SCIENCES & BIOENGINEERING SCIENCES

The Research Group

Elementary Particle Physics

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

Sam Junius

to obtain the degree of Doctor of Sciences

Title of the PhD thesis:
Searching for feebly interacting Dark Matter at Colliders and Beam Dump Experiments

Promotor:
Prof. dr. Laura Lopez Honorez (ULB)
Prof. dr. Alberto Mariotti (VUB)

The defense will take place on
Friday, December 16, 2022 at 16h in auditorium I.0.02

This event will be live streamed via Teams

Members of the jury

Prof. dr. Steven Lowette (VUB, chair)
Prof. dr. Thomas Hambye (ULB, secretary)
Dr. Suchita Kulkarni (University of Graz)
Prof. dr. Felix Kahlhoefer (Karlsruhe Institute of Technology)

Curriculum vitae

In 2018, Sam has obtained its master's degree in physics and astronomy at the VUB. After this, he got the opportunity to continue the work he had started during his master thesis as a PhD student at VUB in collaboration with ULB. During his PhD, he published three articles in peer-reviewed, international journals and presented his work at multiple international conferences. Sam was also active as a teaching assistant and supervised a bachelor and master student while they worked on their respective thesis.

Abstract of the PhD research

Despite the compelling amount of evidence for the presence of dark matter in our universe through gravitational effects, the exact nature of dark matter is still one unknown to us. A great experimental effort has been performed in order to probe a popular dark matter candidate, a Weakly Interacting Massive Particle or WIMP. Despite many searches performed, there has not been any conclusive detection of dark matter yet. Hence, these searches place strong constraints on the WIMP paradigm, restricting the amount of models containing a viable WIMP candidate. The community has therefore persued different dark matter candidates who are able to evade the strong experimental constraints.

A novel dark matter candidate that has gained a lot of attention in the recent years is the Feebly Interacting Massive Particle or FIMP. Unlike the WIMP, which is produced through the freeze-out mechanism, for which it needs sizeable interactions with the standard model particles, the FIMP has very feeble interactions. The FIMP is therefore unable to reach a state equilibrium necessary to produce it trough the freeze-out. There is a variety of mechanisms able to produce the measured amount of dark matter in the universe, despite its feeble interactions. In this work, a selection of these mechanisms, such as freeze-in or conversion driven freeze-out, are discussed in detail.

Since these FIMPs are so feebly interacting with standard model particles, it is difficult to probe these particles through conventional DM search strategies. In contrast, the feeble couplings give rise to long-lived particles coupling to the DM, which can hence be smoking gun signatures for FIMPs. This thesis will therefore focus on searches for long-lived particles, both at hadron colliders and beam-dump experiments. In order to do so, a classification of FIMP models has been put forward within the context of this PhD, in which potential production mechanisms are identified in order to define a viable parameter space. Within this framework, both existing and potential future searches for long-lived particles are discussed and applied to a subset of the proposed classification.