Microscale Mechanics of triggered bundling and unbundling of actin networks

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Diverse cellular processes require active reorganization of actin networks

**Polymerization**

\[ \text{+ATP} \quad -\text{Ca}^{2+} \]

**Contraction**

\[ \text{+Myosin II} \quad +\text{ATP} \]

**Crosslinking**

\[ +\text{binding proteins} \]

**Bundling**

\[ +\text{high MgCl}_2 \]
How do the mechanical properties of actin networks vary during active re-organization?

**Polymerization**

- +ATP
- -Ca$^{2+}$

**Contraction**

- +Myosin II
- +ATP

**Crosslinking**

- +binding proteins

**Bundling**

- +high MgCl$_2$
How do varying salt conditions affect the mechanics and morphology of actin networks?

Bundling

+ high MgCl$_2$

Entangled filaments

Low salt

Highly bundled network

High salt
We use microfluidic chambers to cyclically vary the salt concentration in actin networks in situ.

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We track thermal fluctuations of optically trapped beads to determine mechanical properties of actin networks.

Bead trajectory

NMSD, $\Pi(\tau)$

Generalized Langevin equation

The elastic modulus displays a delayed increase with increasing salt concentration.

Stiffening continues well after [MgCl$_2$] stops increasing.
The entanglement plateau extends to higher frequencies as bundling increases.
As we reverse salt concentration back to initial levels, signatures of irreversible bundling emerge.

Steady-state network mechanics depend on the history of the network.
Irreversible bundling leads to stiffer low salt networks with more persistent entanglements.

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The dynamic mechanics of bundling and de-bundling actin networks display hysteresis and irreversibility.
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Actin network mechanics *encode memory* of previous state & display *delayed response* to environmental changes.
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