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Microrheology in Active Cytoskeletal Networks

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The mechanics of the in vivo cytoskeleton is controlled in part by the details of its non-equilibrium steady-state. In this "active" material, molecular motors (e.g. myosin) exert transient contractile stresses on the F-actin filament network, driving it into a particular non-equilibrium state. Since microrheology traditionally relies of the linear response properties of the soft materials in thermal equilibrium, this departure from equilibrium has profound implications for the interpretation of microrheological data from the interior of living cells and in vitro active networks. In active networks, such as the in vitro systems of Mizuno et al. [Science 315 (5810) pp. 370-373 (2007).] and in living cells, the underlying theoretical foundation of the interpretation of microrheology – the Fluctuation-Dissipation theorem – does not apply. New ideas are needed. In this talk, I review microrheology, and then discuss a new theoretical interpretation of microrheology in active (i.e. molecular motor driven) networks. To develop this new theory, I introduce a motor-driven, two-fluid model of the active network and background (aqueous) solvent. Using this model and knowledge of the statistical properties of the molecular-motor induced forces, I calculate the non-equilibrium fluctuation spectrum expected for one- and two-particle microrheology in the driven system. I then compare these results to the data of Mizuno et al..