Dynamics on multilayer networks with applications to ecology

This Master Project is about dynamical systems on complex networks consisting of multiple layers. These networks are ubiquitous, for example, ecological networks where polinators and plants are living together in a mutualistic community. So far the study of these networks was limited to mean-field descriptions and heterogeneous multilayer networks have largely remained unexplored.

In this Master Project you will attempt to analyze heterogeneous multilayer networks, both using numerical and analytical methods.

Methodology

The dynamical systems on networks are described by a number of ordinary differential equations, which could for example describe populations of biological species. Only populations that are connected will interact. In the multilayer case this interaction consist of interaction between the same species (in the same layer) and between different species (different layers).

Your task will consist of the following 3 subtasks:

- Explore populations for several networks including, random networks, scale free networks and some real life networks taken from the online web-of-life database.
- Try to find an analytical approximation using spectral reduction techniques of the population stationary state and its stability.
- Compare the results with random population networks proposed by Robert May in the nineteenseventies, who found that if networks have random interactions then dynamics will eventually turn unstable as network size increases. In biological context this would be that large ecological systems will always be unstable. This quite surorising statement has led to strong debates that have been going on for decades. The model that will be developed might help to shed some new light on this decade old problem.

Literature

1. Weighted competition fosters structural stability of mutualistic networks, Xiangrong Wang, Thomas Peron, Johan L. A. Dubbeldam, Sonia Kéfi, Yamir Moreno (in preparation)
2. Spectral Dimension Reduction of Complex Dynamical Networks, Edward Laurence, Nicolas Doyon, Louis J. Dubé, and Patrick Desrosiers, Phys. Rev. X **9**, 011042 (2019)

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