

The Research Group

Theoretical Physics

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

Kévin NGUYEN

to obtain the degree of Doctor of Sciences

Title of the PhD thesis:

Gravity beyond General Relativity in anti-de Sitter and
de Sitter spacetimes

Promotor:

Prof. dr. Ben Craps

The public defence will take place on

Wednesday September 18, 2019 at 17:00h

in Auditorium D.2.01 at the Campus
Humanities, Sciences and Engineering of the
Vrije Universiteit Brussel, Pleinlaan 2 - 1050
Elsene, and will be followed by a reception.

Members of the jury:

Prof. Alexander Sevrin (chairman, VUB)
Prof. Stijn Buitink (secretary, VUB)
Prof. Oleg Evnin (co-promotor, VUB)
Prof. Rouslan Efremov (VUB)
Prof. Laura Lopez Honorez (VUB)
Prof. Johanna Erdmenger (Univ. Würzburg)
Prof. Thomas Van Riet (KU Leuven)

Curriculum vitae

Kévin Nguyen graduated with the
greatest distinction as Master in
Physical Sciences: Particle Physics
and Cosmology in 2015 from
Université Catholique de Louvain
(UCL).

During his doctoral research at Vrije
Universiteit Brussel (VUB), he studied
theoretical extensions of gravity
beyond General Relativity. He co-
authored three publications in peer-
reviewed scientific journals and
presented his work at several
international conferences. In
addition, he has been involved in
teaching and mentoring, at both VUB
and UCL.

Abstract of the PhD research

More than a century after its formulation, General Relativity still passes every single experimental and observational test that physicists have designed. However, this does not mean that it is a complete theory of gravity, but rather that observations are not accurate enough to falsify it yet. In this thesis, several theoretical extensions of General Relativity are considered and some of their implications are investigated.

Important developments in the past decades have demonstrated that General Relativity considered in anti-de Sitter spacetimes (AdS) can be used to study strongly interacting conformal field theories (CFT). We use this fruitful AdS/CFT connection to study out-of-equilibrium quantum dynamics, and we develop an understanding of thermalization and quantum chaos in terms of gravitational black hole physics. This description allows us to characterize these quantum phenomena in regimes where conventional computational methods fail. In gravitational language, thermalization corresponds to the disappearance of matter behind a black hole's event horizon, to which one can associate thermal properties such as temperature and entropy. On the other hand, chaos emerges from the gravitational blueshift of particles falling into a black hole, causing them to interact strongly with other particles traveling near the black hole horizon.

In parallel, we study vacuum quantum fluctuations in cosmology, considered one of the best observational windows into fundamental physics. A potentially major role of quantum fluctuations is their contribution to the cosmological constant, which sources the accelerated expansion of our Universe. We revisit the tension between theory estimates and cosmological measurements of the cosmological constant and propose a low-energy effective theory that might potentially resolve this tension. In this model, the cosmological dynamics of a new scalar field tends to screen most of the vacuum energy, such that the Hubble expansion rate is relaxed to the observed small value. Lastly, we also contribute to the development of the AdS/CFT correspondence in application to cosmology, which enables us to generalize part of the known vacuum structure of free quantum fields in de Sitter space. In particular, we find that analogues of the Mottola-Allen vacua also appear in the context of AdS/CFT.