Heternogeneous micro-structure of percolation in complex networks: theory and applications

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We review a message passing (or cavity) approach [1,2] that is able to uncover and analyze a considerable degree of microscopic heterogeneity in the percolation problem on complex networks. Indeed, the probability for individual nodes of a complex networks to remain part of the giant connected component (GCC) or percolating cluster, when bonds or nodes are randomly and independently removed with some given probability varies considerably across a network. Average percolation probabilities which measure the fraction of nodes that belong to a GCC are just the first moments of distributions of percolation probabilities. We evaluate these distributions, both on single large graph instances, and for configuration models in the thermodynamic limit. The underlying message passing approach can also be used to locate articulation points - vertices whose removal would break the cluster on which they sit into two or more smaller components. We discuss applications in the context of SIR/SEIR epidemics and in approaches to efficient network dismantling strategies [3,4].

References

[1] B. Karrer, M. E. J. Newman, L. Zdeborova. Percolation on Sparse Networks. Phys. Rev. Lett., 113, 208702 (2014).
[2] R. Kuehn, T. Rogers. Heterogeneous Micro-Structure of Percolation in Sparse Networks. Europhys. Lett., 118, 68003 (2017).
[3] G. Torrisi, A. Annibale, R. Kuehn, Going Places ... and Catching the Bug, paper in preparation (2023).
[4] H. Bonneau, I. Tishby, O. Biham, E. Katzav, R. Kuehn, Fate of Articulation Points and Bredges in Percolation, Phys. Rev. E 103, 042302 (2021).