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Complex networks are self-similar CHAOMING SONG, Levich Institute and Physics Department, CCNY, SHLOMO HAVLIN, Department of Physics, Bar-Ilan University, HERNAN MAKSE, Levich Institute and Physics Department, CCNY — A large number of real networks are called "scale-free" because they show a power-law distribution of the number of links per node. However, it is widely believed that complex networks are not length-scale invariant or self-similar. This conclusion originates from the "small world" property of these networks, which implies that the number of nodes increases exponentially with the "diameter" of the network, rather than the power-law relation expected for a self-similar structure. Nevertheless, here we present a novel approach to the analysis of such networks, revealing that their structure is indeed self- similar. This result is achieved by the application of a renormalization procedure which coarse-grains the system into boxes containing nodes within a given "size." Concurrently, we identify a power-law relation between the number of boxes needed to cover the network and the size of the box defining a self- similar exponent. These fundamental properties, which are shown for the WWW, social, cellular and protein-protein interaction networks, help to understand the emergence of the scale-free property in complex networks. They suggest a common self- organization dynamics of diverse networks at different scales into a critical state and in turn bring together previously unrelated fields: the statistical physics of complex networks with renormalization group, fractals and critical phenomena.

Hernan Makse
Levich Institute and Physics Department, CCNY

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