NBIA NEWSLETTER

A MESSAGE FROM THE DIRECTOR

Poul Henrik Damgaard

Black holes used to be viewed with skepticism. Did they really exist? They had singularities, and they had horizons. Could they actually be formed under realistic astrophysical conditions? Then came Hawking radiation: they were not even black, or rather: they were perfectly black, like black bodies in thermodynamics, and they would behave accordingly, emitting black body thermal radiation. They became more and more enigmatic, and when quantum mechanics was taken into account other puzzles such as the black hole information loss paradox went to the front page. Finally, within the past decade, black holes became observable: from supermassive black holes to two black holes merging under the emission of gravitational waves. Today, black hole physics reaches from quantum sciences and quantum information theory, through gravitational astrophysics to fundamentals of black hole and high energy physics. In early October it was announced that Vitor Cardoso has been appointed Center Leader of a new Center of Excellence funded by the Danish National Research Foundation. This new 'Center of Gravity' will span from data analysis to theoretical disciplines within astrophysics and high-energy physics. Together with Vitor Cardoso co-PI's Emil Bjerrum-Bohr, Alessandra Buonanno (AEI Potsdam), Troels Harmark, Niels Obers, and Maarten van de Meent will lead the research in five main directions over the next six years, with a possibility of an extension for another four years. Many new young scientists are joining NBIA this fall, not just in the field of gravitational physics but also in astroparticle and neutrino physics, theoretical astrophysics, high energy physics, and biological physics. Read about all these exciting research directions in below!

RESEARCH HIGHLIGHT on Gravitational waves

Jose Maria Ezquiaga

Every time we have been able to look further into the Universe, we have found fascinating surprises. Most notably, we observe that an omnipresent dark energy pushes the Universe to expand ever faster and that its large-scale structures hold together only because of an invisible dark matter. We do not understand how cosmic structures form or whether our laws of gravity are valid at all scales. Gravitational waves offer a unique opportunity to answer these fundamental open questions. In the quest to explore the distant Universe, gravity's universal nature provides crucial aid, as any clump of matter may act as a giant lens to magnify the radiation emitted by otherwise too-faint objects. Thanks to the gravitational lensing of electromagnetic waves, we mapped the elusive dark matter, found the furthest galaxies, and even discovered exoplanets. Gravitational waves represent the next frontier in gravitational lensing. Because of their well-understood waveforms and large wavelengths, they hold unique discovery potential to probe the dark matter substrate and find new populations of black holes in the early Universe. At NBIA, we are part of the LIGO Scientific Collaboration and are exploiting its latest data to search for the first detection of gravitational wave lensing.

NEWS IN BRIEF

Three Individual EU MSCA Fellowships to NBIA

Three young scientists have been awarded Individual EU MSCA Fellowships at NBIA, and in addition one Individual EU MSCA Fellowship will be spent partly at NBIA. Research topics for all fellows are within the blooming area of gravitational wave physics, as will be described in detail below.

Marica Minucci will join the Strong Group as a two-year Marie Skłodowska-Curie Fellow to work on the FundBHspec project: "Fundaments of Black Hole Spectroscopy" in collaboration with Rodrigo Panosso Macedo. This project is funded by the Marie Skłodowska-Curie Actions under the Horizon Europe programme and aims to combine mathematical general relativity, numerical relativity and astrophysics to advance the fundamental theory of black hole spectroscopy.

Christopher Tiede has been awarded a two-year EU Marie Skłodowska-Curie Individual Fellowship to work on a project titled "Swimming Giants: Illuminating the supermassive-binary and gas interaction" in the Theoretical Astrophysics group at the NBIA. Chris received his PhD from New York University in the spring of 2022 and joined the NBIA as a postdoctoral fellow in the Fall of the same year.

Zhengwen Liu has been awarded a two-year EU Marie Skłodowska-Curie Individual Fellowship to work on a project titled "Gravitational Wave Theory: Feynman Toolbox for Einstein Gravity". Zhengwen earned his Doctorate from the Université Catholique de Louvain in 2019. Before joining the NBIA as an Assistant Professor in the fall of 2022, he was a DESY Fellow in Theoretical Particle Physics in Hamburg.

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, Maryna Mesiura, Brian Ratnasinghe, Elsa Messi, Nigar Abbasova, Tianxiang Ma and Philip Kirkeberg.

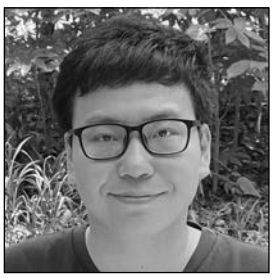
Lorena Magaña Zertuche is a new postdoctoral fellow working on better understanding and modeling the early ringdown of a binary black hole merger. She is interested in learning more about gravitational-wave lensing and its effects on ringdown models.

Marica Minucci is a new Marie Skłodowska-Curie postdoctoral fellow. Her research interests include the stability problem for asymptotically de Sitter spacetimes, the asymptotic structure of the gravitational field, and black hole quasi-normal mode instabilities.

Mariam Gogilashv is a new postdoc in particle astrophysics, focusing on core-collapse supernova explosions, interested in exploring the role of neutrino oscillations in supernovae and mergers, and their influence on explosion dynamics, nucleosynthesis, and galactic chemical evolution.

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.

János Takátsy is a new postdoctoral fellow in gravitational wave astrophysics. 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.



Shunke Ai is a postdoctoral researcher working on high-energy astrophysics. His research interests include the electromagnetic counterparts of gravitational waves, the physics of gamma-ray bursts, high-energy neutrinos, and other high-energy transients in the universe.

NEWS IN BRIEF (CONTINUED)

Tetyana Pitik awarded best PhD thesis in Danish astronomy 2024

Every year the Instrument Centre for Danish Astrophysics awards a prize for the scientifically most outstanding PhD thesis defended at a Danish university within the field of astronomy and astrophysics. For her work on the modeling of the multi-messenger emission from astrophysical transients, Tetyana Pitik has received the 2024 PhD award. Tetyana was a PhD student at the NBIA until last November, working under the supervision of Irene Tamborra. Through her PhD, Tetyana has pioneered the exploration of the non-trivial connection between the neutrino and electromagnetic signals from gamma-rays bursts and superluminous supernovae, highlighting shortcomings in ongoing multi-messenger searches as well as proposing new strategies to address them. Tetyana is now a postdoctoral fellow at University of California, Berkeley and Penn State University, supported by a fellowship funded by the National Science Foundation.

Martin Cramer Pedersen receives Villum Experiment Grant

Active matter systems such as cells, and bacteria are characterized by the continuous injection or conversion of energy by its constituents. Such systems inevitably exhibit intricate structure and dynamics, often in the form of concerted motion, complex phase transitions, and unusual emergent properties. Methods from topological data analysis have been successful in improving our understanding of a wide array of systems in physics and chemistry. This grant will allow Martin to deploy topological data analysis to understand data from experiments, simulations, and theories describing active matter systems and their structure and dynamics. Topological data analysis is particularly promising in this context due to its ability to resolve and quantify structure in topologically complex data and samples, which is exactly what is needed to address current challenges in active matter.

Black holes came to Copenhagen in August 2024

The Niels Bohr Institute is celebrating 50 years of Hawking radiation and a decade of amazing developments in black hole science. Worldwide experts gathered at the Black Diamond and at the Copenhagen Planetarium, to discuss what we don't know yet and what we would like to understand about black holes. The conference was also attended by reporters from the New Scientist and the American Physical Society as well as a science youtuber. In Kongens Nytorv, a central square in Copenhagen, Johan Samsing put up a science/art display that covers all modern aspects of black hole science, thus reaching out to the public as well.

Nicolas Loizeau is a new postdoc in condensed matter theory. He is interested in quantum chaos and the emergence of classicality and locality. Right now his research focuses on dynamical symmetries and new numerical techniques for many body quantum systems.

Connar Rowan is interested in the dynamical interactions of black hole binaries embedded in discs around Active Galactic Nuclei, including single-single and binary-single encounters. He focuses on the role of gas in such encounters and how it can aid in the merger of black holes and modelling the dynamics of these potential gravitational wave sources.

James Cline is a Professor of Physics at McGill University, specializing in elementary particle theory and cosmology, and NBIA Visiting Professor until the end of the year. Currently he is focusing on light dark matter candidates, including axions and dark photons.

Henriette Elvang is visiting the NBIA during her sabbatical from the University of Michigan, where she is a Arthur F. Thurnau Professor of Physics. She works on quantum field theory, string theory, and gravity. She is currently working on bootstrap methods of effective field theories and constraints of symmetries.

NEWS IN BRIEF (CONTINUED)

Vitor Cardoso appointed Center Leader of new Center of Excellence

The Niels Bohr Institute will host a new DNRF Center of Excellence, the Center of Gravity (CoG). The CoG will bring together forefront research in observations of black holes and in the formal theory and quantum aspects of gravity, completing the visions of Bohr and Einstein for the gravitational interaction. The research endeavor will span from data analysis to theoretical disciplines within astrophysics and high-energy physics, driving gravitational wave physics to an exciting future. The Center will capitalize on the remarkable talent at the Niels Bohr Institute, to promote synergies linking fundamental physics with observations.

The Center of Gravity will be run by Center leader, Prof. Vitor Cardoso and his co-PIs: Prof. Emil Bjerrum-Bohr (NBI), Prof. Alessandra Buonanno (AEI), Prof. Troels Harmark (NBI), Prof. Niels Obers (NBI) and Assist. Professor Maarten van de Meent (NBI/AEI). It will focus on five research themes: 1) Motion in curved spacetimes, 2) Spectroscopy of black holes, 3) Quantum effects for black holes and gravity, 4) Precision tools for understanding astrophysical environments, and 5) Templates and new data analysis tools for gravitational waves.

Matthias Wilhelm receives Sapere Aude grant from Denmark's Independent Research Fund

Associate Professor Matthias Wilhelm has been awarded a Sapere Aude Starting Grant from Denmark's Independent Research Fund for his project titled "Leveraging Algebraic Geometry for High-Precision Fundamental Physics." The project addresses the calculation of precision predictions for collider and gravitational-wave physics. A key ingredient for such predictions are Feynman integrals. These integrals are also a key obstacle, both because integration itself is a notoriously hard problem, and because completely new mathematical functions arise in these integrals, which stem from intricate geometries. Using techniques from pure mathematics, the project aims to improve the understanding of the occurring mathematical functions to a degree that allows to circumvent all complications of traditional methods.The grant of over 6 million dkk will allow Matthias to hire a post-doctoral researcher and a PhD-student who will work under his guidance over the next four years.

Coordinator: Gosia Dekempe (Tel. +45 35 33 78 70)
Email: malgorzata.dekempe@nbi.ku.dk
Niels Bohr International Academy - www.nbia.dk
Niels Bohr Institute, Blegdamsvej 17, 2100, Copenhagen, DK

The Niels Bohr International Academy