SIR Fronts in Complex Networks with Metapopulation Structure
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— SIR dynamics has been studied extensively on complex networks, yielding insight into the effects of heterogeneity in contact patterns on the spread of infectious diseases. Separately, metapopulations have provided a paradigm for modeling systems with extended and “patchy” organization. In this paper we demonstrate how multi-type networks can be used to combine these paradigms such that simple disease dynamics models can include heterogeneity in connectivity and multi-scale structure. We first present a multi-type generalization of the Volz-Miller mean-field approximation for SIR dynamics on multi-type random graphs. We then use this technique to study the propagation of epidemic fronts in a simple metapopulation model with population centers composed of configuration model networks coupled on a one-dimensional lattice. Using the formalism of front propagation into unstable states, we derive the effective transport coefficients of the linear spreading: asymptotic speed, characteristic perturbation size, and diffusion coefficient for the pulled fronts, and explore their dependence on the underlying graph structure. We also derive the average steady-state incidence, the equilibrium spectrum, and the threshold for invasion.

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Date submitted: 20 Dec 2012