

The Research Group
High Energy Physics

has the honor to invite you to the public defence of the PhD thesis of

Hannah Duval

to obtain the degree of Doctor of Sciences

Title of the PhD thesis:

**Whispers of the Cosmos:
Investigating the Gravitational-Wave Background and
its Inflationary Origins**

Supervisors:

Prof. dr. Alexander Sevrin (VUB)

Prof. dr. Alberto Mariotti (VUB)

Co-supervisor:

**Prof. dr. Mairi Sakellariadou
(King's College London, UK)**

The defence will take place on

Wednesday, October 14, 2026 at 4 p.m.

VUB Etterbeek campus, Pleinlaan 2, Elsene,
in auditorium K.2.56

The defence can be followed via [Zoom](#)
(Meeting ID: 817 5994 3050 - Passcode:
0GNgvT)

Members of the jury

Prof. dr. Ben Craps (VUB, chair)

Prof. dr. Michael Tytgat (VUB)

Prof. dr. Katrien Kolenberg (VUB)

Prof. dr. Archisman Ghosh (UGent)

Dr. Tania Regimbau (CNRS, FR)

Curriculum vitae

Hannah Duval obtained her Master of Physics from KU Leuven, specialising in Theoretical Physics with a minor in Astronomy and Astrophysics. In 2022, she started her PhD at Vrije Universiteit Brussel within the High-Energy Physics research group, under the supervision of Prof. Alberto Mariotti and Prof. Alexander Sevrin, with Prof. Mairi Sakellariadou (King's College London) as co-supervisor. Her research focuses on the gravitational-wave background and its origins in the early Universe. In particular, she investigates the impact of inflation and non-standard cosmological histories on the resulting gravitational-wave signal. Hannah is a member of the **LVK and Einstein Telescope Collaborations**. Alongside her research, she is involved in teaching and supervises Bachelor's theses.

Abstract of the PhD research

The Early Universe is shrouded in mystery. In our quest to understand it, Gravitational Waves (GWs) provide a powerful probe, carrying information from the earliest moments of cosmic history and from energy scales inaccessible to electromagnetic observations. Predicted by Einstein's General Relativity and first directly detected in 2015 by the LIGO-Virgo-KAGRA (LVK) Collaboration, GWs from numerous astrophysical events have since been observed. Beyond individually resolvable signals from compact astrophysical sources, an all-present background of GWs is expected, forming the Gravitational-Wave Background (GWB). Depending on its origin, this background can be separated into astrophysical and cosmological contributions. While the astrophysical GWB arises from the superposition of unresolved astrophysical sources, the cosmological background would originate from processes in the Early Universe, offering direct insight into fundamental physics at extremely high energies.

This thesis focuses on cosmological contributions to the GWB, with particular emphasis on inflation, a period of accelerated expansion thought to have occurred shortly after the Big Bang. Although various inflationary models have been proposed, no consensus model has yet emerged. Nevertheless, a generic prediction of inflation is the production of a primordial GWB, whose spectral features depend sensitively on the underlying inflationary dynamics and subsequent cosmological evolution. The impact of non-standard post-inflationary histories is studied, demonstrating how GW observations can reveal deviations from the standard thermal history of the Universe. Using LVK observational data, constraints are derived on the cosmological scenarios, while sensitivity forecasts for future detectors highlight the growing capability of GW experiments to test Early-Universe physics. In addition, this thesis explores parity-violating signatures in the GWB, which would provide evidence for physics beyond the Standard Model. The sensitivity of future detector networks to such signatures is investigated, with particular emphasis on the role of detector geometry. By systematically varying the Einstein Telescope design, detector orientations, and arm lengths, the impact of network configuration on the detectability of parity violation in the GWB is quantified.

Overall, these results demonstrate the power of present and future GW detectors to test fundamental physics and explore the cosmological history of the Universe. In this way, GWs fulfill their promise as a unique probe of the Early Universe, offering a direct window into its earliest moments and the fundamental physics that shaped its evolution.