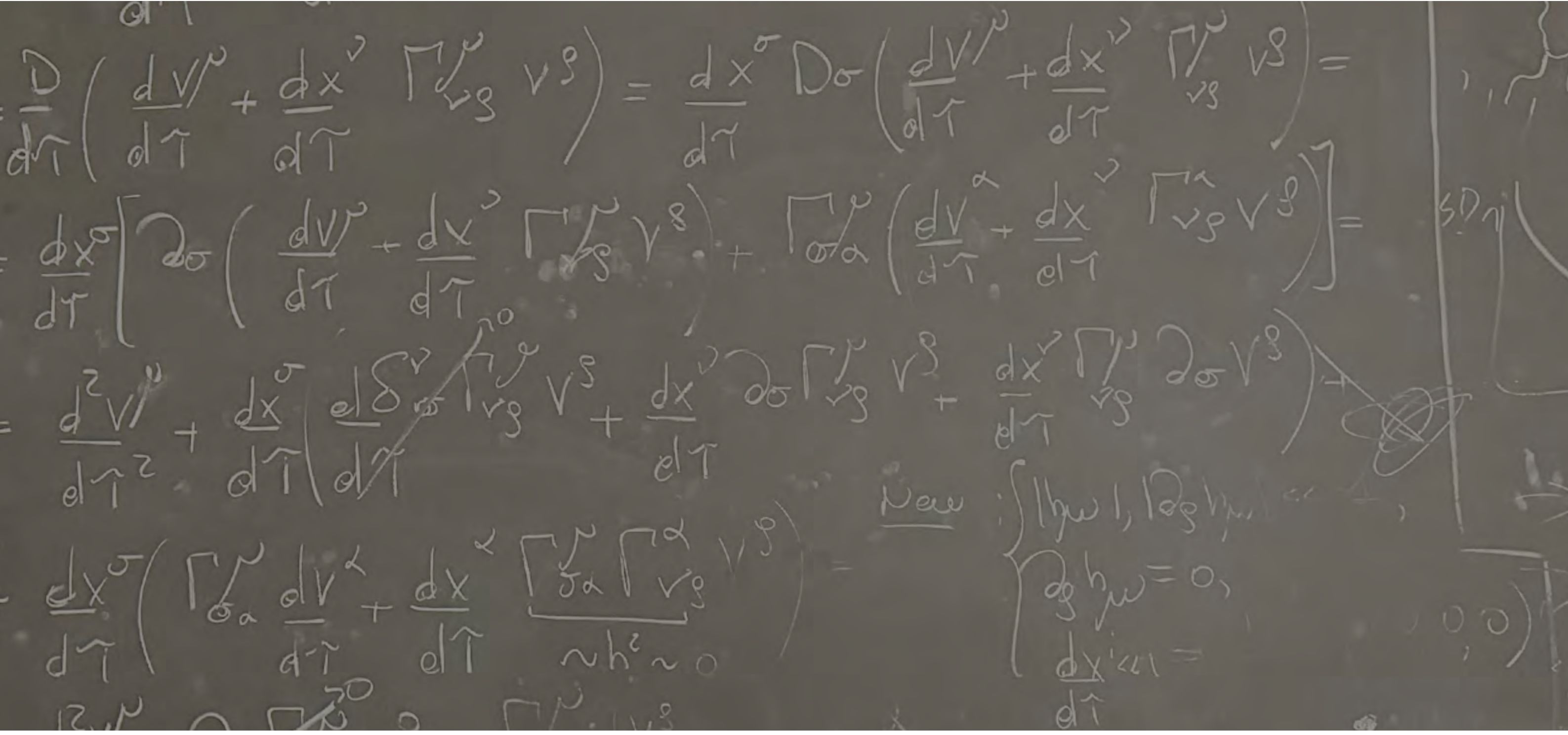
Faculty

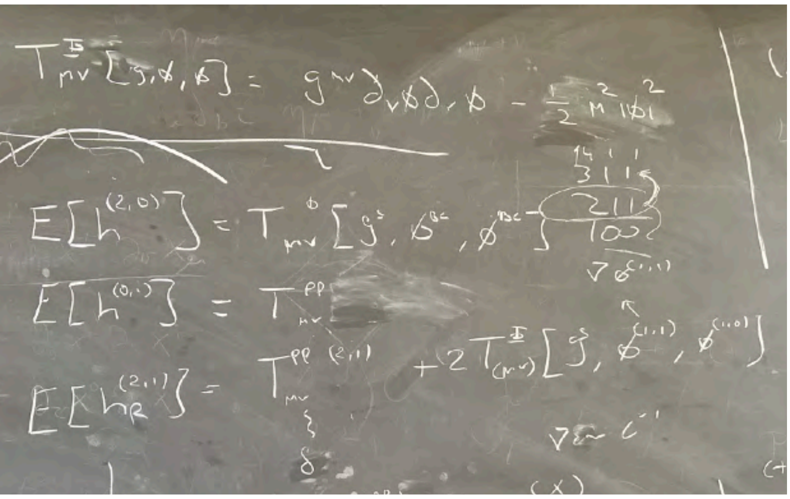
Niels Emil J. Bjerrum-Bohr completed his PhD in Copenhagen in 2004. He was a postdoc in Swansea from 2004 to 2006 and was a member of the Institute for Advanced Study in Princeton from 2006 to 2009. Emil was appointed Knud Højgaard Assistant Professor at the NBIA in 2010 and awarded a Steno grant from the Danish Science Research Council. He was appointed Associate Professor in 2016. Emil's research focuses on amplitudes in Yang-Mills theory and quantum gravity, and he currently works on computing classical observables in Einstein's gravity from scattering amplitudes supported by a grant from the Independent Research Fund Denmark.

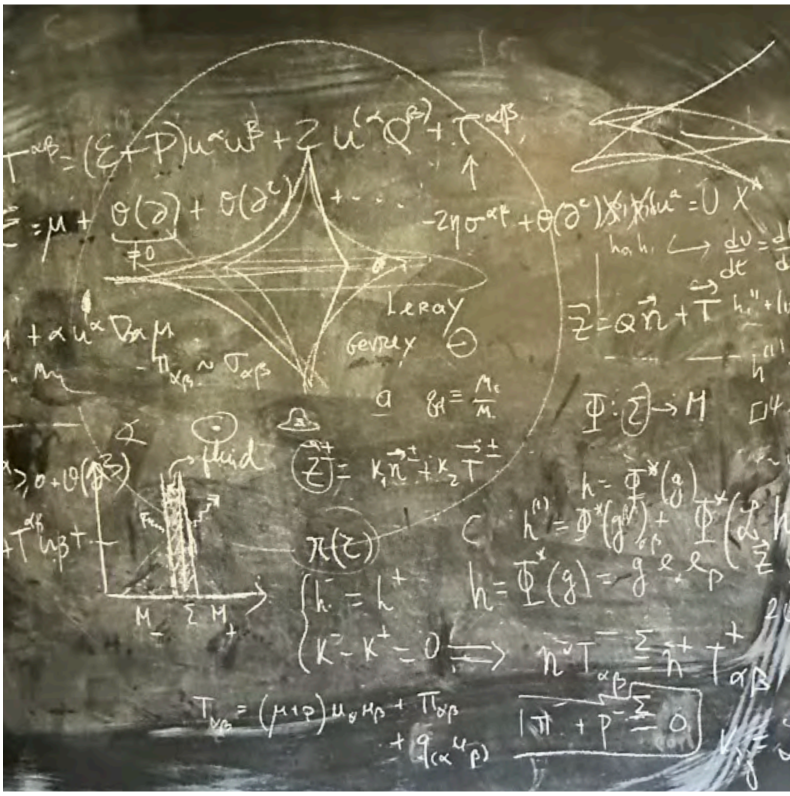
Poul Henrik Damgaard did his undergraduate studies at the University of Copenhagen and then went to Cornell University, where he received his PhD in 1982. He has held post-doctoral positions at Nordita, CERN, and the Niels Bohr Institute, and has for a period of six years been Scientific Associate at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

Amin Doostmohammadi is a Novo Nordisk Foundation Associate Professor at NBIA. He also has a cross-appointment as Specially Appointed Assistant Professor at Bioengineering in Osaka University, Japan. He received his PhD at University of Notre Dame and held a prestigious Royal 1851 Research Fellowship at Oxford before joining NBIA. Amin leads the Active Intelligent Matter research group working at the interface between physics and biology, modeling active materials. 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, Amin's group is generously supported by the Novo Nordisk and Villum Foundations and an ERC Starting Grant.

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.



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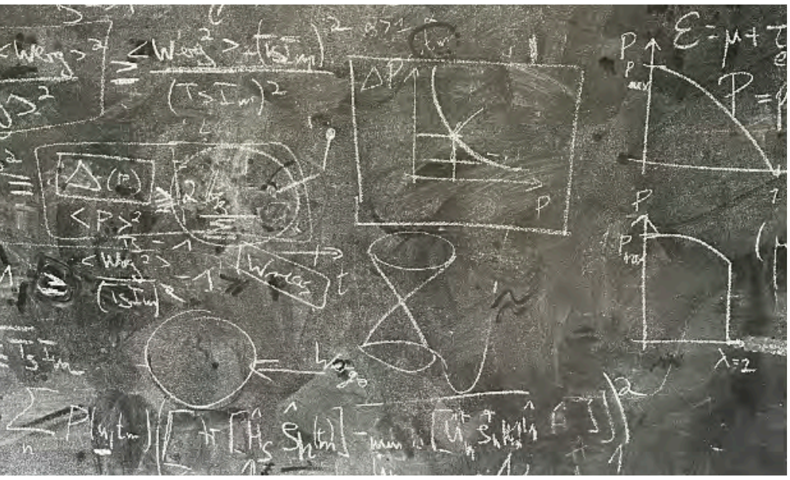

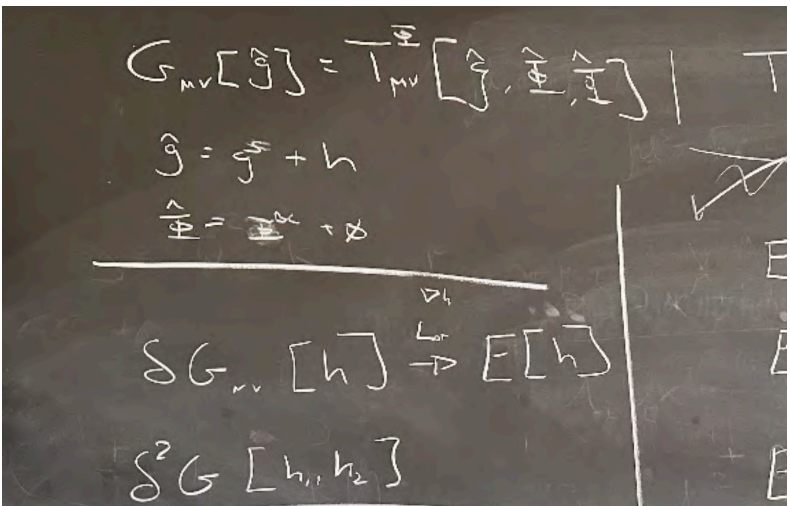
$G_{\mu\nu}[g] = T^{\Phi}_{\mu\nu}[\hat{g}, \hat{\Phi}, \hat{\Phi}]$
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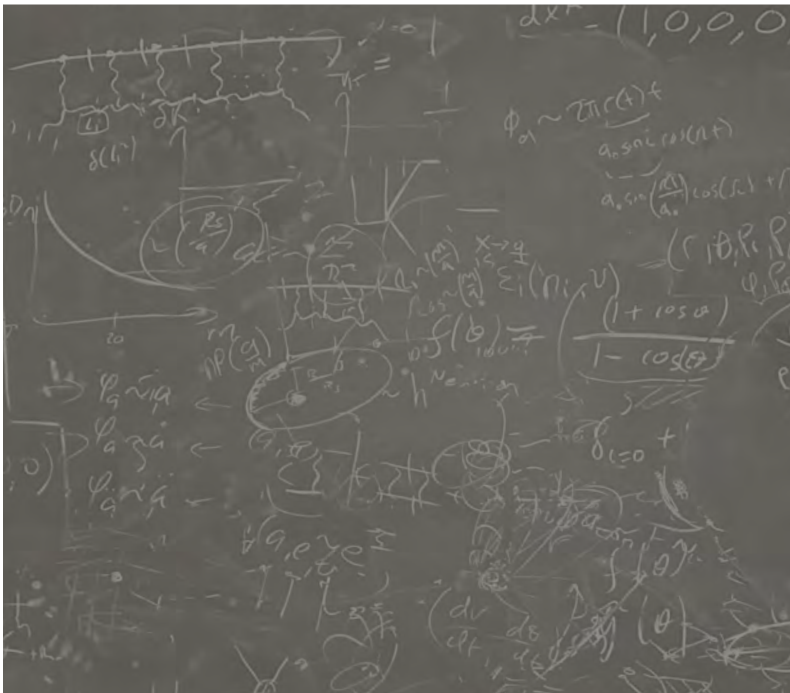


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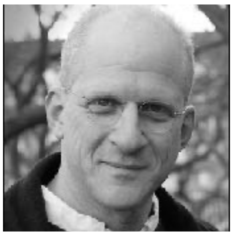
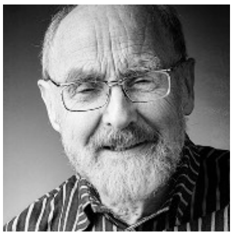
1920

Faculty



Charles Marcus was an undergraduate at Stanford University (1980-84). He received his PhD. 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.

Martin Pessah obtained his first degree in Astronomy in 2000 from the University of La Plata, Argentina and received his PhD in Theoretical Astrophysics from the University of Arizona in 2007. He was a Member at the Institute for Advanced Study in Princeton until 2010 and later moved to Copenhagen as a Knud Højgaard Assistant Professor to break ground for the new Theoretical Astrophysics Group at NBIA. Martin became Associate Professor in 2013, Professor MSO in 2015, and was appointed Professor of Theoretical Astrophysics in 2023. He has been Deputy Director at NBIA since 2016. Martin's research interests span a broad range of subjects in astrophysical dynamics, fluid dynamics, and magnetohydrodynamics.



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.

Alessia Platania is an Associate Professor at the University of Copenhagen and a Full Professor at the University of Graz. Her research lies at the interface between quantum gravity, effective field theory, and black-hole physics. Her work is driven by the idea that effective field theory offers a powerful lens through which we can (i) compare the predictions of different quantum gravity approaches and (ii) confront them with theoretical and observational bounds. The ultimate scope is to test the consistency of various proposals and to unveil novel connections between them. Specifically, Alessia and her group are currently focusing on assessing the consistency of asymptotically safe gravity and its connections to string theory.

Faculty

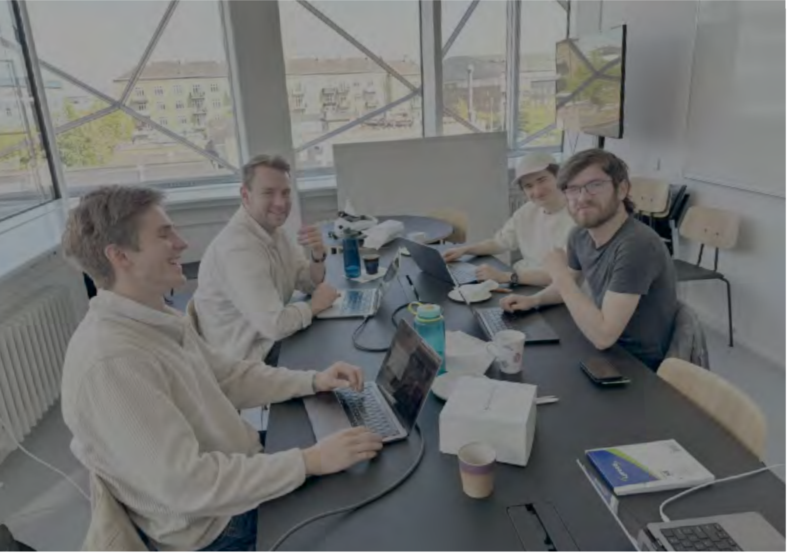
Irene Tamborra is Professor and leader of the AstroNu group. Irene obtained her PhD at the University of Bari in 2011. Before joining the Niels Bohr Institute in January 2016, Irene has held research appointments at the Max Planck for Physics in Munich, as the Alexander von Humboldt Fellow, and at GRAPPA, 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.

Matthias Wilhelm 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.

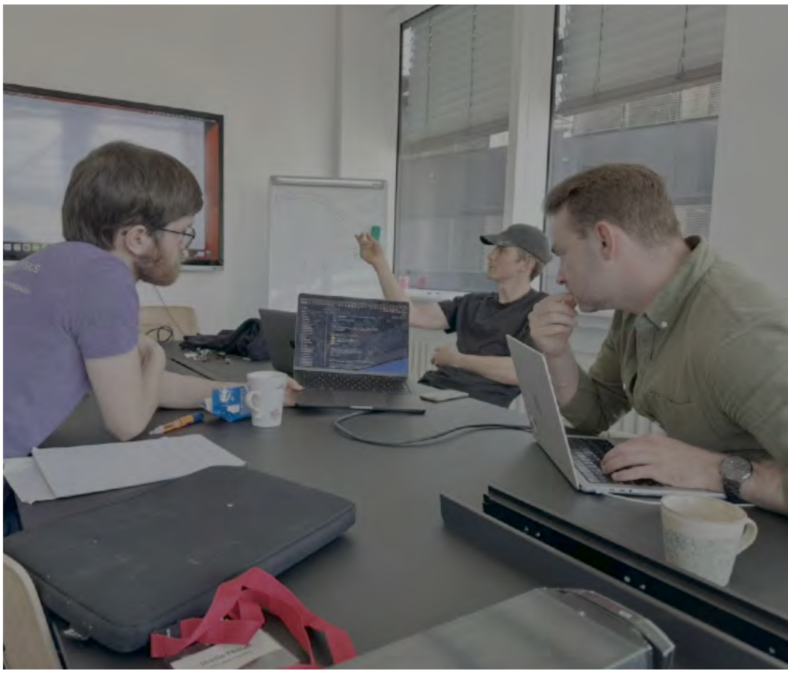
Konstantin Zarembo received his PhD from the Steklov Mathematical Institute in Moscow in 1997. After that he worked at UBC in Vancouver, Uppsala University and École Normale Supérieure in Paris. He became a Nordita Professor in 2010 and holds a joint appointment between NBI and Nordita since 2019. Konstantin's 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.

Associate Faculty

Jácome (Jay) Armas completed his PhD. at the Niels Bohr Bohr Institute in 2012. He was postdoctoral researcher at the University of Bern 2013-2014 and Université Libre de Bruxelles 2015-2017. He joined the University of Amsterdam in 2018 as tenured Assistant Professor and became coordinator of the Dutch Institute for Emergent Phenomena. His research is now focused on hydrodynamics and symmetries with applications to astrophysics, quantum matter, soft and active matter as well as high-energy physics. He is PI of the interdisciplinary program Foundations and Applications of Emergence as well as Emergent Phenomena in Society: Polarisation, Segregation and Inequality where he works on applying quantum methods to complex systems with applications to living systems and social/economic problems. In addition he is founder and main organizer of the internationally renowned and award-winning Science & Cocktails event series. He is also Associated Professor at NBIA and a member of the Institute for Advanced Study in Amsterdam since 2022.





Junior Faculty

Mauricio Bustamante is an Associate 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, first as a postdoc, and then as faculty. 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.

Daniel D'Orazio is a DFF Sapere Aude Research Leader and Assistant Professor at 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.

an assistant professor working on cosmology and general relativity. Her current re-
he novel cosmic drift measurements for determining the expansion rate of the Uni-
geo-metric methods for analysing cosmic observables (cosmographic methods), de-
es between fully general-relativistic models of cosmology andNewtonian descrip-
iving results for the propagation of light in non-trivial space-times. She is also work-
analyses of astrophysical datasets (BOSS-SDSS, Joint Lightcurve Analysis, Pantheon+, and Gaia) with the purpose of consistency testing and constraining the standard model as well as alternative cosmological models.

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.

Martin Cramer Pedersen is an Assistant Professor working in the field of soft matter and biophysics. He is particularly interested in using methods from computational and applied differential geometry and topology to characterize and understand the emergence of order, disorder, and self-assembled geometries in e.g. colloidal and polymer systems, cellular and other active materials, crystals and quasicrystals, or reticular chemical systems. Furthermore, Martin works on extracting and quantifying shape and order from a variety of experimental data and simulations of such systems; and consequently development and curation of data scientific methods, efficient simulation methods, and high-performance computing are central aspects of his research as well.

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

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.

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.

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.

Farzan Vafa is a theoretical soft matter physicist interested in how geometry and topology shape the dynamics of living systems. He obtained his PhD in physics at the University of California, Santa Barbara under Boris Shraiman, and held postdoctoral positions at Harvard with David Nelson and L. Mahadevan, and MIT with Nikta Fakhri. He is now an Assistant Professor at the Niels Bohr Institute, where he leads the TANGLS group (Topology and Geometry of Living Systems).

Mary Wood has a background in surface chemistry and obtained her PhD at the University of Cambridge in 2016 studying adsorption phenomena at metal/liquid interfaces. She held postdoctoral positions in Cambridge and Birmingham, studying corrosion and lipid bilayers respectively, before moving to EPFL in Switzerland to take up a Human Frontiers Science Programme cross-disciplinary fellowship. Her interests lie in bioelectronic interfaces, particularly photosynthetic membranes supported on electrode surfaces, with broader applications in the fields of renewable energies and green treatment of polluting waste.


NIELS BOHR INSTITUTET
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Postdoctoral Fellows

Shunke Ai obtained his PhD from the University of Nevada, Las Vegas (USA) in 2022. He then conducted postdoctoral research at Wuhan University (China) and joined NBIA in September 2024 as member of the AstroNu group. His research interests include the electromagnetic counterparts of gravitational waves, the physics of gamma-ray bursts as well as other high-energy explosive transients, and high-energy neutrino production.

Aleksandra Ardaševa received her PhD 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.

Jonas Berx is a post-doctoral researcher in non-equilibrium statistical mechanics. He has worked on topics ranging from active matter and surface growth to knot theory. He did his PhD at the University of Leuven and worked as a post-doctoral researcher at the Max Planck Institute for Dynamics and Self-Organisation and at the University of Leiden. He joined NBIA as a Marie Curie fellow to investigate the thermodynamics of replication processes at the molecular scale.

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.

Jayeeta Chattopadhyay is a postdoctoral researcher interested in active matter. Her research focuses on studying non-equilibrium properties of active nematics at the continuum level through computer simulation. She is also interested in understanding fundamental properties in tissue mechanics, including cell death, cell integration, collective cell motions, etc., which are governed by activating biochemical signals through mechanical stress generation.

Postdoctoral Fellows

Hjalte Frellesvig received his PhD from the NBI, and has done postdocs in Greece, Germany, and Italy. His 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 problems related to the production of the Higgs boson and electro-weak corrections to the production of the Z and W bosons.

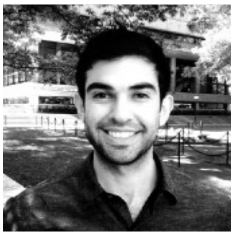
Mariam Gogilashvili obtained her PhD from the Florida State University (USA) and joined NBIA in September 2024 as part of the AstroNu group. Her work focuses on core-collapse supernova explosions. She is interested in exploring the role of neutrino oscillations in supernovae and mergers, and their influence on explosion dynamics, nucleosynthesis, and galactic chemical evolution.

Valeriia Grudtsyna completed her biomedical engineering degree at Lund University, where her master's thesis focused on actin organisation in focal adhesions using polarization microscopy. She later completed her PhD under Amin Doostmohammadi in the Active Intelligent Matter Group, studying collective mechanotransduction in epithelial tissues. She is now a postdoctoral researcher investigating active cellular systems and mitochondrial dynamics through experimental approaches.

Timofey Kozhukov is a postdoctoral researcher working with Dr. Kristian Thijssen. During his PhD at the University of Edinburgh, Tim worked on developing algorithms for simulating active nematic liquid crystals and characterising their behaviour. His current research focusses on advancing simulation tools for active fluids, with particular emphasis on passive and active solutes as well as complex boundaries. This work enables in-depth studies of biological mechanoreciprocity.

Pablo Martínez-Miravé obtained his PhD at the University of Valencia (Spain) and he joined NBIA in October 2023 as part of the AstroNu group. His work focuses on particle astrophysics. He is interested in exploring standard and non-standard neutrino properties relying on terrestrial experiments, the Sun, the early Universe, as well as core-collapse supernovae and binary neutron star mergers.

Postdoctoral Fellows



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.

Francesco del Porro is currently a Postdoc in the Quantum Gravity group. He obtained his PhD in September 2024 at SISSA (Trieste), with a thesis on several aspects of Quantum Gravity and Quantum Field Theory in Curved Spacetime. In particular he focused on the ultraviolet properties Horava Gravity – a Lorentz violating Quantum Gravity proposal – as well as quantum properties of black holes, such as Hawking radiation. His current research investigates different approaches to Quantum Gravity, including Asymptotic Safety, together with black hole physics and semiclassical effects in gravity.

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.

Connor Rowan joined the NBIA as a postdoctoral researcher in 2024 after completing his PhD at The University of Oxford. His research focuses on the dynamics of black hole interactions and mergers in gaseous media, particularly black holes embedded in the gas discs around supermassive black holes, and their potential as sources of gravitational waves.

Pankaj Saini is a new postdoc working on gravitational waves. He is interested in gravitational wave astrophysics, strong-field tests of general relativity with eccentric binaries, gravitational wave data analysis, and the scientific potential of future gravitational wave detectors.


A UNIVERSE THAT
EYES CAN NOT SEE
PAND

Postdoctoral Fellows

Fabian Schuhmann did his PhD at the Carl-von-Ossietzky University in Oldenburg, Germany. His research focused on tailored tools to analyze single protein dynamics and their conformational changes. For instance, he developed the Python package SiMBols, which makes similarity measures easily accessible for biological systems and the comparison of spatio-temporal data. As a postdoc at NBIA, he is building on the computational foundation to transfer and find new ways to analyze and simulate protein clusters and systems, including membranes in coarse-grained and all-atom settings.

Nabha Shah joined NBI as a postdoctoral researcher working in theoretical high energy physics after receiving her PhD. from Caltech in 2024. Her research focuses on the interface between quantum scattering amplitudes, effective field theory, and gravity. In particular, she is interested in exploring structure in gravitational effective field theory and in the application of field theoretic techniques to computations relevant for gravitational wave physics.

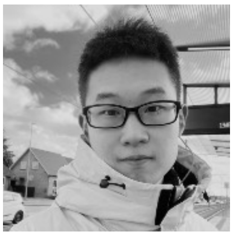
Janos Takatsy is a new postdoctoral fellow in gravitational wave astrophysics. He did his PhD in Budapest, which was focusing on field theoretical description of neutron star matter equation of state, and looking for signatures of phase transitions inside neutron stars. He is interested in the formation and dynamics of eccentric compact binaries, the composition of neutron stars and their tidal dynamics, as well as effective field theories of the strong interaction.

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. Chris obtained a Marie Skłodowska-Curie Actions (MSCA) Fellowship from the EU in 2024.

Alessandro Alberto Trani joined NBIA as INTERACTIONS 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. In 2023 Alessandro received a MSCA Fellowship at NBIA. Alessandro is now an Associate Professor in the Department of Astronomy at the University of Concepción, Chile.

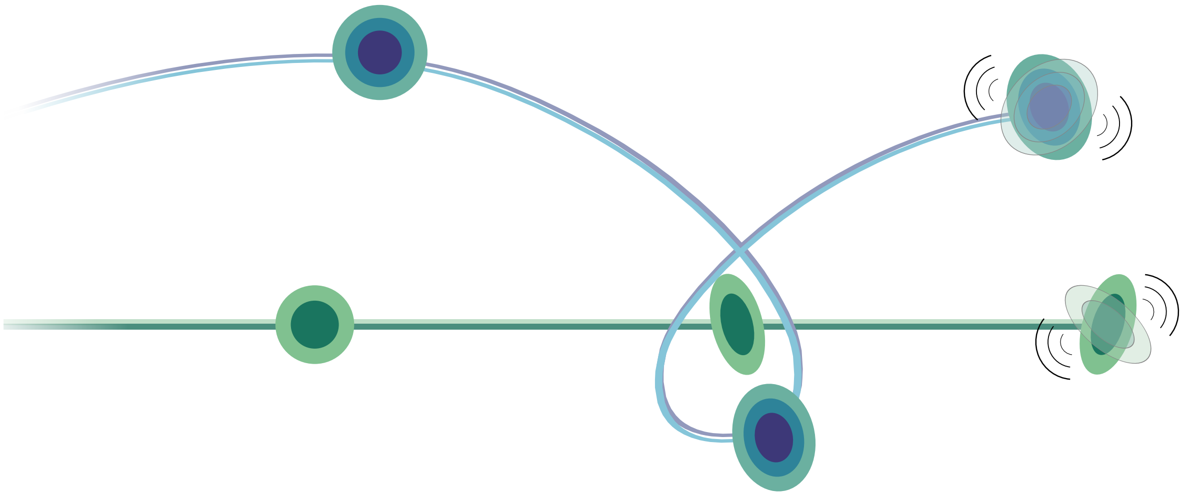
Postdoctoral Fellows

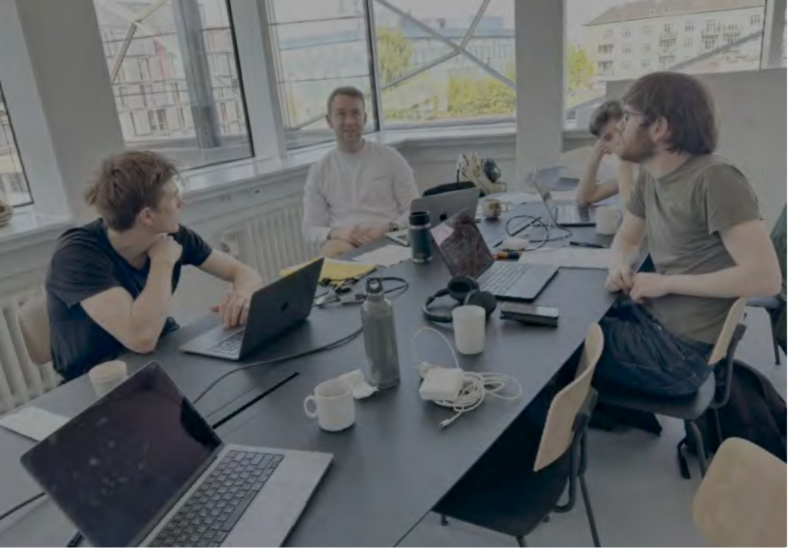
Alejandro Vigna-Gómez earned his PhD at the Institute for Gravitational Wave Astronomy, University of Birmingham. Following his PhD, Alejandro held fellowships at the Niels Bohr Institute (NBI) and the Max Planck Institute for Astrophysics (MPA). He has recently rejoined the NBI, where he holds an independent grant awarded by the Carlsberg Foundation. His research focuses on the interplay between stellar structure, binary interactions, and gravitational dynamics in the context of gravitational-wave sources and high-energy transients.

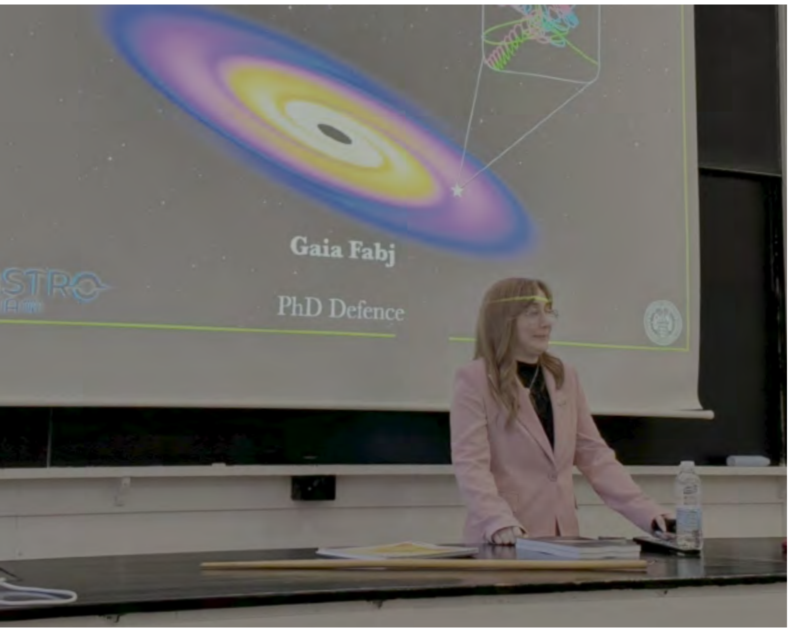


Fan Yang received his PhD from Tsinghua University. His PhD studies focus on theoretical investigation of quantum dynamics in atomic, molecular, and optical (AMO) systems. After that, he joined Aarhus University, University of Copenhagen, and University of Innsbruck as a postdoc. In 2025, he received the Firuza foundation Fellowship and joined NBIA. At NBIA, Fan intends to study many-body quantum optics, including development of theoretical tools for studying quantum nonlinear optics, and construction of novel schemes for quantum information processing with neutral atoms.

Lorenz Zwick joined NBIA as a postdoctoral fellow in 2023 to study the variety of perturbations that astrophysical backgrounds imprint on gravitational waves. Due to the multidisciplinary nature of this endeavor, Lorenz works on a broad range of topics. These include the formation and the dynamical evolution of black hole binaries, accretion discs and the origin of high red-shift quasars. In 2025, Lorenz obtained a Marie Skłodowska-Curie Actions Fellowship from the EU.






Gaia Fabj
PhD Defence

PhD Students

Nigar Abbasova started her PhD in the Active Intelligent Matter group at NBIA supervised by Prof. Amin Doostmohammadi in September 2024. She joined the group after earning her MSc in Physics from the University of Oslo, where she focused on experimentally investigating the dynamics of cellular monolayers. Her current research extends this work by exploring the mechanical forces involved in multicellular motion, aiming to provide new insights into the biophysics of mechanotransduction across biological tissues.

Simon Guldager Andersen is a PhD student in the Active Intelligent Matter (AIM) group under the supervision of Assoc. Prof. Amin Doostmohammadi. He is particularly interested in the near-critical behavior of active matter, which he will be studying using numerical and analytical methods. He obtained his MSc at NBI, during which he studied the spatiotemporal structure of topological defects in active nematics, in addition to developing software for analyzing cell images in collaboration with experimentalists.

Robin Bölsterli is pursuing a PhD in the Active Intelligent Matter group under the supervision of Professor Amin Doostmohammadi. After obtaining his MSc in Interdisciplinary Sciences at ETH Zurich, he started his PhD in August 2023. In his research, he is modelling and theoretically studying the critical phenomena occurring in Collective Mechanotransduction and Active Matter. To this end, he also collaborates with experimentalists.

Lasse Bonn obtained his MSc and one year of research experience working as a research assistant at NBIA in the Active Intelligent Matter group working on the properties of topological defects in fluctuating active nematics under the supervision of Amin Doostmohammadi. He has now started as a PhD student in the same group and will be looking at turbulent flows in active systems using continuum fluid dynamics simulations.

Adria Vidal Bravo is a PhD student at NBIA working in the Computational Microscopy group under the supervision of Weria Pezheskian. He obtained his Master's degree at Aarhus University with a thesis on the dynamic and thermodynamic properties of a system of interacting autonomous thermal motors. Now, his main focus is studying biological membranes' passive and active fluctuations using numerical simulations.

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.

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.

Francesco Ferrarin is a PhD student at the Niels Bohr Institute and a member of the Quantum Gravity Group led by Professor Alessia Platania. He completed both his Bachelor's and Master's degrees at the University of Pisa, conducting a research thesis on cosmological backreaction under the supervision of Professor Giovanni Marozzi. His primary interests lie at the intersection of gravity and effective field theories, specifically focusing on testing the consistency of Asymptotically Safe Gravity by studying the landscape of EFTs compatible with it. More broadly, he is passionate about both primordial and late-time cosmology, black-hole physics, and also investigating quantum gravity phenomenology in these contexts.

Manuel Goimil García received his MSc degree at the Niels Bohr Institute working on high-energy cosmic ray transport and neutrino production in tidal disruption events. He started his PhD in particle astrophysics in fall 2023 under the supervision of Irene Tamborra. His PhD work aims to explore how collective phenomena affect neutrino flavor conversion in dense astrophysical environments, such as supernovae and binary neutron star mergers.

Beatrice Geiger is a PhD fellow at NBI since March 2024. Here, she explores configurations of membranes and surfaces with high-topological genus using multiscale computer simulations. She obtained her master's and bachelor's degrees in physics from Ruprecht-Karls University, Heidelberg, Germany. Her research focus has been on theoretical and computational biophysics, complemented by an internship in medical physics.

PhD Students

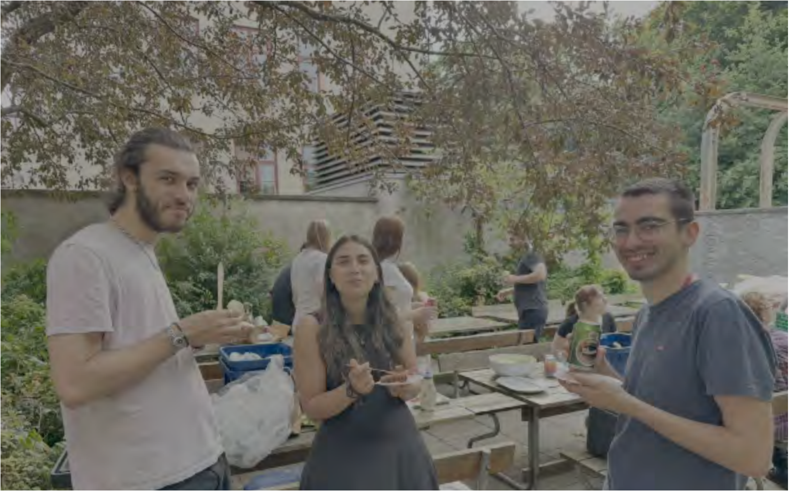
Marcela Grcic received her Master's degree in physics from the University of Copenhagen in 2022 with a thesis on eccentric circumbinary disks. In October 2022, Marcela started working on her PhD with the NBI Astrophysics group. She works under the supervision of Daniel J. D'Orazio and Martin Pessah.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

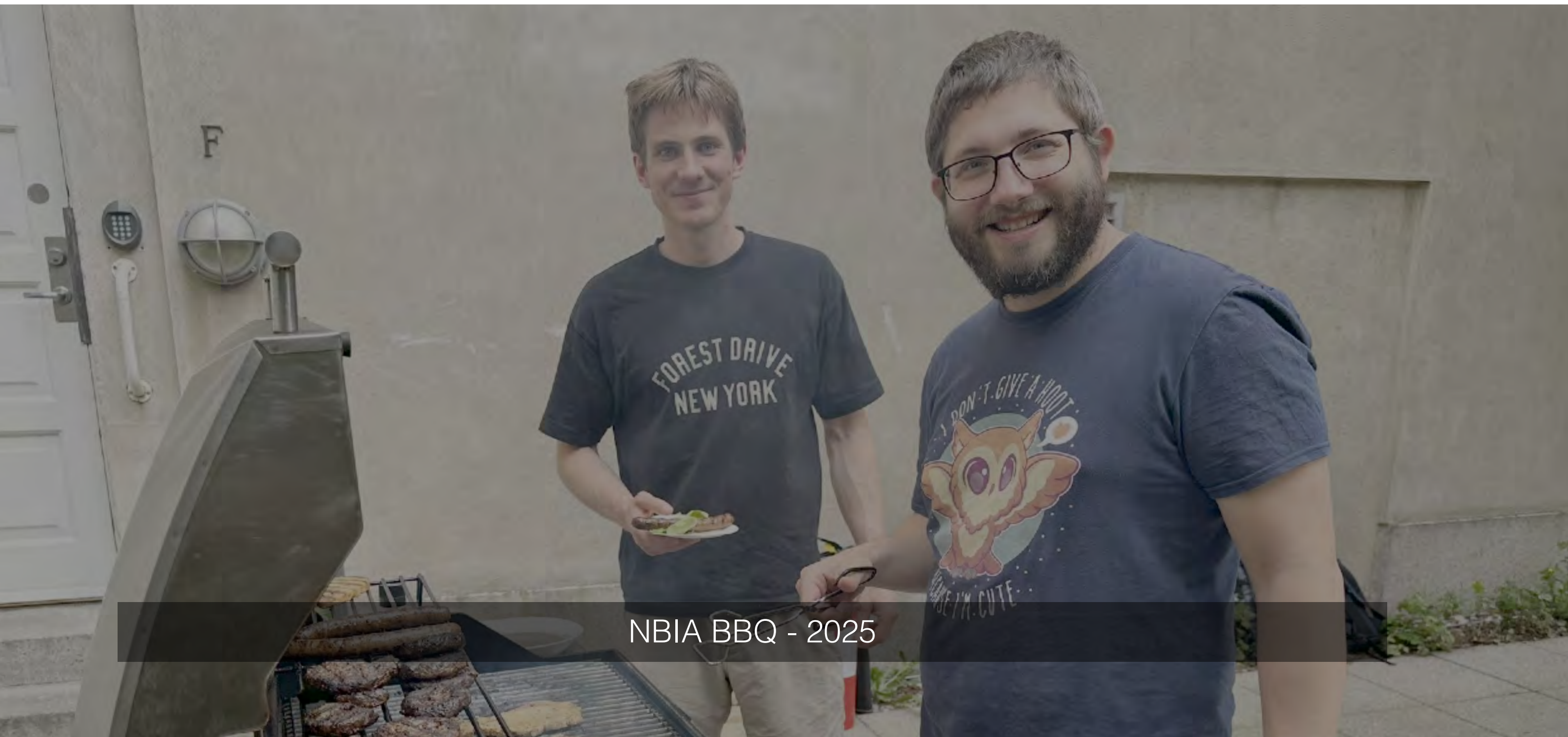
Marie Cornelius Hansen received her MSc degree at the Niels Bohr Institute with a thesis on probing the properties of axion-like dark matter using astrophysical high-energy neutrinos observed in IceCube. She started her PhD in November 2022 under the supervision of Irene Tamborra. Marie's work is within 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 with Johan Samsing. 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 Kamp 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.

Philip Jon Østergaard Kirkeberg finished his Masters project in the GWastro group at NBIA in spring 2024 and has extended his time in the group by beginning his PhD the following summer. He is interested in the interplay between dynamical gravitational systems and surrounding gaseous media, and works with tools from theoretical and numerical magnetohydrodynamics. His current research is concerned with the gaseous effects on the formation and evolution of black hole binaries embedded in the disks of active galactic nuclei.

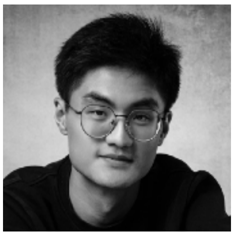




NBIA BBQ - 2025

PhD Students

Isabell Lindahl is a PhD-student in Biophysics in the biocomplexity section. Her project is theoretical and about exploring the mechanisms governing mitochondrial membrane shapes at the molecular scale. Mitochondria are often called the "powerhouse of the cell" as they produce the vast majority of cellular ATP supply through respiration. Isabell is creating computational models of the respiratory chain complexes in the mitochondrial membrane called the cristae and investigating the protein-membrane interactions and whether the complexes induce curvature of the membrane. In this project, molecular dynamic simulations of coarse-grained protein-membrane systems will provide essential insights into the energy balance of cells and promote our understanding of mitochondrial diseases.



Tianxiang Ma is a PhD student in the Active Intelligent Matter group at NBIA, supervised by Prof. Amin Doostmohammadi. He received his MEng in Biomedical Engineering from Beihang University and began his PhD in June 2024. His research focuses on integrating computational modeling with biological experiments to investigate active transport and mechanotransduction in multicellular systems, aiming to understand the role of mechanochemical cues in regulating collective cell behavior.

Maryna Mesiura obtained her MSc degree from the University of Zurich, where she focused on gravitational memory. In September 2024, she began her PhD under the supervision of Irene Tamborra. Her research aims to develop quantum neutrino transport methods in the remnants of binary neutron star mergers.

Elsa Messi completed her undergraduate studies in Biomedical Sciences at the International Hellenic University in Greece. During an internship at the University of Helsinki, she worked on neuroplasticity and TrkB receptor signaling, exploring how the nervous system adapts and remodels in anxiety models in mice. She then pursued a MSc in Neuroscience at the University of Copenhagen. She is now a PhD candidate in Biophysics at NBI, under the supervision of Amin Doostmohammadi and Poul Martin Bendix. Elsa's work focuses on mechanotransduction, investigating how cells sense and respond to mechanical forces, with a particular emphasis on cellular behavior and signaling mechanisms in response to physical stimuli.

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.

PhD Students

Brian Damith Ratnasinghe I am biophysicist from the United States specializing in Molecular Dynamics simulations. I received my both my bachelor's and master's degrees at Virginia Tech. In my master's thesis I focused on the utility of polarizable molecular dynamics in the modeling of non-canonical nucleic acid structures. Here, at the University of Copenhagen, I use multi-scale molecular dynamics simulations to describe the process of wood secondary cell wall formation.

Michela Rocchetti is a PhD student in the FLOCK Group led by Dr. Kristian Thijssen. She holds a Master's degree in Physics of Complex Systems from the Polytechnic Institute of Turin and has two years of professional experience as a software engineer working on radar systems. Her current research focuses on the computational modelling of microswimmers and their interaction with the surrounding fluid, with particular emphasis on chirality and emerging dynamics.

Noah Roux received his joint MSc degree in high-energy physics at ETH Zurich and Ecole Polytechnique of Paris working on the phenomenology of neutrino non-radiative decay in the Diffuse Supernova Neutrino Background (DSNB). He started his PhD in particle astrophysics in October 2025 under the supervision of Irene Tamborra. Noah's work aims to investigate the role of neutrino flavor evolution in dense astrophysical environments such as core-collapse supernovae and binary neutron star mergers.

Niels de Graaf Sousa earned his MSc at the University of Copenhagen, completing his thesis in the Active Intelligent Matter group at NBIA under the guidance of Amin Doostmohammadi. His master's research explored the role and significance of self-propulsion in active systems. He has now begun a PhD in the same group, focusing on the mechanisms of information transfer in active matter systems and examining the role of agency in shaping their behaviour.

Alessio Ludovico de Santis visited the AstroNu group in Oct 2025 as a PhD. researcher from GSSI. His research focuses on multi-messenger astrophysics, particularly Binary Neutron Stars and Core-Collapse Supernovae. At NBIA, he initiated a collaboration with Prof. Irene Tamborra to investigate how neutrino signals can inform Gravitational Wave (GW) searches. This ongoing work aims to address the challenge of detecting faint GW signals by utilizing neutrino-informed templates.

PhD Students

Andrey Shusharin is a new PhD student who has recently started working under the supervision of Prof. Charlotte Kristjansen. He got his BSc degree from the Lomonosov Moscow State University in 2019 and his MSc degree from EPFL in 2023. His master thesis focuses on the computation of correlation functions of non-local CFT operators. He is currently working on integrability and its applications to various field theories, such as defect CFT.

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.

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.

Jakub Trzaska is a PhD student at NBI under the supervision of Dr Kristian Thijssen. He received his master of theoretical physics at the University of Warsaw. work. In his PhD, he is currently investigating how microswimmers can exhibit complex collective behaviour under the supervision of Kristian Thijssen. In particular, he is interested in how heterogeneous bacterial flows in heterogeneous porous media can interact with each other to reveal possible mechanoreciprocity between the swimmers and the medium.

Varun Venkatesh began his masters in physics at the University of Copenhagen in 2020. He joined the Active Intelligent matter group for his thesis in 2021 about the jamming and unjamming of active flexible filaments. Continuing in the same group under the supervision of Amin Doostmohammadi, he began his PhD in February of 2023 on topographical active matter. His project looks at the interplay of substrate wrinkle deformations with cell motility and collective self-organization.

PhD Students

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.

MSc Students

Dimitrios Anastasiou — Biophysics
Julien Combel — Particle Astrophysics
Leonardo Dinoi — Particle Astrophysics
Shuhua Du — Particle Physics
Carl J. Eriksen — Particle Physics
Martin Hyldahl — Theoretical Astrophysics
Johannes Jacobsen — Theoretical Astrophysics
Makito Katsume — Biophysics
Yifei Li — Particle Astrophysics
Hengdong Lu — Biophysics
Elena Lucas — Biophysics
Aske Matthiesen — Particle Astrophysics
Franciszek Nawrocki — Quantum Sciences
Pablo L. Ortega — Particle Physics
Konstantinos Papadimos — Particle Physics
Jonas P. S. Rasmussen — Particle Physics
Tias Schick — Biophysics
Andrew B. Villadsen — Biophysics

Adjunct Faculty

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

James Cline — McGill University, Montreal, 15.09.25—15.10.25

Henriette Elvang — University of Michigan, Ann Arbor, 01.08.24 —30.07.25

Prof. Gordon Baym — University of Illinois Urbana-Champaign

Visitors

The NBIA maintains a vigorous visitor program, usually attracting a large number of scientists from all over the world 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 2025 follows below.

Name	Affiliation	Arrival	Departure
C. Badsgaard Jepsen	Korea Inst. Advanced Study	23.12.25	02.01.25
T. McLoughlin	Trinity College Dublin	10.12.25	12.12.25
P. Moesta	University of Amsterdam	07.12.25	09.12.25
J. Subils	Utrecht University	03.12.25	05.12.25
M. Nicholl	Queen’s University of Belfast	28.11.25	02.12.25
C. Heisenberg	Institut de Physique Théorique	26.11.25	29.11.25
L. Mayer	University of Zurich	25.11.25	27.11.25
R. P. Nelson	QMUL	25.11.25	27.11.25
C. Lopez Arcos	FZU	25.11.25	27.11.25
J. Touma	American University of Beirut	24.11.25	28.11.25
L. Souvaitzis	MPA Garching	17.11.25	21.11.25
V. Van Hemelryck	Uppsala University	13.11.25	15.11.25
R. Goldstein	Cambridge University	07.11.25	07.11.25
J. Matulich	IFT, Madrid	03.11.25	07.11.25
H. Whitehead	Oxford University	03.11.25	07.11.25
A. Chael	Princeton University	03.11.25	06.11.25
A. Fontanella	Trinity College Dublin	29.10.25	01.11.25
J. Qu Zhu	Stanford University	27.10.25	28.10.25
O. Gressel	AIP	25.10.25	30.10.25
A. J. Gamboa Castillo	Max Planck Institute for Gravitational Physics	22.10.25	24.10.25
T. Foglizzo	LMPA	19.10.25	22.10.25

F. Di Filippo	Goethe University Frankfurt	12.10.25	16.10.25
J. Ambjorn	Emeritus	01.10.25	10.10.25
R. Patil	Max Planck AEI	29.09.25	03.10.25
A. L. De Santis	Univ. Mainz	27.09.25	25.10.25
R. T. Da Costa	Cambridge University	27.09.25	02.10.25
A. M. Raclariu	King's College London	24.09.25	26.09.25
K. Zarembo	Stockholm University	22.09.25	14.10.25
J. Cline	McGill University	22.09.25	14.10.25
G. Xu	NBI	15.09.25	01.10.25
S. Taylor	Vanderbilt University	15.09.25	19.09.25
A. S. Hafner	Radboud University	10.09.25	12.09.25
A. Kapadia	Radboud University	09.09.25	12.09.25
B. Becsy	Birmingham University	07.09.25	10.09.25
G. Dalya	Ghent University	07.09.25	10.09.25
E. Been	UCLA	05.09.25	16.09.25
W. Muniz	UCLA	05.09.25	16.09.25
S. Hughes	MIT	05.09.25	06.09.25
L. Lehner	Perimeter Institute for Theoretical Physics	04.09.25	06.09.25
P. Pani	Sapienza University of Rome	04.09.25	06.09.25
A. Wallberg	CERN	01.09.25	12.09.25
G. Carrullo	Birmingham University	01.09.25	05.09.25
Y. Lei	Soochow University	01.09.25	05.09.25
E. Cannizzaro	IST	01.09.25	26.09.25
P. Di Vecchia	Emeritus	28.08.25	05.09.25
J. Yeomans	Oxford University	27.08.25	29.08.25
A. Spiers	Nottingham University	26.08.25	30.08.25
Y. Horiike	Nagoya University	25.08.25	29.08.25

Y. Zhang	Univ. Science & Technology, Hefei	22.08.25	29.08.25
J. Nian	ICTP	18.08.25	30.08.25
S. Bussieres Lopez	Universidad Autonoma de Madrid	31.07.25	01.10.25
K. Lee	Korea Institute of Advanced Study	29.07.25	10.08.25
R. Ball	University of Edinborough	28.07.25	01.08.25
F. Tuncer	Bilkent University	08.07.25	14.09.25
V. Poulin	LUPM	07.07.25	13.07.25
M. Petropoulos	University of Athens	07.07.25	13.07.25
G. Vasilopoulos	University of Athens	07.07.25	13.07.25
M. Tortola	University of Valencia	07.07.25	13.07.25
K. Taylor	University of Victoria	03.07.25	30.04.26
M. Rahman	Kyoto University	01.07.25	11.07.25
J. Gomez	Universidad Autonoma de Madrid	01.07.25	31.08.25
P. Narang	UCLA	27.06.25	04.07.25
F. Yang	NORDITA	24.06.25	25.06.25
V. Savov	IST Lisbon	22.06.25	30.08.25
J. Marajh	QMUL	19.06.25	19.06.25
A. Ferdinand	MIT	19.06.25	26.06.25
P. Fleury	LUPM	16.06.25	20.06.25
F. Scarcella	IFCA	16.06.25	20.06.25
S. Aydogdu	Bilkent University	16.06.25	15.08.25
M. Garg	University of Zurich	16.06.25	18.06.25
M. Rozner	Cambridge University	16.06.25	20.06.25
Z. Bern	UCLA	10.06.25	12.06.25
J. Stone	Princeton University	10.06.25	14.06.25
L. Michelutti	Aix - Marseille University	09.06.25	04.07.25
M. Menu	Aix - Marseille University	09.06.25	18.07.25

M. Kardar	Princeton University	09.06.25	20.06.25
L. Thorlacius	University of Iceland	04.06.25	04.06.25
H. Johansson	Uppsala University	01.06.25	04.06.25
G. Baym	University of Illinois	29.05.25	10.06.25
R. Janik	Jagiellonian University	26.05.25	26.05.25
A. Petrov	Paraiba University	26.05.25	26.05.25
M. Hills	University of Canterbury	25.05.25	21.06.25
J. Figueroa-O'Farrill	Edinburgh University	25.05.25	29.05.25
K. Zoubos	University of Pretoria	21.05.25	17.06.25
L. Bohnenblust	AEI / Humboldt University	21.05.25	22.05.25
D. Spergel	Princeton University	19.05.25	21.05.25
A. Chael	Princeton University	20.05.25	25.05.25
H. Ubach	University of Barcelona	13.05.25	13.06.25
A. Crepinge	Univ. Claude Bernand Lyon	12.05.25	15.08.25
G. Faggioli	Potsdam University	12.05.25	14.05.25
M. DuPont	Princeton University	11.05.25	16.05.25
R. Rodgers	NORDITA	11.05.25	16.05.25
J. Penedones	EPFL	07.05.25	09.05.25
I. Basile	MPP	06.05.25	10.05.25
J. Zosso	ETH Zurich / NBI	06.05.25	30.06.25
Z. Yan	NORDITA	05.05.25	09.05.25
E. Tsolakidis	Iceland University	05.05.25	09.05.25
T. Backdahl	University of Gothenburg	04.05.25	10.05.25
T. Rahnuma	APCTP	04.05.25	10.05.25
Y. Qian	University of Minnesota	01.05.25	03.05.25
L. Sebastiani	University of Perugia	01.05.25	30.06.25
L. Dino	University of Perugia	01.05.25	31.07.25

C. Lopez Jurado	Lund University	28.04.25	31.10.25
R. Emparan	Universitat de Barcelona	28.04.25	01.05.25
D. Siegel	University of Greifswald	27.04.25	29.04.25
M. De Leeuw	Trinity College of Dublin	22.04.25	25.04.25
S. Silveravalle	SISSA	14.04.25	18.04.25
C. Ugolini	GSSI	14.04.25	14.04.25
H. Zhu	IBS CTPU - CGA	13.04.25	18.04.25
S. Catterall	Syracuse University	09.04.25	10.04.25
G. Jacobsen	Humboldt University of Berlin	09.04.25	10.04.25
J. Andersen	University of Trondheim	08.04.25	09.04.25
M. Sergola	IPhT, Saclay	02.04.25	05.04.25
P. Narang	UCLA	27.03.25	28.03.25
H. Choi	Yale University	26.03.25	02.05.25
G. Xu	ETH Zurich	24.03.25	25.03.25
A. Tanikawa	Fukui University	17.03.25	30.03.25
N. Geiser	Michigan University	17.03.25	30.03.25
A. Chandra	Michigan University	17.03.25	30.03.25
L. Lin	Michigan University	17.03.25	30.03.25
J. Lestigni	University of Nottingham	16.03.25	23.03.25
A. Brandhuber	Queen Mary University of London	12.03.25	13.03.25
C. Vafa	Harvard University	10.03.25	12.03.25
C. Fiore	University of São Paulo	10.03.25	23.03.25
S. Vandoren	University of Utrecht	05.03.25	07.03.25
S. Gezari	STScl	03.03.25	06.03.25
J. Shilcock	SSV	02.03.25	07.03.25
S. Knibbeler	Heriot-Watt Univ.	28.02.25	02.03.25
C. Jones	University of Amsterdam	26.02.25	01.03.25

J. Bourjailly	Penn State University	24.02.25	26.02.25
Z. Yan	NORDITA	24.02.25	27.02.25
O. Dias	University of Southampton	19.02.25	22.02.25
P. Pani	Sapienza University of Rome	19.02.25	21.02.25
A. Sfondrini	University of Padua	16.02.25	19.02.25
G. Grignani	Perugia University	17.02.25	25.02.25
C. Lopez Jurado	Lund University	13.02.25	13.02.25
M. Schiffer	Radboud University Nijmegen	09.02.25	12.02.25
D. Panella	Perugia University	03.02.25	28.02.25
L. F. Alday	Oxford University	04.02.25	07.02.25
J. Sadiq	SISSA	31.01.25	31.01.25
A. Watts	University of Amsterdam	27.01.25	28.01.25
S. Rufrano Aliberti	SSM Naples	16.01.25	16.04.25
D. Cardenar	PUCP	17.01.25	13.03.25
H. Reall	University of Cambridge	15.01.25	17.01.25

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.

Student Assistants: During 2025, students Leon Bojčić assisted the NBIA administration with running daily NBIA activities.






NIELS BOHR INSTITUTET
1920


NBIA Activities

Prof. Jim Stone — NBIA Workshop on Open Problems in Astrophysical Dynamics - 2025

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 year we have had talks on such varied topics as the distinction between correlation and causation, the origin and evolution of the elements, new understanding of turbulence, the evolution of multicellularity, and many more. The full list of talks and speakers follows below.

Peter Lodahl (NBI) — 28.11.2025
"Interfacing one photon and one atom - from fundamental physics to revenue"

Raymond Goldstein (University of Cambridge) — 07.11.2025
"Algal Phototaxis and the Evolution of Multicellularity"

Paolo di Vecchia (NBI) — 26.09.2025
"The Birth of String Theory"

Anne-Sophie Hafner (Radboud University) — 12.09.2025
"Re-think Alzheimer's Disease: A New Molecular Perspective"

Edward Belbruno (Yeshiva University) — 29.08.2025
"Permanent capture into the Solar System and moving chaotically within it: What could get in?"

Predrag Cvitanovic (Georgia Institute of Technology) — 01.08.2025
"Turbulence, and what to do about it"

Mary Wood (NBI) — 20.06.2025
"The Future's bright: the future is green?"

James Stone (Institute for Advanced Study, Princeton) — 13.06.2025
"Astrophysical Fluid Dynamics at Exascale"

David Spergel (Princeton University & Flatiron Institute.) — 16.05.2025

Laura Kreidberg (Max Planck Institute, Heidelberg) — 09.05.2025
"Copernicus Revisited: is the Earth special?"

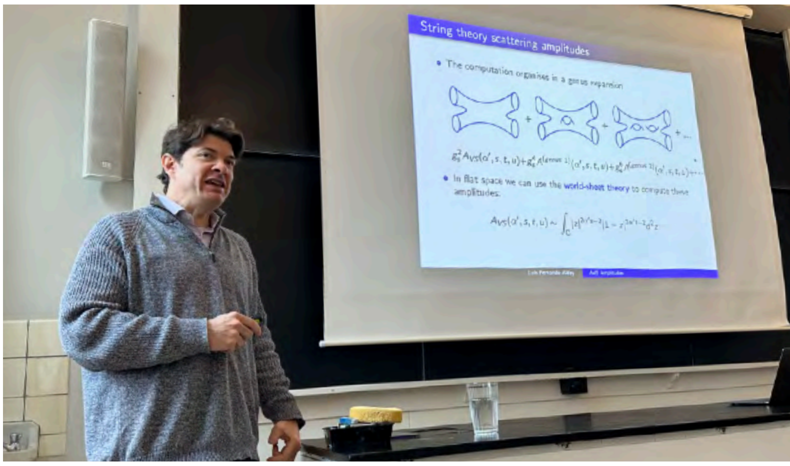
Yongzhing Qian (University of Minnesota) — 02.05.2025
"The Origin and Evolution of the Elements: A Modern Perspective"


Photon and One Atom:
undamental research to revenue
Peter Lodahl
DNRF Center for Hybrid Quantum Networks Hy-Q
NNF Center of Excellence Solid-Q
Founder and CQO of Sparrow Quantum
Niels Bohr Institute, University of Copenhagen
erc
innovationsfonden
novo nordisk fonden

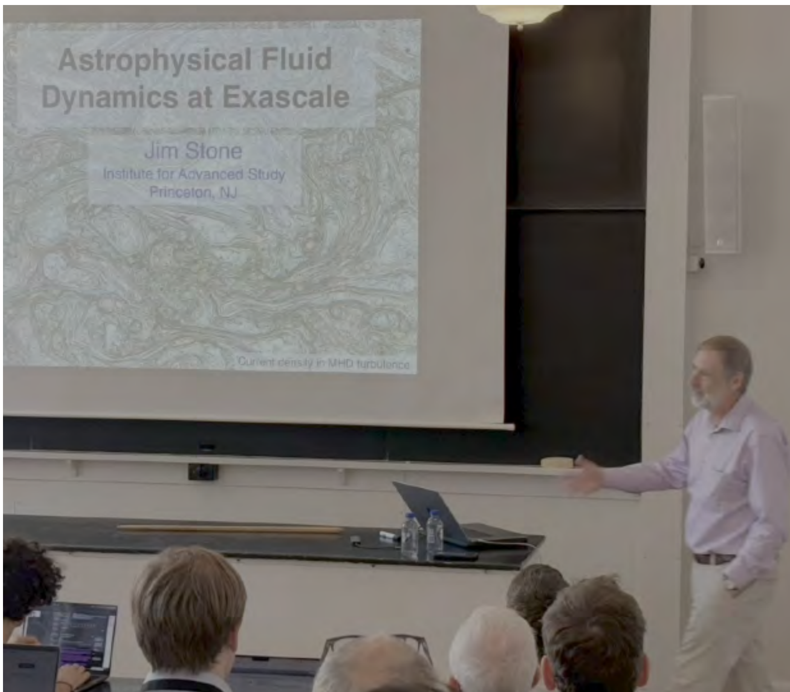

Algal Phototaxis and the
Evolution of Multicellularity
Raymond E Goldstein
DAMTP
University of Cambridge


Big Bang
Cosmological magnetic fields?
3 minutes
Big Bang Nucleosynthesis
400 000 years
Cosmic Microwave Background
Large-Scale Structure
Axel Brandenburg
(Nordita)


ENERGY


String theory scattering amplitudes


the Elements Heavier than Iron Produced?


Astrophysical Fluid
Dynamics at Exascale
Jim Stone
Institute for Advanced Study
Princeton, NJ

NBIA Colloquia

Axel Brandenburg (NORDITA) — 25.04.2025
“Primordial magnetic fields and relic gravitational waves: messengers from the first microseconds”

Niels Richard Hansen (MATH, University of Copenhagen) — 11.04.2025
“Correlation is not causation; but what is causation then?”

Prineha Narang (UCLA) — 28.03.2025
“Scaling Hybrid Quantum Systems: The road from hardware and algorithms to impact”

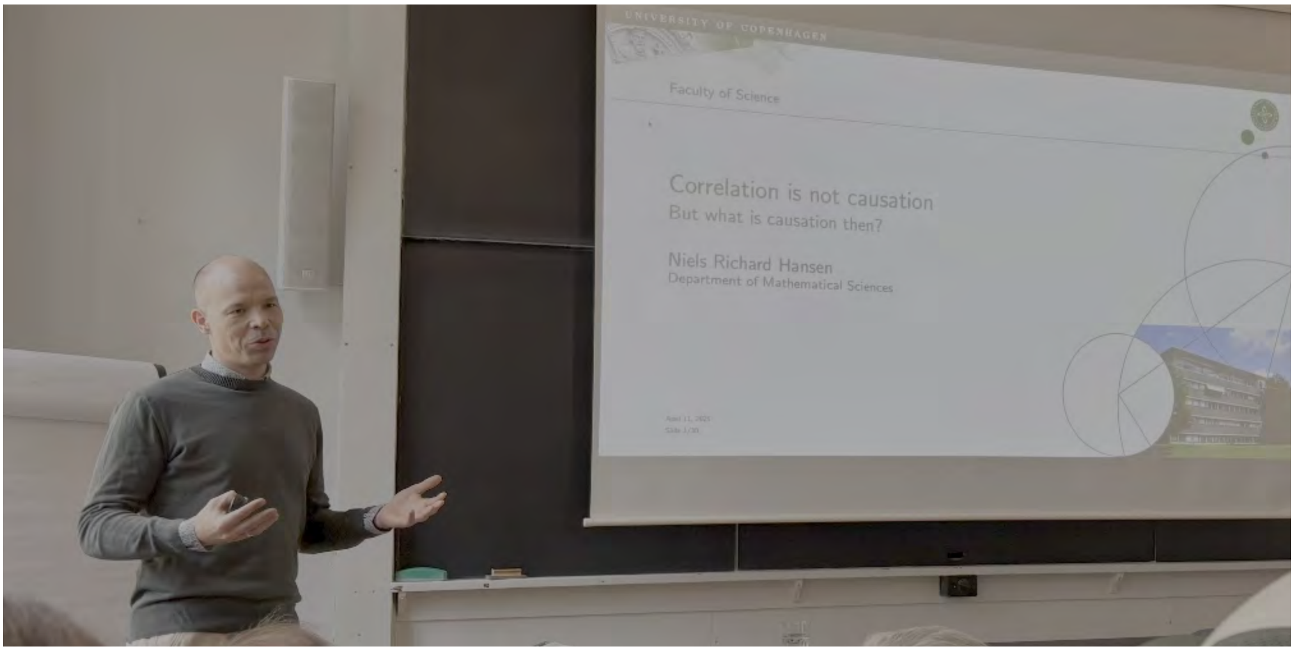
Mauricio Bustamante (NBI) — 21.02.2025
“Higher, further, faster: high-energy cosmic neutrinos for particle physics and astrophysics”

You Zhou (NBI) — 31.01.2025
“ALICE in Wonderland: Mystery of the Early Universe”

Henriette Elvang (University of Michigan, Ann Arbor) — 24.01.2025
“Boiling Water, Beta Decay, and Pions”

Stine Falsig Pedersen (Dept. of Biology, University of Copenhagen) — 17.01.2025
“Protons pave the way to aggressive cancers”


ALICE in Wonderland:
Mystery of the Early Universe
You Zhou
Niels Bohr Institute, University of Copenhagen
INDEPENDENT RESEARCH FUND DENMARK
THE VELUX FOUNDATIONS

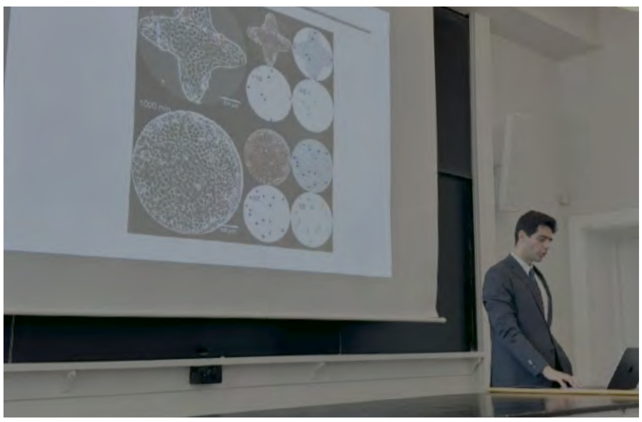

Faculty of Science
Correlation is not causation
But what is causation then?
Niels Richard Hansen
Department of Mathematical Sciences


Protons pave the way to
aggressive cancers
Jan 17 2024
NBIA seminar
Stine Falsig Pedersen
Department of Biology

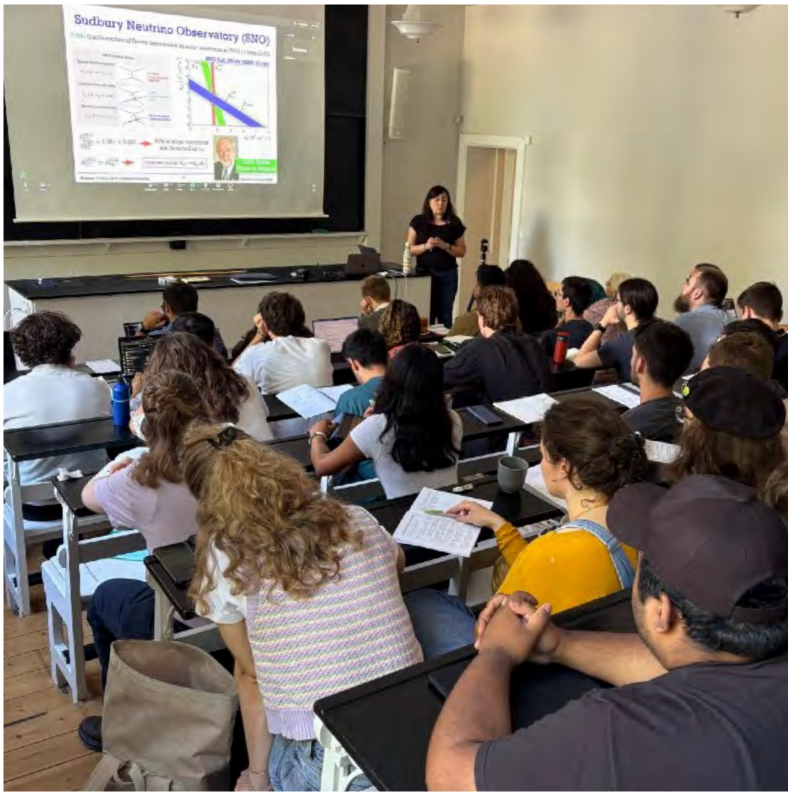
NBIA Seminars & Talks

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 2025 we launched a new series of seminars on Quantum Science, bridging between theoretical high energy physics, quantum computation, quantum optics, condensed matter physics, and mathematical aspects of quantum information. 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.



IV PHD SUMMER SCHOOL ON NEUTRINOS HERE, THERE & EVERYWHERE



IV PhD Summer School on Neutrinos Here, There & Everywhere - 2025

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 2024:

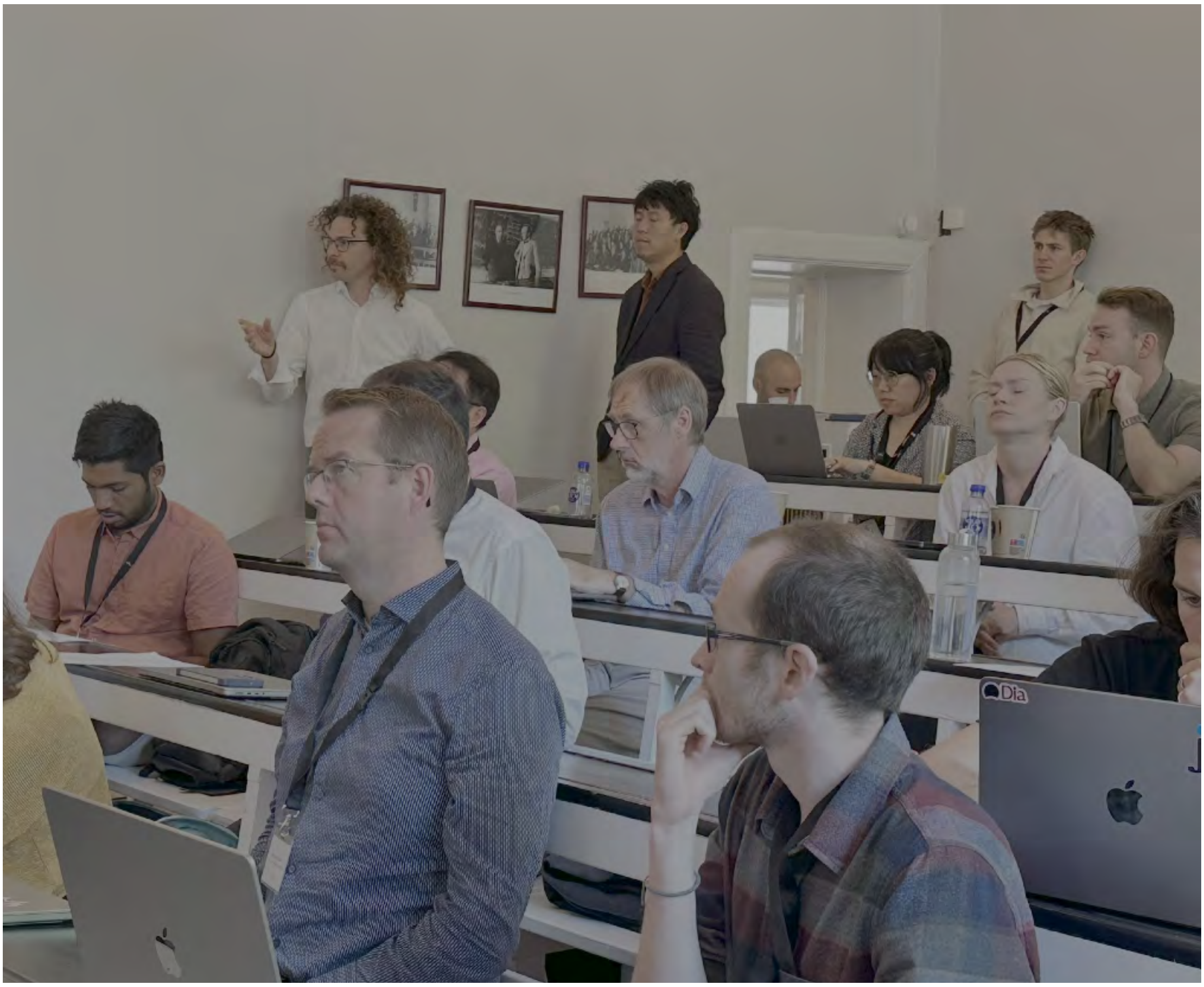
"Joint NBIA-APCTP Symposium" — 08.12. / 10.12.2025

"Current Themes in Astrophysics and Particle Physics" — 25.08. / 29.08.2025

"Danish Quantum Field Theory Meeting" — 13.08. / 14.08.2025

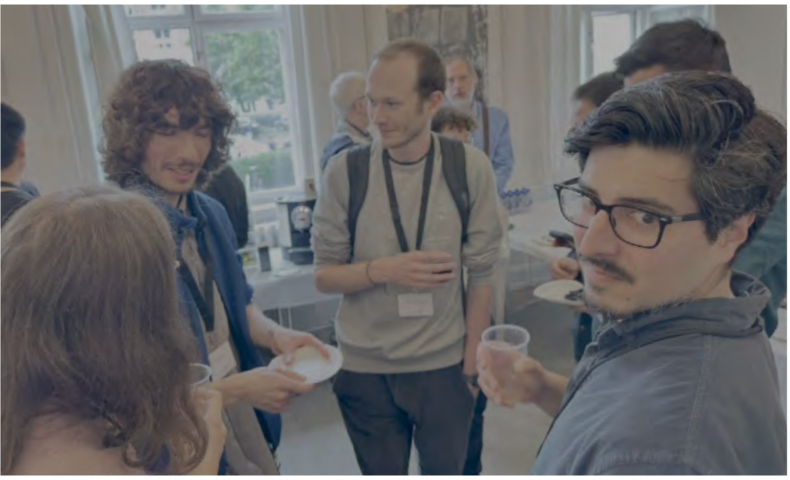
"PhD Summer School on Neutrinos" — 07.07. / 11.07.2025

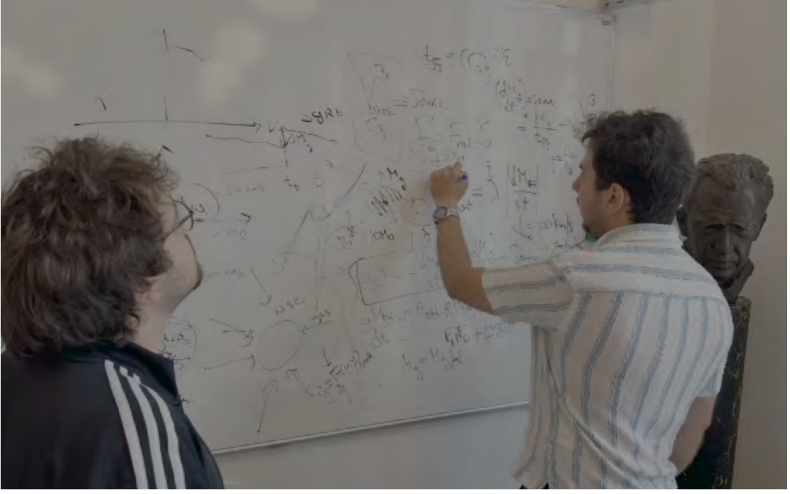
"NBIA Workshop on Open Problems in Astrophysical Dynamics" — 10.06. / 13.06.2025

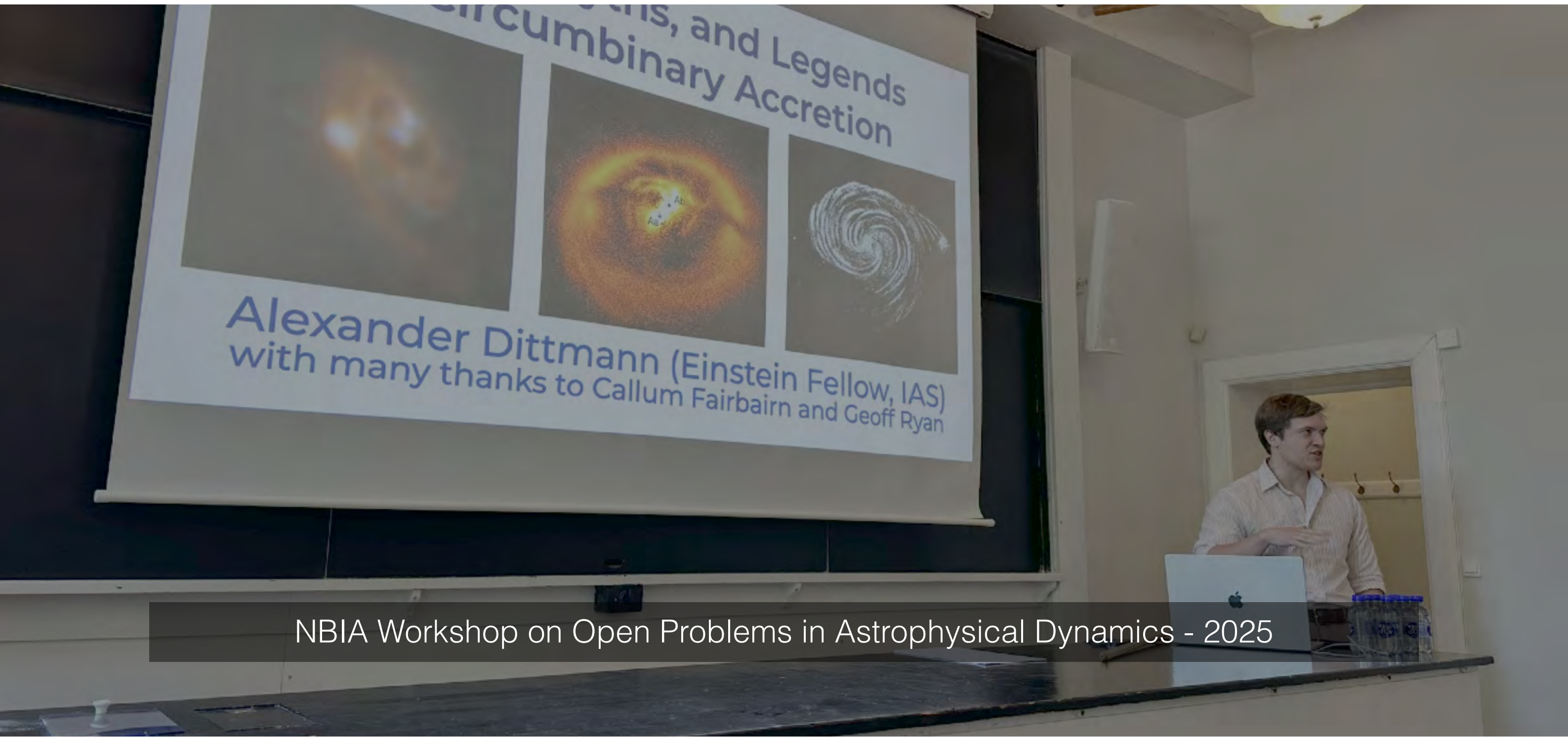



NBIA Workshop on Open Problems in Astrophysical Dynamics - 2025


NBIA Copenhagen
Open Problems in Astrophysical Dynamics
12th of June 2025
Magnetic Field Evolution during Tidal Disruption Events
Simona Pacuraru
PhD student at the University of Birmingham
In collaboration with Clément Bonnerot and Martin Pessah

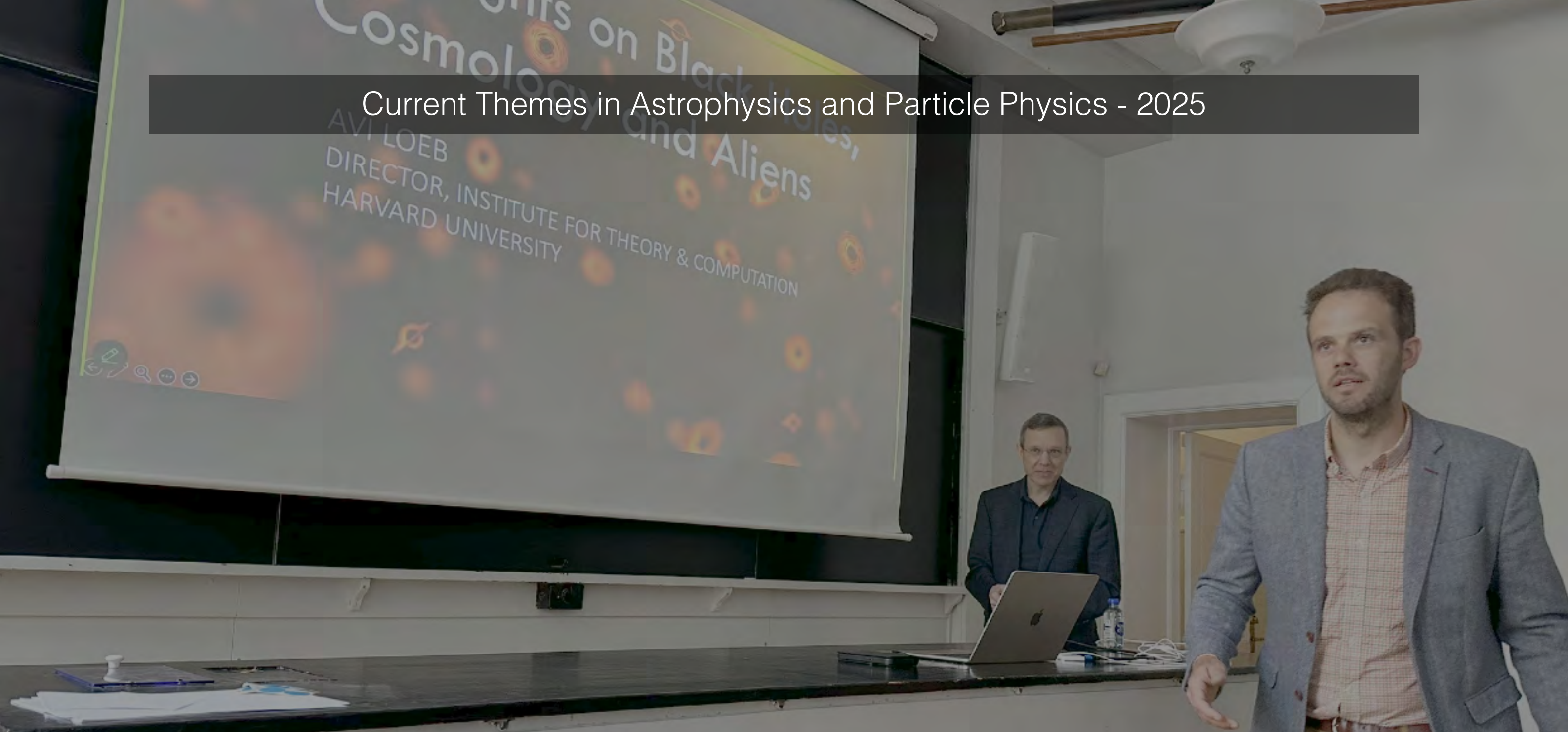


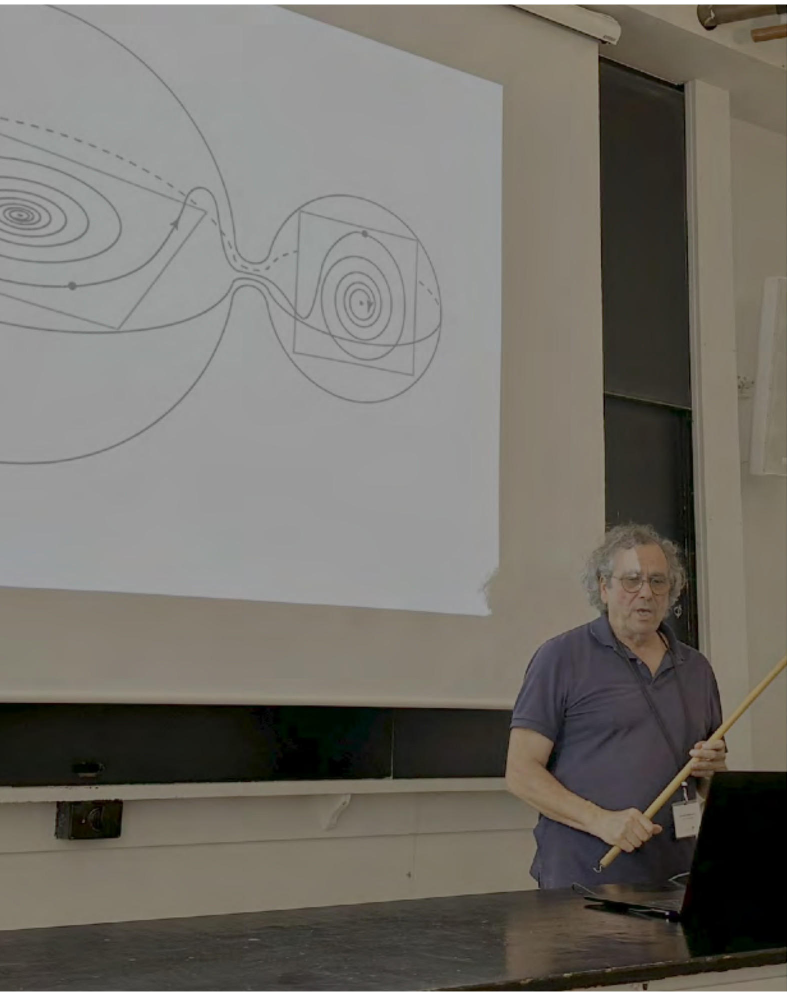




NBIA Workshop on Open Problems in Astrophysical Dynamics - 2025

Current Themes in Astrophysics and Particle Physics - 2025






Current Themes in Astrophysics and Particle Physics - 2025

NBIA MSc Day 2025

October 21, 2025
Niels Bohr Institute
Europe/Copenhagen timezone

Enter your search term

- Overview
- Timetable
- Contribution List
- My Conference
  - My Contributions
- Registration
- Participant List

Contact

mpessah@nbi.dk
mbustamante@nbi.ku.dk

NBIA MSc Day 2025

The Niels Bohr International Academy (NBIA) invites prospective MSc students to an informal event "MSc Projects @ NBIA" on **Tuesday, October 21, 09:00 a.m. to 12:30 p.m. (lunch included!).** 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 of carrying 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. Many NBIA Assistant Professors and Associate Professors have started new research groups in their disciplines by attracting prestigious national and European grants. The NBIA hosts many post-docs, PhD students, and MSc students. We have a steady stream of international visitors 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 several activities, including an annual series of public lectures in collaboration with the Danish Open University. All in all the NBIA offers an incredibly stimulating environment for students!

Starts Oct 21, 2025, 9:00 AM
Ends Oct 21, 2025, 1:30 PM
Europe/Copenhagen

Niels Bohr Institute
Auditorium A
Blegdamsvej 17
DK-2100 Copenhagen

Martin Pessah
Mauricio Bustamante
N. E. J Bjerrum-Bohr

nbia-brochure-2025.pdf

Registration
You are registered for this event.

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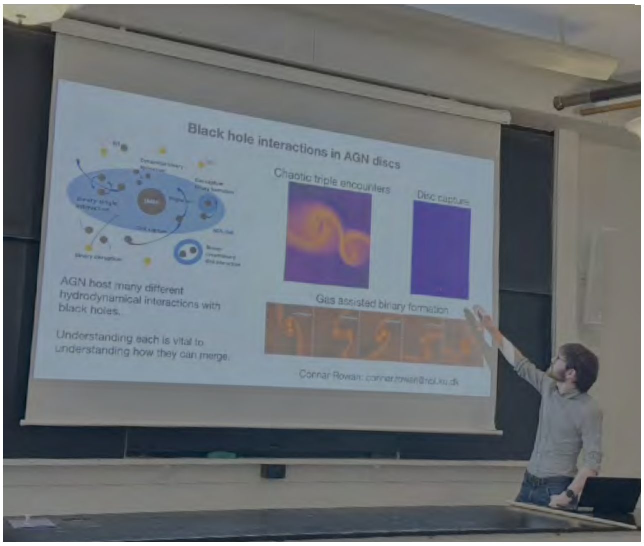
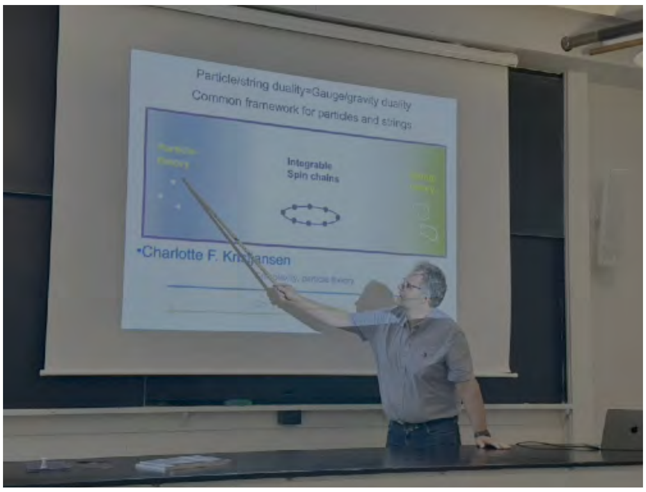
See details

NBIA MSc Day 2025

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.





NBIA Public Lectures - 2025

NBIA Public Lectures & Outreach

Since 2011 NBIA has organized an annual series of public lectures on physics in collaboration with the Danish Open University "Folkeuniversitetet". All lectures take place in the historic Auditorium A in Blegdamsvej 17. The idea was from the start to engage the public and benefit from the presence of scientists and visitors at NBIA. The talks are at a level appropriate for an audience with no background in science and the speakers present topic very close to their on-going research. By design, these lectures 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 turned out being a very successful formula! There is always good attendance to learn about a broad range to topics at the forefront of present-day research. In 2025, the lectures were organized by Emil J. Bjerrum-Bohr (NBI), with the following program:

Mogens Høgh Jensen (NBI) — 07.10.2025
"Mathematics that Describes the Complexity of Life"

Morten Bo Madsen (NBI) — 21.10.2025
"Colonizing Mars: Preparing For a New Era of Exploration"

You Zhou (NBI) — 28.10.2025
"ALICE in Wonderland: Mystery of the Early Universe"

Vitor Cardoso (NBI) — 04.11.2025
"The Dark Universe: What's Lurking Out There?"

Julia Yeomans (University of Oxford) — 11.11.2025
"The Physics of Living Matter"

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.

Lars Kann-Rasmussen presents Jacob Bourjaily with the Lars Kann-Rasmussen Prize 2025

Lise Arleth — Associate Dean of Research, College of Science, University of Copenhagen

Lene Kann-Rasmussen, Jacob Bourjaily, Lars Kann-Rasmussen, Lise Arleth, Poul Damgaard and Joachim Mathiesen

Lars Kann-Rasmussen Prize 2025

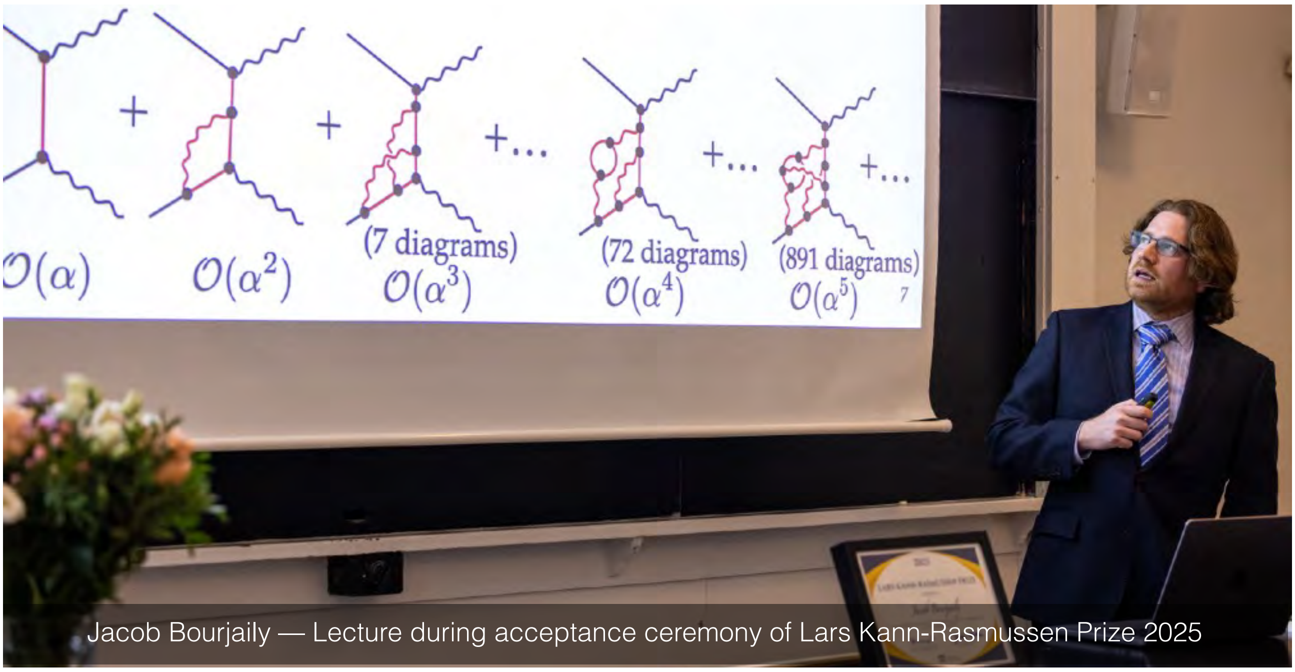
At an award ceremony on February 24, former NBIA Associate Professor Jacob Bourjaily received the Lars Kann-Rasmussen Prize for 2025. The Prize was presented by Lars Kann-Rasmussen to Jacob Bourjaily in Auditorium A following speeches by Deputy Dean of Research Lise Arleth, Head of Niels Bohr Institute Joachim Mathiesen, and NBIA Director Poul Henrik Damgaard.

Jacob Bourjaily finished his undergraduate studies at University of Michigan with Highest Honors in Physics and Mathematics. He was awarded a Marshall Fellowship to spend a year at Cambridge University where he earned a Master's Degree in Mathematics before moving on to Princeton University from where he received his PhD in Physics in 2011. He was a Junior Fellow at Harvard Society of Fellows 2011-14 before joining NBIA on a personal fellowship from the Danish Science Research Council. He received a Villum Young Investigator grant in 2017, followed two years later by an ERC Starting grant from the EU. He took up his current position as Associate Professor at Penn State University in 2020.

Jacob Bourjaily's research is characterized by a drive to step beyond the boundaries of the established formalism of relativistic quantum field theory. By a combination of new developments in mathematics with parallel new understanding of the structure of scattering amplitudes, Jacob Bourjaily's research is changing the understanding of scattering amplitudes. He has followed up on the resulting reformulations of quantum field theory computations to characterize the set of mathematical functions that contribute to the perturbation theory expansion of quantum mechanical observables at cutting-edge high orders. This work is still on-going but is already now impacting the way scientists perform calculations for scattering processes such as those occurring at the Large Hadron Collider (LHC) at CERN.

Jacob Bourjaily receives the Lars Kann-Rasmussen Prize 2025

"*For his fundamental and original contributions to quantum field theory, guided by an on-going quest for both simplifications and deeper understanding*."



Jacob Bourjaily — Lecture during acceptance ceremony of Lars Kann-Rasmussen Prize 2025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2025
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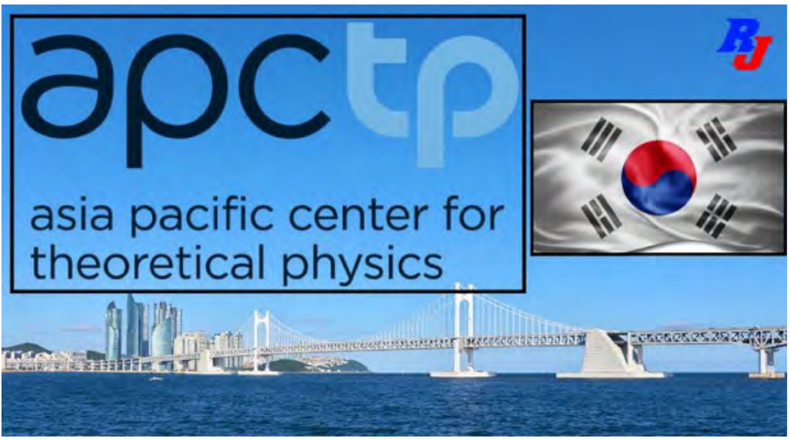
apctp
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theoretical physics


Collaboration with APCTP
Among individual scientists
Joint conferences, PhD-schools, workshops
Shorter exchange visits
Reaching out to the Asia-Pacific region


Role in dense environments and compact astrophysical objects
Source physics carried by cosmic messengers
Impact of neutrino flavor conversions on the stellar dynamics and formation of elements
NEUTRINOS
PHOTONS
GRAVITATIONAL WAVES
COSMIC RAYS
Efficient particle acceleration in astrophysical sources
Non-standard physics from astrophysical sources
Particle production in cosmic accelerators
Detection prospects in existing and future facilities

Collaboration with APCTP

In 2024 NBIA signed a Memorandum of Understanding with Asia Pacific Center for Theoretical Physics (APCTP) in Pohang, Korea. APCTP was established in June 1996, with Nobel Laureate C. N. Yang as its founding President. It is an international non-governmental organization with currently 17 member countries & regions Its aim is to lead in fundamental theoretical physics in the larger Asian-Pacific region. It provides an academic platform to discuss frontier research topics and it promotes international collaborations. Every year, a staggering number of more than 4,000 researchers participate in the conferences, workshops, schools, or long-term academic programs at APCTP.

The agreement between NBIA and APCTP focuses specifically on developing financial plans to co-sponsor international workshops on theoretical physics on either the Pacific Rim or in Denmark, upon agreement between the two institutions. In December 2025 NBIA was host to a delegation from APCTP for discussions on how to move forward, and at the same time we organized a three-day informal scientific meeting on common subjects of interest. It was agreed that in 2026 APCTP will host a scientific conference on topics of interest to both NBIA scientists and scientists in Korea and the surrounding Asian-Pacific region.

The visit from APCTP also led to a delegation from the Embassy of Korea subsequently visiting NBIA where it was agreed to establish closer contacts as well as a one-day workshop on quantum computing with participation from Korean scientists.


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Articles published week ending
23 DECEM

NBIA Publications

Refereed Papers

1. **Beyond first light: Global monitoring for high-energy neutrino astronomy**
Schumacher, L. J., Bustamante, M., Agostini, M. et al., 2025, Phys. Rev. D, 112, 083027 - DOI: 10.1103/lxx2-ss5w - ArXiv: 2503.07549

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Bustamante, M., Ellis, J., Konoplich, R. et al., 2025, Phys. Rev. D, 111, 123031 - DOI: 10.1103/yyv3-mtmy - ArXiv: 2408.15949

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Alves Batista, R., Benoit-Lévy, A., Bister, T. et al., 2025, Computer Physics Communications, 308, 109461 - DOI: 10.1016/j.cpc.2024.109461

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