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4D Structural Dynamics of Sheared Collagen Networks[1]
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— Soft biopolymer networks undergo substantial bulk stiffening when subject to shear strain. This nonlinear rheological signature has been observed for a wide range of semiflexible and stiff biopolymers, but the underlying geometric fiber rearrangements have not been measured and the resulting stress propagation through the network has not been experimentally assessed. We apply steady shear strains to collagen gels adhered to a thin elastic polyacrylamide gel substrate embedded with fluorescent displacement markers, while simultaneously imaging the three-dimensional network with a coupled confocal-rheometer. We observe dramatic network realignment towards the shear gradient driven by the nonaffine stretching, buckling, and rotation of constituent fibers and simultaneously measure stress inhomogeneities at the collagen-polyacrylamide interface. These observations elucidate the physical mechanisms governing strain-stiffening and our recent observation of the system-size dependence of this effect.

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