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Myosin Activity Drives Cytoskeletal Networks to a Critically Connected State

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The cytoskeleton is a fascinating material, where myosin pulling forces drive actin networks out of equilibrium. Recent studies have found that network response to motor activity is governed by connectivity: weakly connected networks give rise to ordered patterns and dynamic clusters, whereas well connected networks are elastic and propagate tension. Theory has predicted critical intermediate states between these two regimes, but experimental evidence for such states remains elusive. Here we experimentally study motor-driven activity in in-vitro actin networks over a broad range of network connectivities. We show the network contracts into clusters that exhibit a scale-free distribution of sizes, characteristic of a critical state. Surprisingly, this critical behavior occurs over a broad range of network connectivities. To explain this robustness, we perform simulations of contractile networks taking into account network restructuring: motors can reduce connectivity by promoting crosslink unbinding. We demonstrate that this coupling between activity and connectivity drives initially well connected networks to a critically connected state. Furthermore, we propose that recent examples of cytoskeletal rupture in cells and tissues can be simply explained by network restructuring, which controls the length scale of contraction (see figure).