Contagion-diffusion processes with recurrent mobility patterns of distinguishable agents

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The analysis of contagion-diffusion processes in metapopulations is a powerful theoretical tool to study how mobility influences the spread of communicable diseases. Nevertheless, many metapopulation approaches use indistinguishable agents to alleviate analytical difficulties. Here, we address the impact that recurrent mobility patterns, and the spatial distribution of distinguishable agents, have on the unfolding of epidemics in large urban areas. We incorporate the distinguishable nature of agents regarding both, their residence, and their usual destination. The proposed model allows both a fast computation of the spatio-temporal pattern of the epidemic trajectory and. the analytical calculation of the epidemic threshold. This threshold is found as the spectral radius of a mixing matrix encapsulating the residential distribution, and the specific commuting patterns of agents. By the end of this paper it will become clear that very subtle differences in the way we treat the system's agents will have very important consequences, in a similar way that the distinguishability of particles matters in statistical physics. We prove that the simplification of indistinguishable individuals overestimates the value of the epidemic threshold (Fig. 1) and show how the new formalism can be a powerful tool to assess control strategies aimed at increasing the epidemic threshold under scenarios of epidemiological risk.

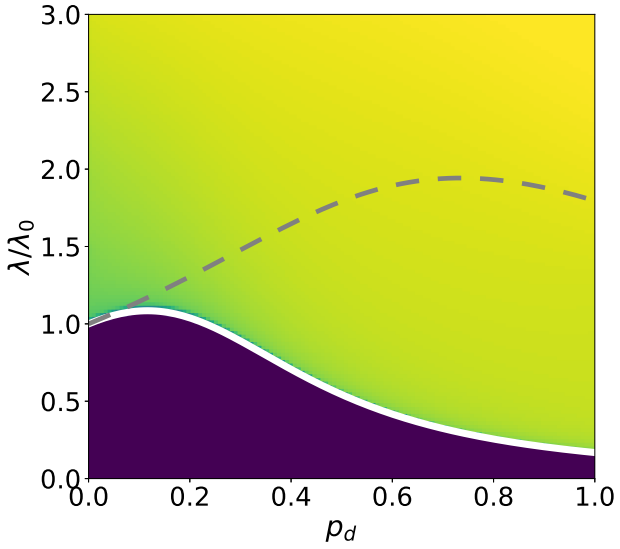

Fig. 1. Epidemic diagram with the normalized epidemic threshold (vertical axis) against the mobility parameter (horizontal axis) of the city of Miami, Florida. The dashed grey line accounts for the epidemic threshold of the indistinguishable agents, and the continuous white line shows the epidemic threshold of the distinguishable agents.