Applying and Quantifying Forces in Soft Matter

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Abstract:

Soft and biological materials often exhibit disordered and heterogeneous microstructure. In most cases, the transmission and distribution of stresses through these complex materials reflect their inherent heterogeneity. We are developing a set of techniques that provide the ability to apply to quantify the connection between microstructure and local stresses. We subject soft and biological materials to precise deformations while measuring real space information about the distribution and redistribution of stress.

Using our custom confocal rheometer platform we can determine the role of shear stress in a variety of materials. First, I will discuss the flow properties of a jammed emulsion. The flow behavior of a compressed emulsion above its yield point can be characterized by a velocity profile as well as the rearrangement of individual droplets on top of this average motion. The velocity profiles exhibit a strong dependence on the applied stress, which can be taken well above yield. In addition, the occurrence of rearrangements is influenced by the overall volume fraction of the droplets and inhomogeneities in their local packing. Second, I will describe our recent results on the nonlinear rheology of in vitro collagen networks. We apply precisely controlled shear strains to collagen networks that are adhered to a thin elastic polyacrylamide gel substrate embedded with fiduciary markers. By utilizing a modified version of traction force microscopy we can calculate the distribution of forces as a function of the applied strain. We find that the signatures of yielding in these materials follow a universal form.

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