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Seeing is believing: Direct visualization of fluctuations in biopolymer networks with 3D thermal noise imaging

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Intracellular biopolymer networks perform many essential functions for living cells. Most of these networks show a highly nonlinear mechanical response that originates from the properties if the individual filaments and the network architecture. While much theoretical work has been done to connect the macroscopic response to specific network properties, such as filament persistence length, cross-linking geometry and pore size, there is a lack of experimental techniques that can simultaneously determine the structure and the mechanical properties of a network in situ on the single filament level and thus basic assumptions made in theoretical and computer models are untested. Here we describe three-dimensional thermal noise imaging as a novel submicroscopic imaging technique that visualizes biopolymer networks on length scales and under conditions that are inaccessible to any other microscopic technique.

Thermal Noise Imaging is a scanning probe technique that utilizes the confined thermal motion of an optically trapped particle as a three-dimensional, noninvasive scanner for soft, biological material. It achieves nanometer precision in probe position detection at MHz bandwidth. Thermal noise imaging visualizes the excluded volume generated by the interaction of the probe particle with the filaments and allows for the quantification of their mechanical properties from their transversal fluctuations. The experiments presented here also pave the way for measuring force distributions inside biopolymer networks as well as establish thermal noise imaging as a quantitative tool for studying soft material on the nanometer scale.

References

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