Internship proposal for master 2, 2019-2020:

Dynamics of pathogen ecology on interconnected populations

Keywords: spreading on complex networks, network theory, non-linear dynamics, ecology, infectious diseases.

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Additional information: the internship can be followed by a PhD on the same subject.

Pathogen do not spread in isolation, instead they are embedded in a larger ecosystem, characterized by a complex web of interactions among constituent elements. Among ecological forces shaping such ecosystems, pathogen-pathogen interactions have drawn increasing attention during recent years due to their epidemiological implications. The examples are many. HIV enhances the susceptibility to tuberculosis increasing the burden associated to latter infection [1]. On the other hand, the competition between different strains of influenza hampers the design of effective vaccines [2]. The network of human-to-human contacts, by mediating infection transmission play a critical role on pathogen ecology. For example, it was found that the dominant among two competing pathogens depends not only on the infection parameters, but also on the network structure [3]. Still, many questions remain open. For instance, how the network mediates the interaction between pathogens, when these are allowed to co-infect the same individuals (as e.g. in some bacterial infections [4])? Or when the pathogen confers some level of immunity following infection?

The student will work on these problems through numerical and analytical approaches. The design and use of network algorithms will lead to realistic models of human interactions. Montecarlo simulations will be used to simulate the infection diffusion, and analysis tools for temporal networks (e.g. randomized reference models [5]) will allow identifying the properties of the network that more affect the system's dynamics. In addition, the Markov equations of the process can be analyzed to quantify the spreading potential of a disease. A tensorial representation have been introduced recently for the case of a single pathogen [6,7]. This theory can represent the starting point of the theoretical treatment for the case of more complex ecological dynamics.

References:

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