VRIJE UNIVERSITEIT BRUSSEL

The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Camila De Jesús Castillo Pinto**

The public defense will take place on **Monday 6th May 2024 at 4:00 pm** in the room **D.2.01** (Building D, VUB Main Campus)

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FREQUENCY COMB GENERATION IN VECSELS: INVESTIGATION OF POLARIZATION DYNAMICS, CHAOS, AND 2D SATURABLE ABSORBERS

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Abstract of the PhD research

Vertical External-Cavity Surface-Emitting Lasers (VECSELs) have emerged as a promising platform with the potential to generate versatile optical frequency combs (OFCs). OFCs, comprising ultra-short laser pulses, are of immense significance in diverse scientific and technological domains, including spectroscopy, optical communication, and time-frequency metrology.

When delving deeper into OFC generation within VECSELs, diverse, unexplored and challenging opportunities arise. These prospects revolve around key aspects of the VECSEL system, including understanding the polarization dynamics, using different saturable absorber materials for efficient pulse formation, and exploring the route to chaos in these lasers. Addressing these issues is imperative to achieve the full potential of VECSEL-based frequency comb sources.

This thesis is dedicated to advancing the fundamental understanding of VECSEL-based OFC sources and exploiting the potential of 2D materials to enhance OFC performance. The research begins with an experimental examination of the polarization dynamics within VECSELs, shedding light on the underlying mechanisms governing the laser's output and providing a simple method for polarization control. Moreover, this research analyzes the emergence of chaos in VECSELs, focusing on its potential applications for optical comb generation, accompanied by experimental characterizations of the route to chaotic regimes. Furthermore, this thesis investigates the incorporation of 2D materials, including graphene and MXenes, as saturable absorbers within a VECSEL. By exploiting the unique characteristics of these materials, the research demonstrates their potential to generate ultrafast pulses, thereby enhancing the performance of OFCs.

In summary, the contribution of these investigations relies on the comprehensive understanding of the underlying phenomena in VECSELs and their potential for advanced OFC generation through the incorporation of 2D materials.