Strain propagation of entangled actin networks in response to actively-driven microspheres

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Actin Networks Respond Non-Linearly to Force, but how do individual filaments respond?

- We know a lot about non-linear force response due to mechanical perturbations.

- But how do individual filaments respond and rearrange?

- How far do such forces propagate through the network?

- We extend our previous work with image analysis to begin to answer some of these questions.
Selective Filament Labeling and Tracking

- Each Filament is constructed so that it is partially labeled, markers are separably trackable, and long enough to become embedded within the network.
- Appx 1:944 actin filaments are labeled
- 0.5 mg/ml network
Video Example of Motion

Accelerated 17 second movie (7x speed)
Data is aggregated and segmented by space and time

- Single movie tracks several fiducial marks at low density

- Data is aggregated over many runs and can be sectioned to obtain statistical information about motion within regions around the beads
Aggregated Data Shows Affine Motion Along Bead Path

**X-direction-affine**

**Y Direction (non-affine)**

Solid Annulus Width = 4 bead diameters

1670 Tracks
Response to bead motion is far reaching.

Max Width = 51um

Apparent near linear decrease in Velocity & displacement - Half value after 25 entanglement lengths.
Relaxation is exponential

- Relaxation displacement fits to Simple exponential $f(x) = Ae^{-Bt} + C$

\[ f(x) = Ae^{\tau} - Bt + C \]

\[ \tau = \frac{1}{e} \]

\[ \tau_{1/e} = 4.43 \pm 1.09 \]
Matrix Based Analysis

- 32,500 traces, 1400 sections @ 1.8um² sections
Affine/non-affine motion (matrix)

→ 0.5μm <displacement>
Quadrant Analysis Reveals Non-Affine Response

Solid Annulus Y-Direction (non-affine)

- Average over all data shows no response in Y
- When separated into quadrants, we regain affine response
- Max Velocity ~1/4 of affine value

Quadrant Segmentation

Quadrants 1, 4

Quadrants 2, 3
Future Steps

- **Nonlinear effects of speed**
  - initial dataset with 5um/s shows potential differences in relaxation dynamics and overall displacements, but more data will be collected to understand the response of the system.

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