Mitigation of Epidemic Spreading in Random Environments: The Impact of Testing and Quarantining

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Epidemic-like spreading dynamics arise in diverse contents, ranging from rumor or misinformation dissemination on social networks to malware propagation on computer networks and, of course, spreading of pathogens (e.g., Covid-19) in susceptible populations. In this paper, we investigate the large-scale spreading dynamics in spatially random (i.e., heterogeneous) propagation media in the presence of carrier mobility, when mitigation means are deployed, for example, testing or fact-checking and quarantining or blocking carriers, depending on the epidemic context.

We show that the spatially heterogeneous infectivity function, determines whether the epidemic spreads widely or not. Interestingly, it turns out that the average infectivity is deceiving and does not comprise the determining factor for the epidemic spreading widely or not; instead, rare fluctuations akin to "super-spreader" events in epidemic dynamics are the drivers for the onset of spreading. The introduction of mitigation measures are shown to strongly affect the spreading. Optimizing over the mitigation measure density, we find that a drastic gain in preventing the spreading occurs if we know the infectivity distribution.

We analyze such systems in the infinite-size regime, as well as the relatively large (but finite) one, and investigate the emerging transition, taking into account critical finite-size scaling. The analytical results are leveraged to optimize the efficiency of mitigation measures versus their cost.