Internship proposal for master 2, 2018-2019:
Multi-scale modeling of pathogen emergence on interconnected populations

Keywords: infectious disease dynamics, disease ecology, spreading on complex networks, network models, reaction-diffusion phenomena, non-linear dynamics.

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

The complex networks of human contacts represent the substrate for pathogen's spread and ecological dynamics. The understanding of how the structure and dynamics of such network shape spreading processes on the top of that represents a fundamental biological and ecological problem [1,2]. Modern challenges are represented by the complexity of multi-pathogen interactions and pathogen/ immune-system interactions occurring within a host [3]. In particular, theoretical modeling is needed to understand how human contact dynamics impacts phenomena occurring at the interface between the intra-host and the inter-host level, such as the emergence of a new pathogen strain and its interaction with previously existing ones. The student will work on these problems through numerical approaches. The design and use of network algorithms will lead to realistic models of human interactions. The theory of reaction-diffusion processes will be used to simultaneously describe the pathogen/ immune system interaction, taking place within an individual, and the transmission dynamics from one individual to another [2]. Eventually, analysis tools for temporal networks will allow identifying the properties of the network that more affect the system's dynamics. On a more theoretical side, analytical calculation can be carried out to explain the behavior observed in the numerical analyses. The interrelated temporal and topological dimension of the network can be captured by a tensorial representation allowing for the use of eigenvalue calculation for describing the phase-space of different dynamical regimes. Studies conducted so far, focusing on the spread of a single pathogen [4,5], will represent the starting point of the theoretical treatment for the case of a more complex ecological dynamics.

References:

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