NBIA NEWSLETTER

A MESSAGE FROM THE DIRECTOR

Poul Henrik Damgaard

The centennial celebrations of the Niels Bohr Institute and the Nobel Prize awarded to Niels Bohr in 1922 continued all the way to August 2023 when NBIA co-organized the conference "Crossing the Disciplinary Boundaries of Physics" which was hosted at, and sponsored by, the Novo Nordisk Foundation. NBIA was especially involved in a three-day part of the meeting with a focus on cutting-edge research on the borderline between physics and biology. It is interesting that just ten years after the founding of his theoretical physics institute Niels Bohr was already contemplating the implications of physical laws, and especially quantum mechanics, on biological processes. Entitled "Light and Life", a talk delivered by Niels Bohr in 1932 viewed with an open mind the possible new opportunities for research in biology that could then be contemplated. The topic was probably also more widely in the air but the impact of Niels Bohr's new ideas on some visitors to his institute was powerful. For example, the theoretical physicist Max Delbrueck (who later received the Nobel Prize in Physiology) was heavily influenced by Niels Bohr when he switched field completely, becoming one of the founders of quantitative biology. Today, this crossing of boundaries between physics and biology is not uncommon at all, around the world. NBIA is continually exploring the possibilities for finding new pathways between subjects and this fall we are reaching out towards theoretical chemistry and biology when new NBIA Assistant Professor Mary Wood arrives from Cambridge University. Every new avenue holds the promise of the unexpected happening and NBIA's generous grant from the Novo Nordisk Foundation allows us to pursue these novel ways of reaching a fertile interdisciplinary environment around life sciences. We look forward to following these new developments!

UPCOMING WORKSHOPS AND SCHOOLS

Please visit our NBIA web page for details and updates.

- RESCEU-NBIA Workshop on Gravitational Wave Sources (December 7 - 15)

NEWS IN BRIEF

Irene Tamborra is new Chair of NBIA's Science Advisory Board

Irene Tamborra has been appointed Chair of NBIA's International Science Advisory Board, replacing Charles Marcus, who served for three years (2021-23).

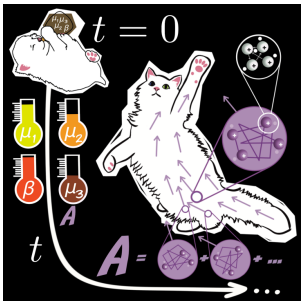
Irene Tamborra moved to Denmark in 2016, joining NBIA as Knud Højgaard Foundation Assistant Professor. She was appointed Associate Professor with tenure in 2017 and became Professor in 2021. Irene Tamborra has received numerous international awards, grants, and honors for her research achievements at the interface between astrophysics and particle physics. At NBIA, she established from the very beginning the flourishing AstroNu research group working on particle and multi-messenger astrophysics. Her research has up to now been supported by the Villum Foundation, the Independent Research Fund through a Sapere Aude Grant, the Carlsberg Foundation, and, most recently, the European Research Council with a Consolidator Grant.

Martin Pessah receives grant from Independent Research Fund Denmark

Martin Pessah, together with Johan Samsing and Daniel D'Orazio at NBIA, has received a grant from the Independent Research Fund Denmark | Natural Sciences to carry out a research project on the subject of black hole binary mergers.

The detection of gravitational waves ignited one of the most exciting revolutions in modern science by opening up a new window into our Universe. We will soon have access to statistical information about the distribution of masses, eccentricities, and spins of black holes in merging binary systems. There is currently an international race to develop the machinery to connect theoretical models to observations and understand how black hole binaries form and evolve like never before. The project will be carried out in close collaboration with researchers at Princeton and Harvard Universities. The grant for 6.2 MDKK will support a PhD student and a postdoctoral researcher.

RESEARCH HIGHLIGHT
on Quantum physics
Berislav Buca



A quantum many-body system's (cat) initial state (kitten) can be written in terms of another equilibrium-like, but time-dependent, state by fixing a set of chemical potentials and temperature. The dynamics of the system is then determined via a set of time-dependent conservation laws ('dynamical symmetries').

Berislav Buca at NBIA developed a new theory that solves the dynamics of quantum systems composed of many particles with short-range interactions, which include the effective interactions of electrons and nuclei in numerous kinds of materials. Fundamental laws of physics describe how any two particles interact, but to compute dynamics of many-particle systems one needs to apply them to all the pairs of particles, e.g., all the pairs of atoms of a cat, in order to understand the dynamics of existence of the cat, which is otherwise intractable and very challenging.

The theory proves that the dynamics of all short-range interacting systems, including very complex ones, is unified within an effective description based on a few elegant principles that determine macroscopically relevant motion of the particles in the system, e.g., the dynamics of a cat as a whole. The only difference between the dynamical behavior of these systems and their behavior when they do not display any dynamics (equilibrium), is that the 'chemical potentials' determining the state of the system in general are changing in time, thus giving the collective dynamics.

This theory provides analytical solutions for the dynamics of otherwise intractable many-particle systems including those with exotic (non-ergodic) dynamics, e.g., far-from equilibrium superconductivity, which could have significant technological applications in the future. Future studies will focus on applications of this theory.

NEWS IN BRIEF (CONTINUED)

Annika Rudolph receives PhD-thesis prize from German Astronomical Society

The German Astronomical Society has awarded a PhD-Thesis Prize to NBIA post-doc Annika Rudolph for her work on high-energy astrophysical phenomena such as gamma-ray bursts. The prize is awarded to a young astronomer for the best PhD thesis of the past calendar year. The PhD thesis titled "Emission of Multiple Messengers from Gamma-Ray Bursts" was based on work performed at the Humboldt University of Berlin and DESY Zeuthen, and defended in 2022 with overall grade "summa cum laude." In her thesis, Annika explored gamma-ray bursts as potential sources of ultra-high-energy cosmic rays, making multi-wavelength photon and neutrino predictions with state-of-the-art numerical models. Annika is now part of the AstroNu group lead by Irene Tamborra, where she continues her research on multi-messenger astrophysics.

Damiano F. G. Fiorillo receives joint prize "Giovannia Bignami" from SAIt-SIF

Damiano F. G. Fiorillo, postdoc at NBIA, has received the joint prize "Giovannia Bignami" from the Italian Astronomical Society and the Italian Physical Society (SAIt-SIF) for the development of innovative ways in the use of multimessenger observations of gamma rays and neutrinos, in order to investigate high energy processes in their sources, both for astrophysical implications and to verify the validity of the Standard Model and its possible extensions.

OUTREACH PROGRAM AT THE NBIA
From the Research Frontier at the Niels Bohr International Academy

The series of lectures will be given by assistant professor Berislav Buca, NBI, associate professor Christian J. Bjerrum, NBI, Assistant Professor Jose Maria Ezquiaga, NBI, professor Jens Hesselbjerg Christensen, NBI and assistant professor Weria Pezeshkian, NBI. Course leader: Associate Professor Emil Bjerrum-Bohr, NBI. Time: 5 Tuesdays at 17.15-19.00 (10/10-14/11) Note: No lecture reon 17/10

Description and location: The lecture series' purpose is to show a glimpse of various exciting front lines of modern research and was created in collaboration with the Niels Bohr International Academy (NBIA). All lectures are in the fabled Auditorium A, Niels Bohr Institute, Blegdamsvej 17.

Titles:
1. Unveiling the Dark Universe with Gravitational Waves (JME)
2. The evolution of multicellular life did not happen as we thought - or did it? (CJB)
3. The melting platform: Are climate extremes man-made? (JC)
4. Reductionism strikes back (BB)
5. Computational Microscopy of Cells (WP)

NEW NBIA MEMBERS

This Fall, NBIA welcomes a number of new staff members and visitors. You can find a brief description of their work below. We also give a warm welcome to our new PhD students, Robin Bolsterli, Adria Bravo Vidal, Martin Seltman, Luka Vujeva and Pedro Dedin , and our new MSc student, Adam Brcek.

Marie Skłodowska-Curie fellow Thomas Berlok works on the physics of the intracluster medium found in galaxy clusters, plasma physics and astrophysical fluid dynamics. At NBIA, he intends to produce the first cosmological galaxy cluster simulations that move beyond the collisional assumption.

Emil Have is a new postdoctoral researcher who is working on holographic dualities in quantum gravity and string theory. His research currently focuses on the application of non-Lorentzian geometry in the contexts of holography, string theory, gravity and fluids.

Rodrigo Panosso Macedo is a postdoctoral researcher, working on black holes and gravitational wave physics. He applies Penrose's conformal treatment of infinity to black-hole perturbation theory and develops a novel framework for black-hole spectroscopy and gravitational self-force programs.

Asta Heinesen is a postdoctoral researcher working at the interface between theoretical and observational cosmology, and focuses on developing model-independent methods for analysing, for instance, standard candles, standard sirens, and the ages and distribution of galaxies in the Universe.

Jens O. Andersen is a full professor at the NTNU in Trondheim, who is currently on a sabbatical at NBIA. His background is QCD at finite temperature, cold Bose gases, effective field theory, and renormalization group methods. Recently he has been working on QCD phase transitions in strong magnetic fields.

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 joined NBIA as a Marie Sklodowska-Curie fellow to investigate the thermodynamics of replication processes at the molecular scale.

Assistant Professor Martin Pedersen works in the field of soft and biological matter. He is particularly interested in using methods from differential geometry and topology to understand the emergence of order and self-assembled geometries in e.g. polymer systems, active materials, or reticular chemical systems.

Takuya Katagiri is a new postdoc in the Strong Gravity group. His research interests include black-hole physics and gravitational-wave physics. He currently focuses on unveiling the fundamental properties of theories of gravity toward testing strong-field gravity with gravitational-wave observation.

Rico Lo is a new postdoc at the Strong group working on both data-analysis and theoretical aspects of gravitational wave science. His current research focuses on gravitational lensing of gravitational waves and its implications to cosmology and test of general relativity.

Apoorv Tiwari joined NBIA as an assistant professor. He is interested in applying concepts related to generalized symmetries, anomalies and topological aspects of quantum field theories and quantum lattice models to the study of phase diagrams of quantum matter.

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The Niels Bohr International Academy