Disease Spreading Processes in Multilayer Networks

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Most epidemic models assume that the spreading process takes place on a single level (be it a single population, a meta-population system or a network of contacts). The latter results from our current limited knowledge about the interplay among the various scales involved in the transmission of infectious diseases at the global scale. Therefore, pressing problems rooted at the interdependency of multi-scales call for the development of a whole new set of theoretical and simulation approaches. In this talk, we show that the recently developed framework of multilayer networks allows to tackle many of the existing challenges in the study of multi-scale diseases, ranging from interacting diseases [1] to new phenomena like disease localization [2].

Specifically, we (1) characterize analytically the epidemic thresholds of two interacting diseases for different scenarios and numerically compute the temporal evolution characterizing the unfolding dynamics (Fig. 1, top panel); and (2) we present a continuous formulation of epidemic spreading on multilayer networks using a tensorial representation, showing the existence of disease localization (Fig.1, bottom panel) and the emergence of two or more transitions, which are characterized analytically and numerically through the inverse participation ratio. Our findings show the importance of considering the multilayer nature of many real systems, as this interdependency usually gives raise to new phenomenology.

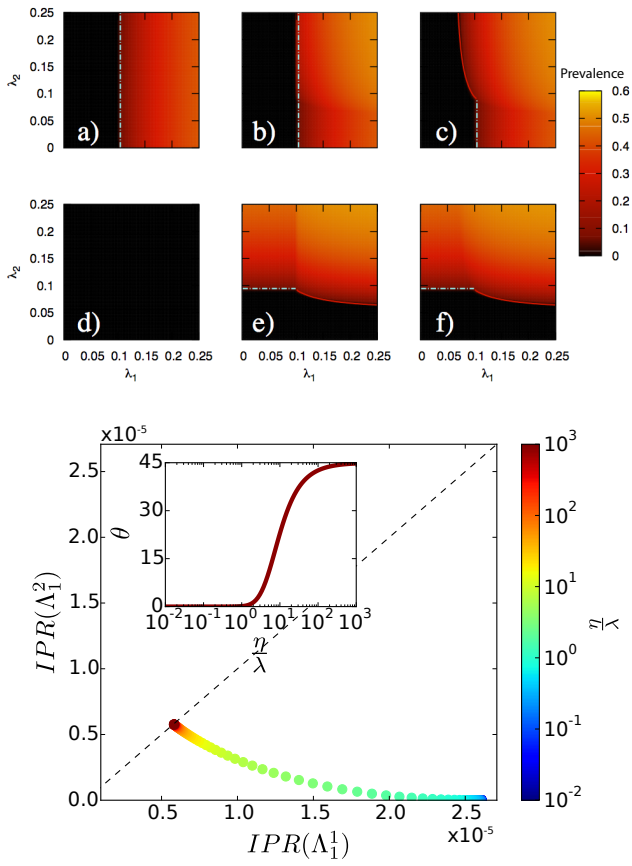

Figure 1: (Top) Phase diagram of the incidence of two interacting diseases for the case of homogeneous networks and (bottom) localization effect in the spreading of diseases in multilayer networks.

[1] J. Sanz, C.-Y. Xia, S. Meloni and Y. Moreno, "Dynamics of interacting diseases", *Physical Review X* **4**, 041005 (2014).

[2] G. Ferraz de Arruda, E. Cozzo, T. P. Peixoto, F. A. Rodrigues, and Y. Moreno, "Disease Localization in Multilayer Networks", *Physical Review X* , in press (2017).
(preprint: https://arxiv.org/pdf/1509.07054v2.pdf)