Ollscoil Mhá Nuad
Maynooth University

Maynooth University
National University of Ireland Maynooth

Research and Innovation Overview 2024
Department of Physics Theoretical Physics

The Department of Theoretical Physics at Maynooth University, part of the Faculty of Science and Engineering, continues to make significant contributions to the field, aligning with the university's strategic aim of becoming a globally recognized leader in research excellence. The department's research, fundamental to all science, has the potential for long-term contributions across multiple areas, with immediate impact on Data and Digital Transformation and Sustainability and Climate Change, two of the university's beacons of excellence.

Head of Department of Theoretical Physics: Dr Joost Slingerland

Research Themes and Focus Areas

The department's research spans a range of core areas in theoretical physics, with key focus areas including:

- **Quantum Matter and Information:** Research in quantum systems, such as topological phases in condensed matter physics, and their applications in quantum computing and information processing.
- **Astrophysics and Cosmology:** Work in this area focuses on statistical cosmology and the early universe, including contributions to the European Space Agency's Euclid mission.
- **Particle Physics:** The department's research includes non-perturbative approaches to particle physics, and develops high performance computing techniques for this purpose.

Collaborations and Partnerships

The department is highly collaborative, engaging with national and international researchers across various subfields:

- **Euclid Consortium:** Professor Peter Coles is the only full member of the Euclid consortium in Ireland, contributing to the preparation and launch of the Euclid space telescope in 2023.
- **FASTSUM Collaboration:** Dr Jonivar Skullerud's research on non-perturbative approaches to particle physics is supported by the FASTSUM collaboration, which focuses on quantum field theory.
- **Quantum Computing:** Professor Jiri Vala leads projects on quantum computing, including the Stochastic Optical Quantum Circuit Simulator (SOQCS), a cutting-edge quantum computing platform.

Significant Research Outputs

In 2022-23, the Department of Theoretical Physics produced 22 publications recorded in SCOPUS. These outputs appeared in top-tier international journals, reflecting the department's commitment to high-impact research:

Publications

- Dr Joost Slingerland published a paper describing a method of generating all fusion rings of a specific rank and multiplicity in the Journal of Mathematical Physics.
- Professor Peter Coles published significant work in statistical cosmology, contributing to preparations for the European Space Agency's Euclid mission. His publications appeared in journals such as Open Journal of Astrophysics, which he founded and manages.
- Dr John Regan published a number of papers on the formation and growth of the first black holes including a paper titled, Massive star formation in overdense regions of the early universe.

Awards

- The department secured €645,000 in new research grants, with €215,000 allocated for the 2022-23 period. Ongoing grants, amounting to approximately €2.7 million, support long-term research projects across multiple fields of theoretical physics.

Research Impact and Societal Contributions

The department's research reaches beyond academia, engaging with the public and contributing to societal understanding of physics:

- **Outreach Programs:** The department hosts several outreach initiatives, including the International Particle Physics Masterclass and the Astrophysics & Cosmology Masterclass, which engage thousands of students in hands-on learning.
- **Public Engagement:** The launch of the EUCLID Space Telescope was featured in a NewsTalk interview with Professor Peter Coles, highlighting the public interest and relevance of the department's research.

Future Directions

Looking forward, the department will continue its work on quantum computing, statistical cosmology, and topological phases in condensed matter physics. Future projects will include expanding collaborations on quantum information processing and furthering research on astrophysical phenomena such as black holes.

The Department of Theoretical Physics at Maynooth University remains a leader in research excellence, international collaboration, and public engagement. Its achievements in 2022-23 demonstrate the department's critical role in advancing theoretical physics and contributing to the global scientific community.

Find out more **www.maynoothuniversity.ie/theoretical-physics** **Email** **physics.department@mu.ie**