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Negative-weight percolation[1]

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We describe a percolation problem on lattices (graphs, networks), with edge weights drawn from disorder distributions that allow for weights (or distances) of either sign, i.e. including negative weights. We are interested whether there are spanning paths or loops of total negative weight. This kind of percolation problem is fundamentally different from conventional percolation problems, e.g. it does not exhibit transitivity, hence no simple definition of clusters, and several spanning paths/loops might coexist in the percolation regime at the same time. Furthermore, to study this percolation problem numerically, one has to perform a non-trivial transformation of the original graph and apply sophisticated matching algorithms. Using this approach, we study the corresponding percolation transitions on large square, hexagonal and cubic lattices for two types of disorder distributions and determine the critical exponents. The results show that negative-weight percolation is in a different universality class compared to conventional bond/site percolation. On the other hand, negative-weight percolation seems to be related to the ferromagnet/spin-glass transition of random-bond Ising systems, at least in two dimensions. Furthermore, results for diluted lattices and higher dimensions up to d=7 are presented, to address, respectively, questions of (non-)universality and the transition to mean-field behavior at the upper critical dimension.

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