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Micromechanics of Cytoskeletal Actin Networks

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The cytoskeleton in living cells comprises an interpenetrating network of actin microfilaments, intermediate filaments and microtubules, each made of different proteins. We propose a multiscale modeling methodology for cytoskeletal mechanics starting from the scale of individual cytoskeletal filaments, via networks of filaments to the entire cell. The focus of the current paper is on the scale transition of the actin filament scale to the network scale. First we critically examine the commonly adopted worm-like chain model for the coupling between the chain deformations and thermal undulations. Next, based on this single filament model, we construct random three-dimensional actin networks using the finite element method, featuring a tunable density of cross-links. This allows us to explore the dependence of the overall response on network architecture, the strength of cross-links/entanglements and the actin poperties. Special emphasis will be put on the structural alterations that occur in the networks during straining.

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