Mixed-order phase transition of the contact process near multiple junctions

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Abstract

The contact process is a basic stochastic lattice model of epidemic spreading or population dynamics. It displays a nonequilibrium phase transition between a fluctuating active phase and an absorbing phase, which is continuous in any dimensions and falls into the universality class of directed percolation. Discontinuous transitions are rare in low dimensional fluctuating systems; for the particular case of one-dimensional systems with short-range interactions they are conjectured to be impossible. We demonstrated by numerical simulations that a suitable topology of the underlying lattice is able to induce a discontinuous local transition even with a simple dynamics such as the contact process. We have studied, namely, the local critical behavior near a multiple junction composed of M semi-infinite chains. As opposed to the continuous transitions of the translationally invariant (M=2) and semi-infinite (M=1) system, the local order parameter is found to be discontinuous for M> 2. The temporal correlation length is found to diverge algebraically as the critical point is approached, so the transition is of mixed order. Interestingly, the corresponding exponents on the two sides of the transition are different. In the active phase, the estimate is compatible with the bulk value, while in the inactive phase it exceeds the bulk value and increases with M. We proposed a scaling theory, which is compatible with the numerical results. According to a strong-disorder renormalization group analysis, quenched spatial disorder makes the transition continuous for M> 2.

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