SCIENCES & BIOENGINEERING SCIENCES

The Research Group

Elementary Particle Physics

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

Matthias VEREECKEN

to obtain the degree of Doctor of Sciences

Title of the PhD thesis:

Aspects of astrophysical particle production and beyond the Standard Model phenomenology

Promotor(s):

Prof. Dr. Alexander Sevrin
Prof. Dr. Jorgen D'Hondt
Prof. Dr. Nick Van Eijndhoven

The defence will take place on

Thursday October 10 2019 at 15h30

in Auditorium I.0.03 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. Dr. Stijn Buitink (chairman, VUB)

Prof. Dr. Krijn De Vries (secretary, VUB)

Prof. Dr. Alberto Mariotti (co-promotor, VUB)

Prof. Dr. Dominique Maes (VUB)

Prof. Dr. Laura Lopez-Honorez (ULB/VUB)

Prof. Dr. Kumiko Kotera (IAP, Paris)

Prof. Dr. Benjamin Fuks (LPTHE, Paris)

Curriculum vitae

Matthias Vereecken obtained a degree in Master of Science in Physics and Astronomy at the University of Ghent in 2014, after which he started his PhD research at the VUB. His research is focused on (astro)particle physics phenomenology, drawing the link between the theory of elementary particles and observations in particle accelerators on Earth (LHC) and in the universe (active galaxies). He (co-)authored three peer-reviewed publications and participated in two international conferences. His research was supported by FWO Vlaanderen.

Abstract of the PhD research

The building blocks of the universe are described by the Standard Model of particle physics. Together with gravity, this theory can explain almost all phenomena we observe, from the smallest scales of fundamental particles to the largest scales of galaxies and clusters using a single framework.

However, the Standard Model must be incomplete, since it provides no explanation for the smallness of the Higgs mass, the existence of dark matter, neutrino masses or the predominance of matter compared to antimatter. One possibility to extend the Standard Model is to include supersymmetry (and its breaking at low energy), which doubles the particle content whilst maintaining a predictive framework for the possible interactions. However, up to now, searches for new physics in proton-proton collisions at the LHC have not yet found significant deviations from the Standard Model, strongly constraining conventional new physics models. In this thesis, we interpret a particular excess in ATLAS in a model with an extended supersymmetry breaking sector, which can evade the constraints from which the conventional models suffer.

On the other hand, we can also study the most extreme objects in the universe, such as active galaxies. Such objects emit high-energy cosmic rays, gamma rays and neutrinos, whose production is described by the Standard Model, as well as gravitational waves. By combining information from these different types of emission in a multimessenger approach, we can increase our understanding of their sources. While still unknown, the properties of possible neutrino sources are constrained by the gamma-ray background observed, since the processes which produce neutrinos must also produce gamma rays in similar quantities. The relative brightness of the diffuse neutrino and gamma-ray fluxes suggests that the neutrino sources must be obscured in gamma rays. We investigate the neutrino flux produced by a class of sources which exhibit signs of obscuration by gas. The presence of this gas can explain both neutrino production and gamma-ray obscuration. We find that a population of such obscured sources can account for the diffuse neutrino flux while alleviating the tension with the limits on the corresponding gamma-ray flux. Finally, we also investigate the limits on neutrino production from binary black hole mergers following the first ever detection of such an event in gravitational waves. We find that, currently, direct observations can not exclude a significant contribution of binary black hole mergers to the diffuse neutrino flux. With mild assumptions on their cosmological evolution, this possibility can be constrained in the following years.