

Statistical Physics, Ecology and Evolution: Eco-evolutionary dynamics of multi-species communities

Dynamics of interacting species is a central ingredient determining ecosystem behaviour. Studies for small communities started long ago, however very few results are known in cases where the number of species is very large. Recent advances in observational and experimental techniques, notably high-throughput genomic methods, have established that natural communities are very complex and possess a high number of ecological degrees of freedom (see Figure).

In the past few years, a considerable theoretical effort has been devoted to understanding the dynamical behaviour of many species that interact through cooperation and competition, see e.g. [1]. Yet, one fundamental ingredient— evolution — has rarely been taken into account and is currently sparking a lot of attention both in theory and applications [2].

The internship and the PhD will focus on simple models combining ecological interactions and evolution, such as Lotka-Volterra equations where species are allowed to evolve along the ecological dynamics. The aim of the models will be to understand the interplay between ecological interactions and evolution, in particular identifying general mechanisms for the change over evolutionary time scales of ecosystem-level properties – such as diversity, productivity and resilience – and the associated variations in community ecology.

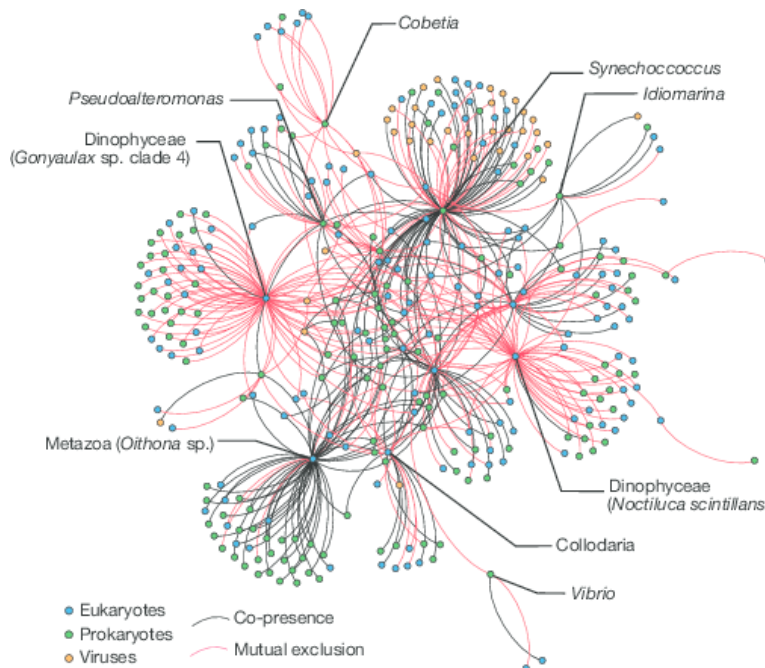


Figure : Marine plankton community network built from eukaryotic, prokaryotic and viral

subnetworks related to carbon export, illustrating ecological interactions in natural communities (from Guidi et al. *Plankton networks driving carbon export in the oligotrophic ocean*. Nature, 2016).

This topic is for theoretically oriented students that have a very good background in statistical physics. It will combine analytical and numerical work. The internship and the PhD will be supervised by Giulio Biroli (LPENS) and will be performed in strong collaboration with Silvia De Monte (IBENS; MPI Evol. Biol., Plön, Germany).

References:

[1] Kessler, Shnerb, Phys. Rev. E **91** 042705 (2015)
Bunin, Phys. Rev. E **95** 042414 (2017)
Biroli, Bunin, Cammarota, New Journal of Physics 20 2018
Roy, Biroli, Bunin, Cammarota, J. Phys. A 484001 **52** 2019
Roy, Barbier, Biroli, Bunin arXiv 1908.03348

[2] William, Lenton, PNAS 104 8918 (2007)
Doulcier, Lambert, De Monte, Rainey, biorxiv 10.1101/827592v2
Arias-Sánchez, Vessman, Mitri, PLoS Biol. 17(8):e3000356

Advisor: Giulio Biroli

Email: giulio.biroli@ens.fr

Co-Advisors: Silvia De Monte

Email: demonte@biologie.ens.fr

Lab: LPENS Paris

Funding: NO