Complex Epidemic Spreading

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Epidemic modeling has proven to be a powerful tool for the study of spreading and contagion phenomena in biological, social and technical systems. The addition of numerous compartments and the incorporation of complex contact topologies has yielded evermore accurate models, prompting their use as real-time predictive tools. Notwithstanding, most approaches assume memoryless and independent processes, an approximation partially invalidated by empirical evidence [1]. We propose an alternative, cumulative infection mechanism, and study its effects in the susceptible-infected-susceptible model.

In our description, susceptible agents accumulate exposition time from all their infected neighbors and become infected following a given probability density. When the last infected neighbour recovers, this exposition time starts to decay with a characteristic relaxation time ζ. Infected agents recover spontaneously following a given inter-event time distribution. Here we use a Weibull distribution for infections (with shape parameter α) and exponentially distributed recoveries. We study the limit cases $\zeta = 0$ (instantaneous decay) and $\zeta = \infty$ (long-term memory) in random degree regular networks.

Performing extensive numerical simulations we obtain the bifurcation diagrams (Fig. 1) and critical properties of the absorbing phase transitions. Our results [2, 3] show a variety of phenomena, including loss of universality and, counterintuitively, an apparent memory-loss in systems equipped with long-term memory. These features arise from different combinations of infection distributions and relaxation times, evidencing a crucial role of non-Markovian effects.

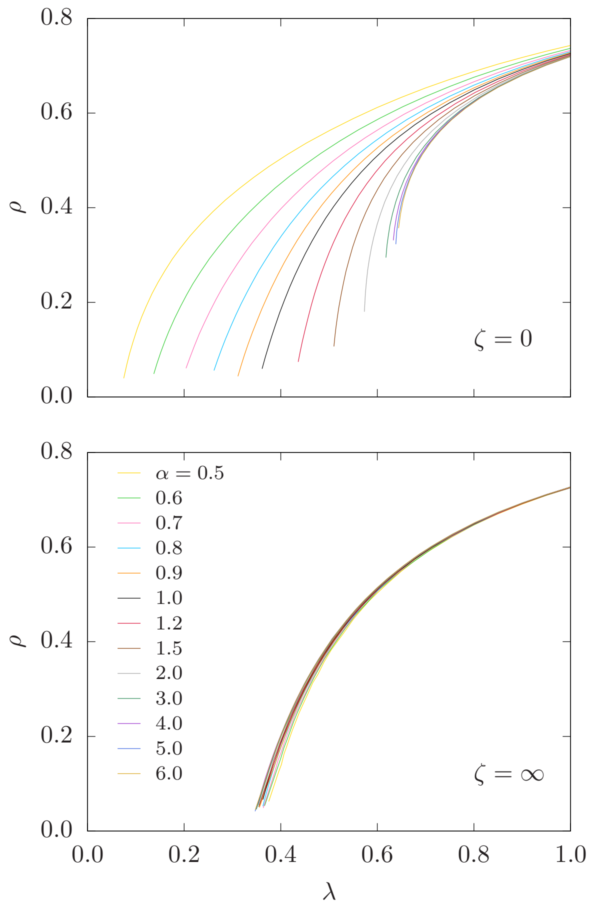

Figure 1: Fraction of infected agents, ρ, as a function of the effective spreading ratio, λ, for various infection distributions (α indicated in legend). **Top**: Instantaneous decay of exposition time (short-term memory). **Bottom**: Exposition time does not decay (long-term memory).

[1] Pastor-Satorras, R. et al. *Reviews of Modern Physics* **87** (3): 925 (2015).

[2] Hoffmann, X. R. (supervisors Boguñá, M., and Toral, R.) *Cooperative Epidemic Spreading* (Master's thesis, Universitat de les Illes Balears, 2016). Retrieved from http://ifisc.uib-csic.es/publications/ on 31-01-2017.

[3] In preparation.