SCIENCES & BIOENGINEERING SCIENCES

The Research Group

Applied Physics Research Group

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

Stefan Vet

to obtain the degree of Doctor of Sciences

Title of the PhD thesis:

Dynamical analysis of nutrient-explicit models for small microbial communities

Supervisors:

Prof. Dr. Ir. Lendert Gelens (VUB)
Prof. Dr. Jan Danckaert (VUB)
Prof. Dr. Didier Gonze (ULB)

The defence will take place on

Wednesday, July 8, 2020 at 16h00

You can find the link and instructions to attend the defense here[1].

1: https://ibsquare.be/public-phd-defense-stefan-vet/

Members of the jury:

Prof. Dr. Geneviève Dupont (Chairman, ULB)
Prof. Dr. Krijn De Vries (Secretary, VUB)
Prof. Dr. Ir. Luc De Vuyst (VUB)
Prof. Em. Dr. Thomas Erneux (ULB)
Prof. Dr. Aisling Daly (UGent)
Prof. Dr. Béatrice Laroche (INRA, France)

Curriculum vitae

Stefan Vet (°1990) obtained a Master degree in Physics in 2014 at the Universiteit Gent (UGent). In 2014 he started his PhD research in the Applied Physics Research Group (APHY, VUB) and in the Unit of Theoretical Chronobiology (ULB), via a joint-PhD between VUB and ULB at the Interuniversity Institute of Bioinformatics, Brussels (IB2). His interdisciplinary research results were presented at several international conferences. Stefan is first author of 4 research papers that appeared in international peer-reviewed journals. Stefan taught and coordinated different introductory physics classes in the Faculty of Sciences and Bioengineering Sciences.

Abstract of the PhD research

Microbes form complex communities on Earth. They are crucial for global nutrient recycling in soil and oceans. Inside our body, our intestinal microbiome contributes to our metabolism and protects us against diseases. The dynamics of these microbial communities and their response to environmental changes depend on intra- and inter-species interactions. Computational models are useful to simulate the behavior of such systems and to predict their response to prebiotics or to antibiotics for example. However, due to the multiple, nutrient-dependent interactions, modeling the behavior of such communities remains a real challenge.
Mathematical modeling allows for an understanding of the general principles underlying the nonlinear dynamics of microbial communities. Population-based models are based on the abundances of each species but typically do not incorporate the interaction mechanism. Interactions can be mediated by the metabolism of microbes. Therefore, explicit modeling of nutrients is required for a mechanistic understanding of the dynamical behavior of interacting communities.

In this work we developed and analyzed models accounting for the nutrient-mediated microbial interactions, focusing on competition and mutualistic cross-feeding. In the first part of the thesis, we constructed a nutrient-explicit model that reproduced experimental time series of a small synthetic microbial community, consisting of three species that interact via cross-feeding and competition. The comparison of mono-culture and co-culture dynamics reveals emergent behaviors in co-cultures and highlights the influence of key factors on the population dynamics. In the second part of the thesis, we showed how nutrient-explicit models for mutualistic cross-feeding are related to population-based models, such as the Lotka-Volterra equations. This allows to predict the occurrence of bistability and the presence of a survival threshold. Finally, we extended these results by considering the spatial dimension, and studied how diffusion and advection influence the survival of the community.

Our results demonstrate that nutrient-explicit models are able to reproduce experimental time series of microbial communities and to predict the factors determining survival or extinction. By providing a mechanistic understanding of the nonlinear behavior related to microbial interactions, we take a step forward towards the development of predictive models of microbial communities.