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Cluster aggregation model for first-order percolation transitions
BYUNGNAM KAHNG, Seoul National University — The evolution of the Erdos-Renyi (ER) network by adding edges can be viewed as a cluster aggregation process. Such ER processes can be described by a rate equation for the evolution of the cluster-size distribution, in which the connection kernel $K_{ij} \sim ij$, the product of the sizes of two merging clusters. Here, we study more general cases in which K_{ij} is sub-linear as $K_{ij} \sim (ij)^w$ with $0 \leq w < 1/2$, finding that the percolation transition (PT) is discontinuous. Moreover, when the ER dynamics evolves from proper initial conditions, PT is also discontinuous. The rate equation approach for such discontinuous PTs enables us to uncover the mechanism underneath the explosive PT under the Achlioptas process (AP). We also study the AP problem in scale-free networks, finding that a first-order transition does not always occur: a continuous transition is also possible depending on the degree distribution of the scale-free network. This originates from the competition between the AP that discourages the formation of a giant component and the existence of hubs that encourages it. We also estimate the value of the characteristic degree exponent that separates the two transition types.

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