SCIENCES & BIOENGINEERING SCIENCES

The Research Group

Applied Physics

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

Dorota Youmbi Fouego

to obtain the degree of Doctor of Sciences

Joint PhD with Yaoundé Université I

Title of the PhD thesis:

Study of coupled self-sustaining oscillators: circadian oscillations in cyanobacteria and powering of biological loads

Promotors:
Prof. dr. Paul Woafo (Yaounde Université I)
Prof. dr. Sophie de Buyl (VUB)

The defense will take place on
Monday, February 20, 2023 at 9h in Yaoundé Université I

https://tinyurl.com/mwrcsemv

Members of the jury

Prof. dr. Jan Danckaert (VUB)
Prof. dr. Blaise Roméo Nana Nbendjo (Yaoundé Université I, secretary)
Prof. Dr. Serge Ibraid Fewo (Yaoundé Université I)
Prof. dr. René Yampi (University of Douala Cameroon)
Prof. dr. Bernard Essimi Zobo (Yaoundé Université I , chair)

Curriculum vitae

Dorota Youmbi Fouego obtained a master diploma in Physics. She works on the fields of nonlinear dynamics and complex systems. Her research interests cover biological inspired modeling and physical implementation of the models in electrical circuits. She is the first author of two publications and the first author of one submitted article. She is doing a joint PhD between VUB and Yaoundé University I in Cameroon.

Abstract of the PhD research

This thesis deals firstly with the analysis of the dynamics of coupled systems considered here as a set of self-sustained oscillators (Van der Pol, Grudzinski-Zebrowski, Hindmarsch-Rose) powering an electrical load (RLC, RL, RC or R). Secondly, we model the circadian clock of cyanobacteria and studied the coupling between the transcriptional regulation and the post-translational regulation. The harmonic balance method, the Kirchoff's laws, Runge-Kutta RK4 method and the criteria of synchronization have been used in our different projects.

We considered an array of Van der Pol oscillators coupled to a load and found that after a threshold number of oscillators under which the power is equal to zero, the power increases with the number of oscillators. A high order nonlinearity in the damping of the Van der Pol oscillator increases the power in the load.

In the case of an array of Grudzinski-Zebrowski oscillators coupled to a load, we design an equivalent electrical circuit whose equation is similar to the self-sustained oscillator model presented by Grudzinski-Zebrowski. It is then demonstrated that the power in electrical loads (RLC, RL, RC and R) coupled to an array of such oscillators increases with the number of oscillators untill a constant value which depends on the types of loads and values of the load parameters. The synchronization domain is seen to depend on the values of the direct coupling, the values of the indirect coupling and on the number of oscillators in the array.

In the case of an array of Hindmarsch-Rose oscillators coupled to a load, it is shown that varying the coupling coefficient leads to the appearance of chaotic dynamics in the system. It is also found that the voltage amplitudes decrease when the size of the array of the HR oscillators increases.

We propose an *in vivo* model of cyanobacterial circadian clock based on the hexameric *in vitro* model and it is shown that there is a large range of values leading to an oscillatory behavior, both for the wild type cyanobacteria and for the mutants lacking the transcriptional regulation. This result suggests that although the transcriptional feedback slightly enhances the robustness of the clock, the effect is not as strong as previously claimed. Our conclusion is in agreement with the experiments.