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Quantifying the effects of cyclic defects on the mechanical properties of polymer gels RUI WANG, MINGJIANG ZHONG, KEN KAWAMOTO, JEREMIAH JOHNSON, BRADLEY OLSEN, Massachusetts Institute of Technology — Understanding the correlation between the topology and properties of polymer gels is an outstanding challenge in polymer science. Classical theories of gel elasticity assume acyclic tree-like network topology; however, all polymer gels inevitably possess cyclic defects: loops that have profound, yet previously unpredictable, effect on gel properties. Here, we develop a modified phantom network theory that describes the effects of loops on the modulus of polymer gels. We demonstrate that small loops (primary and secondary loops) have vital effect on the modulus; whereas this negative impact decreases rapidly as the loop order increases, especially for networks with higher junction functionalities. Loop effect is non-local, which can propagate to its neighborhood strands. We show that adjacent loops weaken the network cooperatively, resulting in the nonlinear decrease of the dimensionless modulus (G/vkT, where v is the total density of polymer strands) with the loop fraction. The theory is in good agreement with the experimental data without any fitting parameters.

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