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Universality of Spreading Processes with Spontaneous Activity

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Spreading processes on networks are ubiquitous, including neuronal avalanches, human and computer viruses, and information spreading on social networks. Spreading processes exemplify a nonequilibrium phase transition into an absorbing state; the transition to the absorbing state will certainly occur when the mean branching ratio falls below one. These processes are typically studied assuming some number of initial seeds from which the activity spreads and fall into the universality class of directed percolation. This approach is best justified for processes in which the initiation of activity occurs on timescales much greater than the timescale of spreading. However, this separation of timescales is not always justified. For example, transmissible zoonotic diseases spread amongst humans concurrent with new infections from animals. In this talk, we introduce the spreading process with spontaneous activity. Spontaneous activity destroys the absorbing state and therefore changes the underlying universality class of the spreading process. We argue, from extensive numerical simulation and analytical arguments that the universality class changes from directed percolation to that of undirected percolation. In numerical simulations, we identify critical exponents of directed percolation on small scales, but asymptotic behaviour governed by undirected percolation exponents. Using a tree-like mean-field approach, we identify a critical line along which universal scaling occurs. Our mean-field predictions are borne out reasonably well for power-law and small-world graphs. The inclusion of spontaneous activity in the spreading process bridges the universality classes of undirected and directed percolation. This enriched spreading process has potential application in epidemiology and in neuroscience.

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