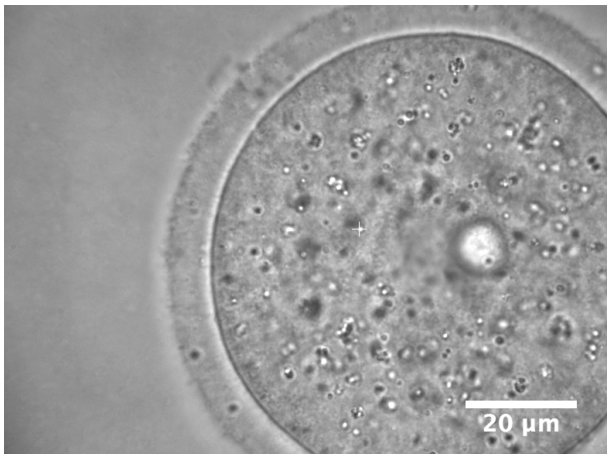
Modeling Active Fluctuations in Living Matter

Étienne Fodor[1], Wylie W. Ahmed[2], Timo Betz[2], Matthias Bussonnier[2], Nir S. Gov[3], Ming Guo[4], Vishwajeet Mehandia[5], Daniel Riveline[5], Paolo Visco[1], David A. Weitz[4], Frédéric van Wijland[1]



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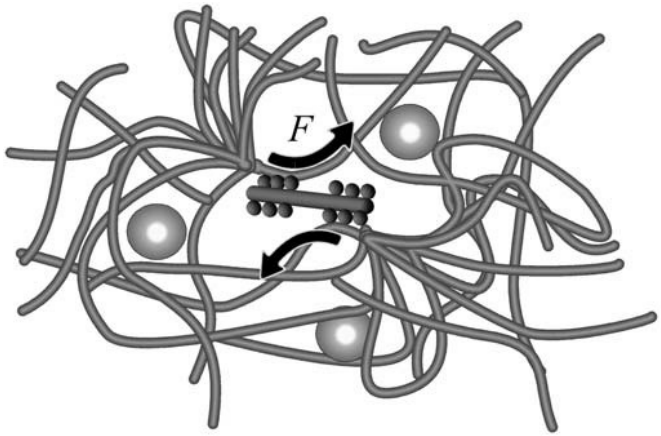
5. Laboratoire de Physique Cellulaire, Université de Strasbourg

7^{e} Rencontres MSC

Introduction



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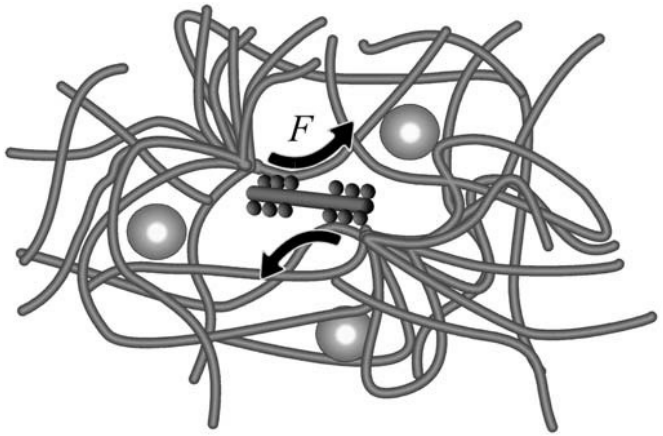
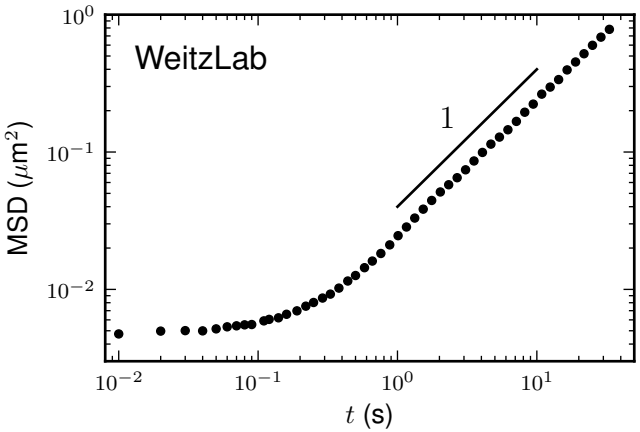
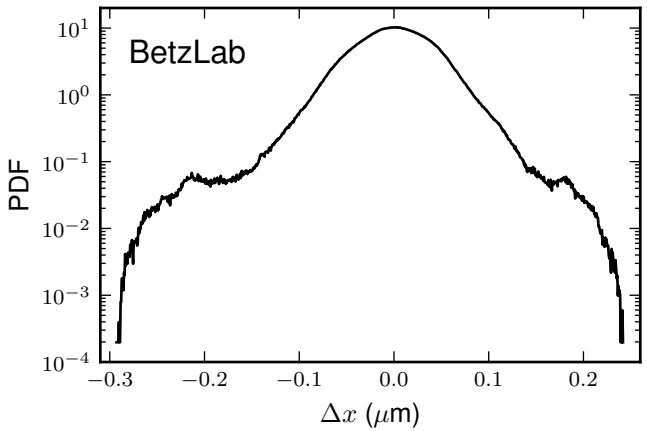


Mean square displacement



PDF of displacement



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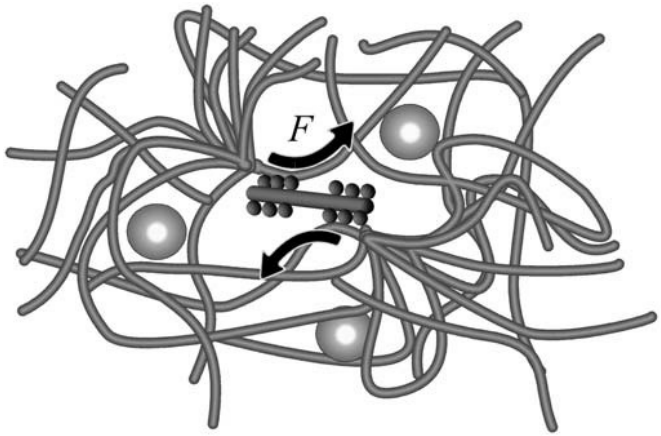

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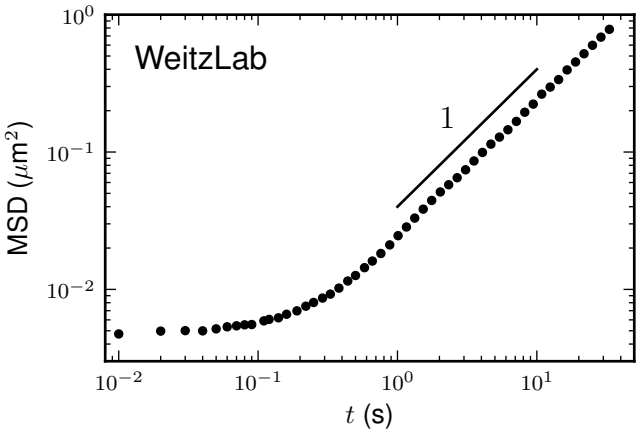

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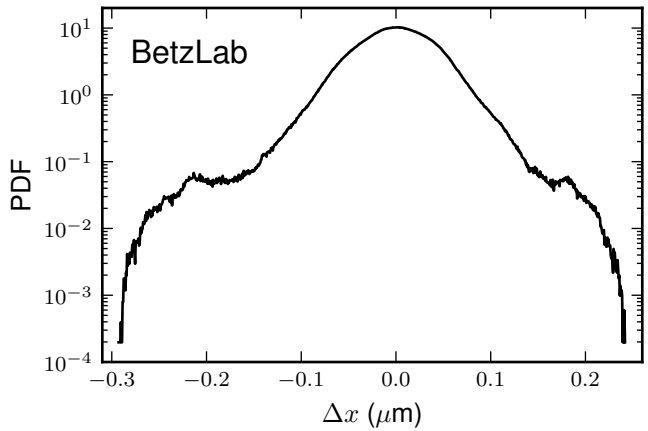
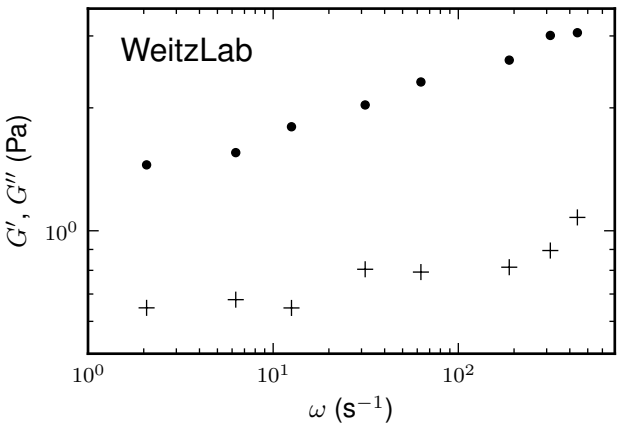


Complex modulus



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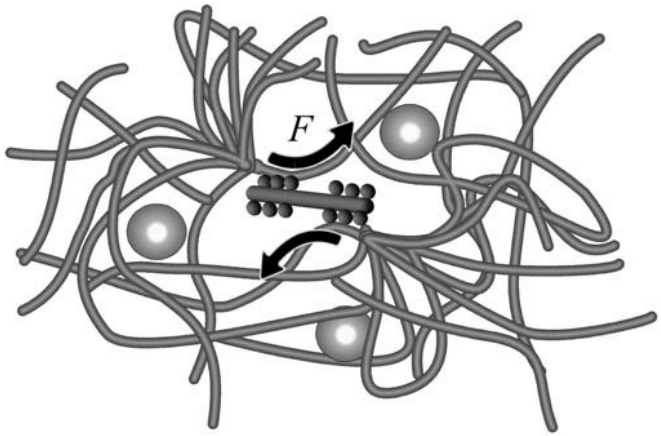

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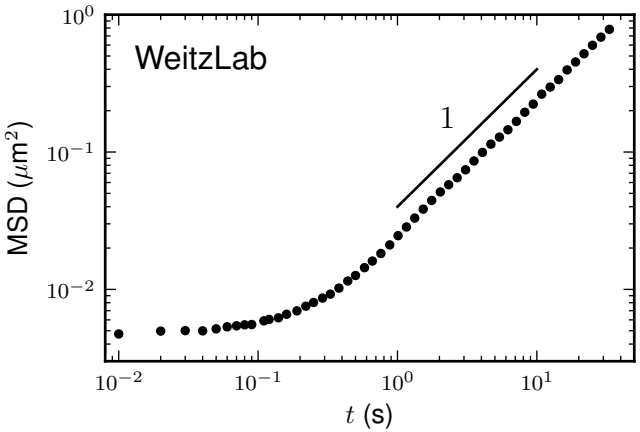

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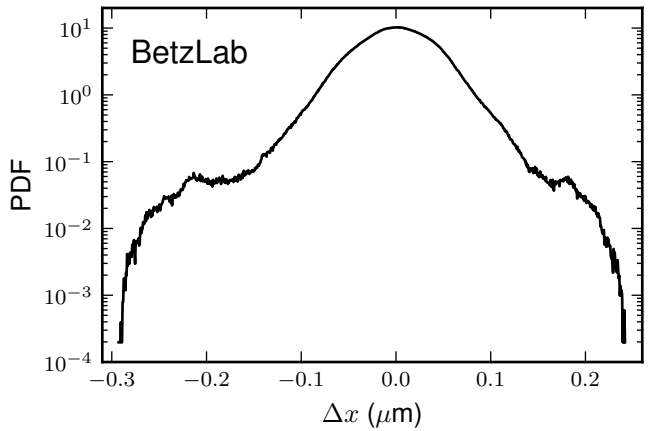

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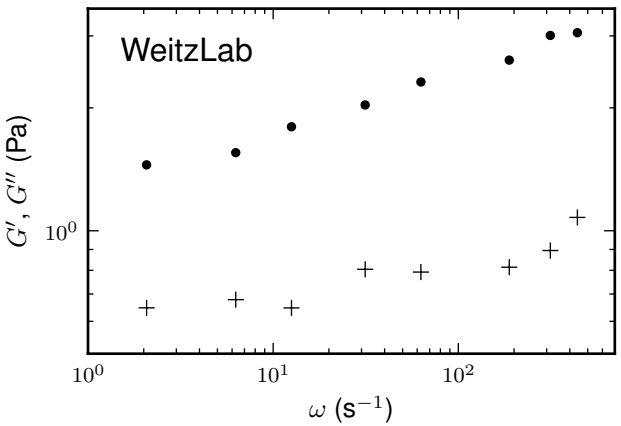

Is it possible to extract information about molecular motor activity?

Propose a model for the tracers' dynamics.

Outline

1. Activity driven fluctuations in living cells

   Ming Guo, David A. Weitz

   School of Engineering and Applied Sciences, Harvard University

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3. Epithelial tissues as fluctuating active foams

   Vishwajeet Mehandia, Daniel Riveline

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Activity driven fluctuations in living cells

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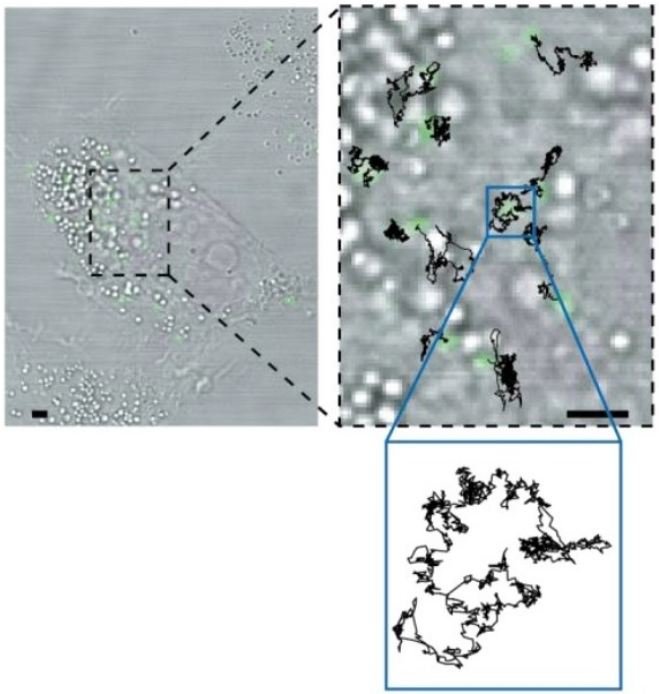
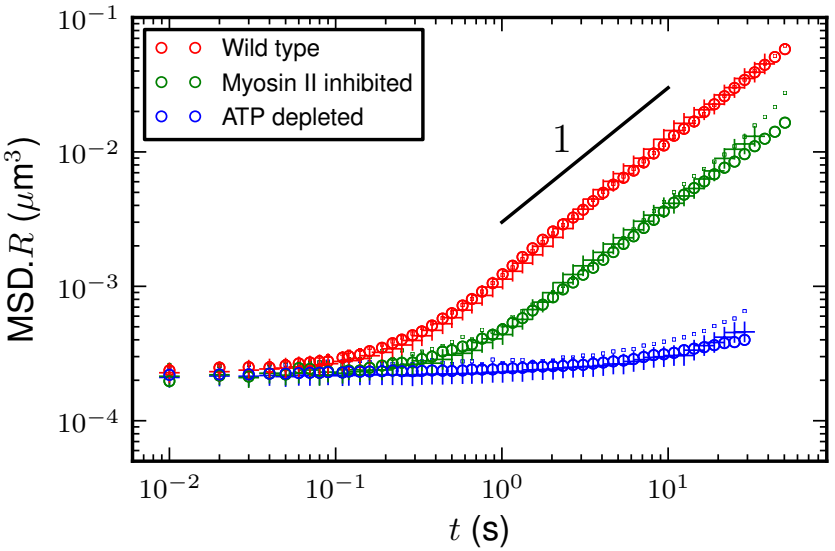


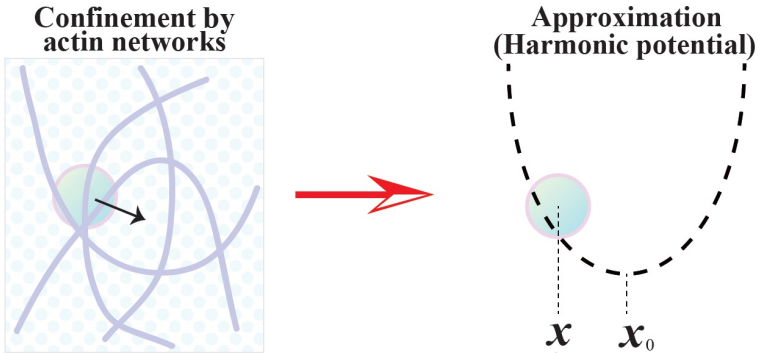


Activity driven fluctuations in living cells

Ming Guo, David A. Weitz

Tracer's dynamics

$$m\frac{d^2\mathbf{r}}{dt^2} = -\nabla U + \mathbf{F}_s + \mathbf{F}_{th}$$



Harmonic potential: $U = \frac{k}{2}(\mathbf{r} - \mathbf{r_0})^2$

Stokes force: $\mathbf{F}_s = -\gamma\frac{d\mathbf{r}}{dt}$

Gaussian white noise: $\mathbf{F}_{th}$

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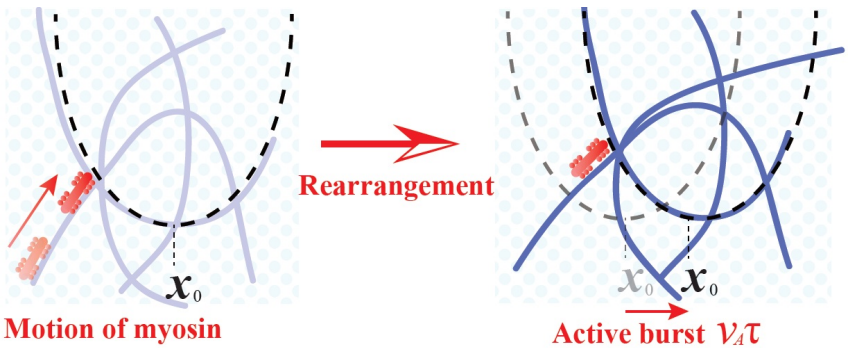
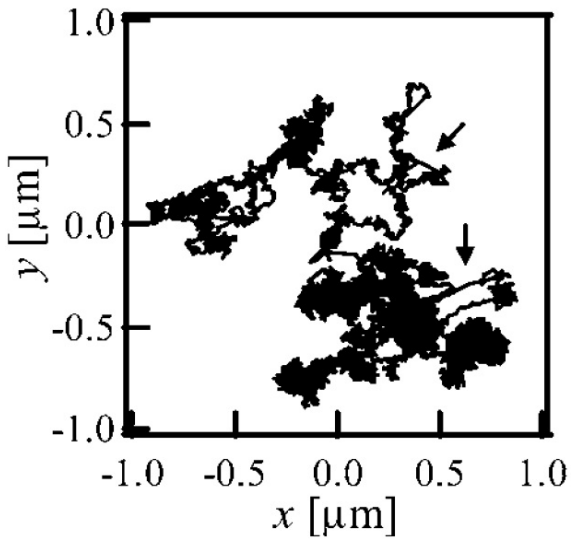
Tracer's dynamics

$$\gamma \frac{\mathrm{d}\mathbf{r}}{\mathrm{d}t} = -k(\mathbf{r} - \mathbf{r_0}) + \mathbf{F}_{\mathrm{th}} \ , \qquad \frac{\mathrm{d}\mathbf{r_0}}{\mathrm{d}t} = \mathbf{v}_{\mathrm{A}} \ .$$

Active motion of local minimum



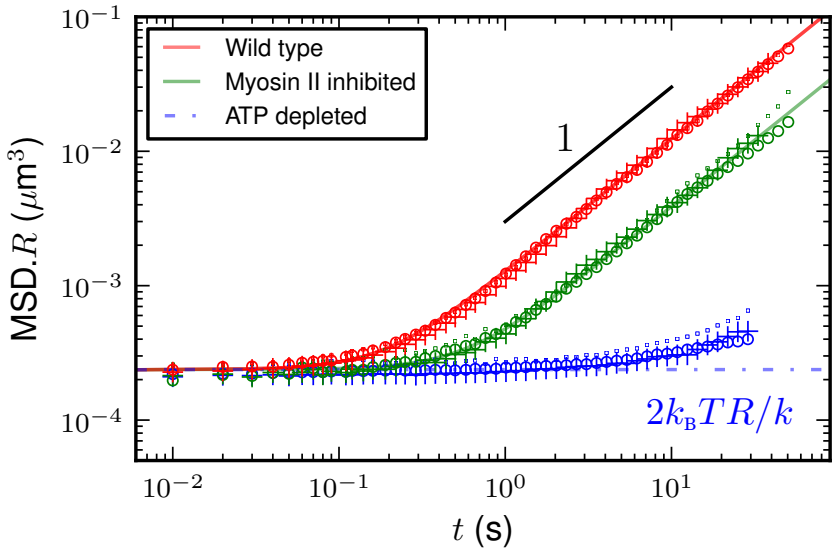


Activity driven fluctuations in living cells

Ming Guo, David A. Weitz

Short time Confinement

Large time Free diffusion
MSD $\sim 2D_{\mathrm{A}}t$



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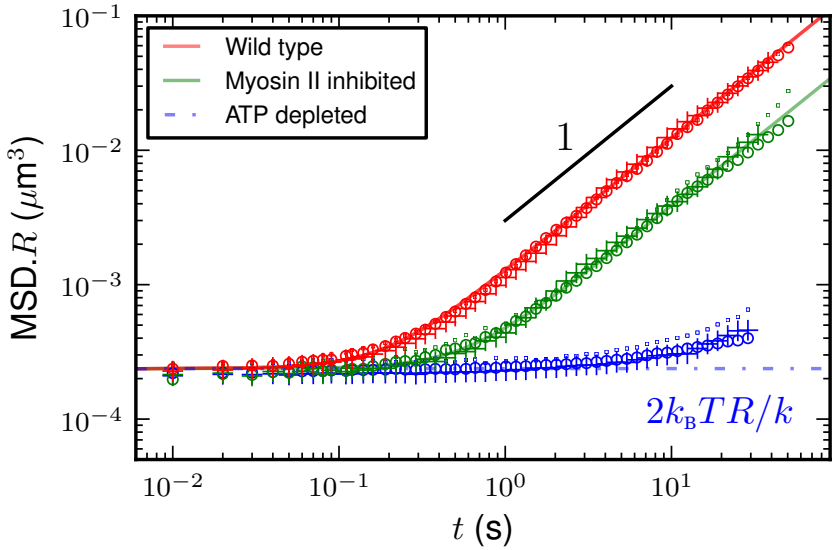
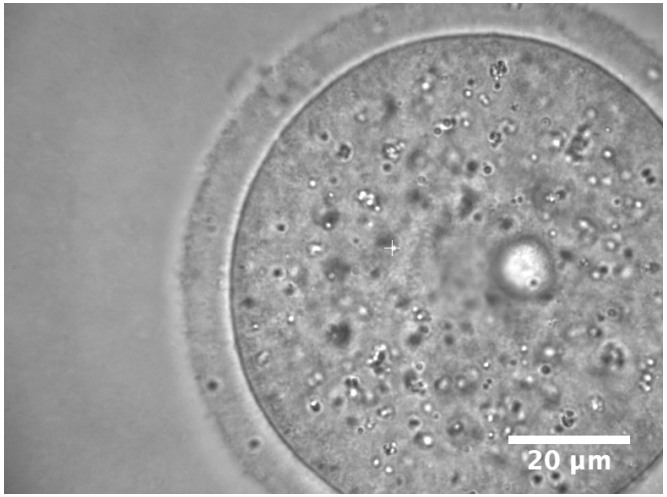


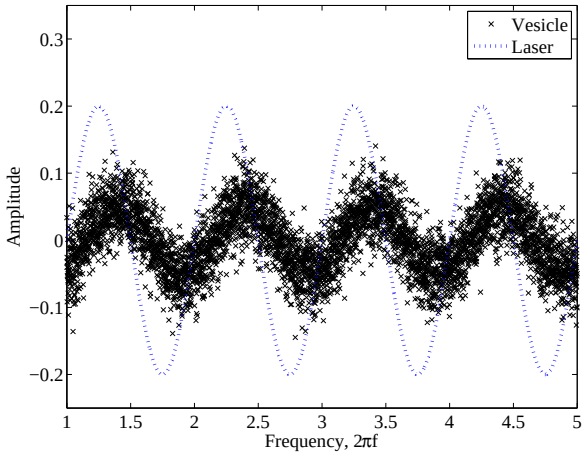
Microscopic features

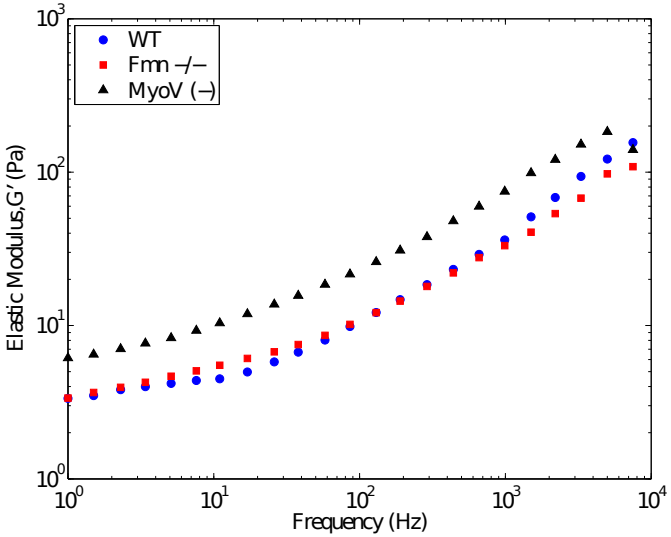
- Typical time of activity: $\tau_{\mathrm{wt}} \simeq 0.15$ s, $\tau_{\mathrm{b}} \simeq 0.41$ s
- Amplitude of active fluctuations:
  $T_{\mathrm{A,wt}} \simeq 5.2 \cdot 10^{-3}\,T$, $T_{\mathrm{A,b}} \simeq 1.6 \cdot 10^{-3}\,T$

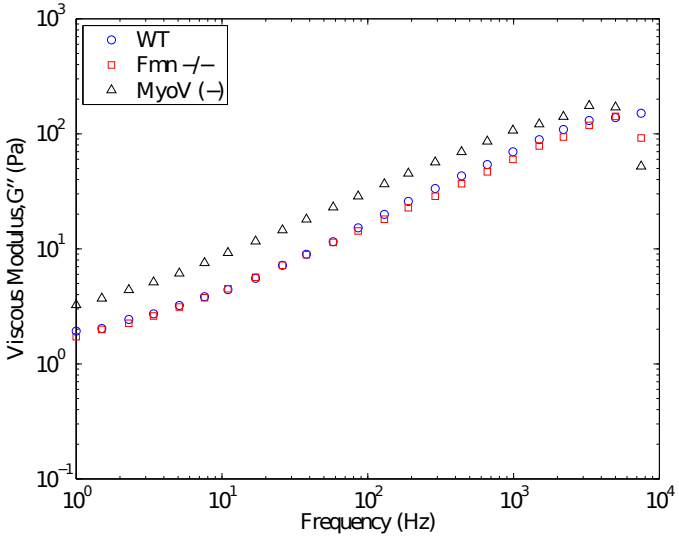
Nonequilibrium mechanics in living oocytes

Wylie W. Ahmed, Timo Betz, Matthias Bussonnier









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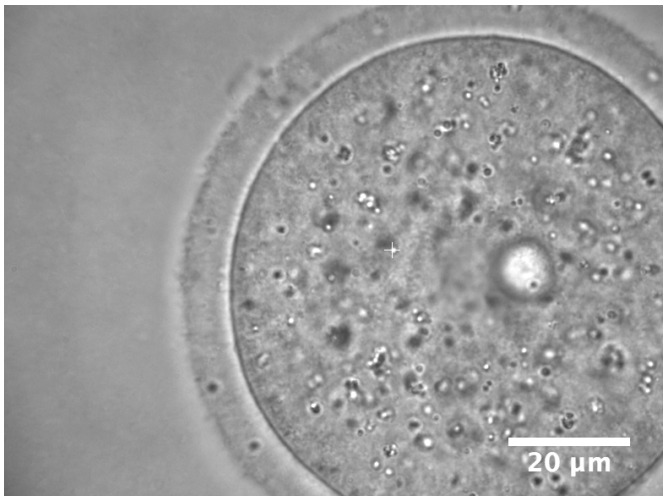

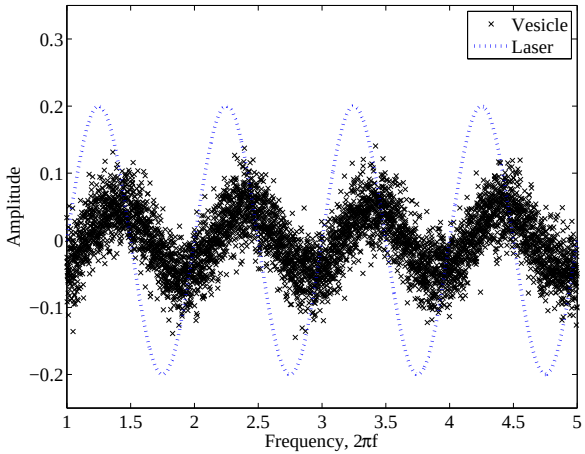

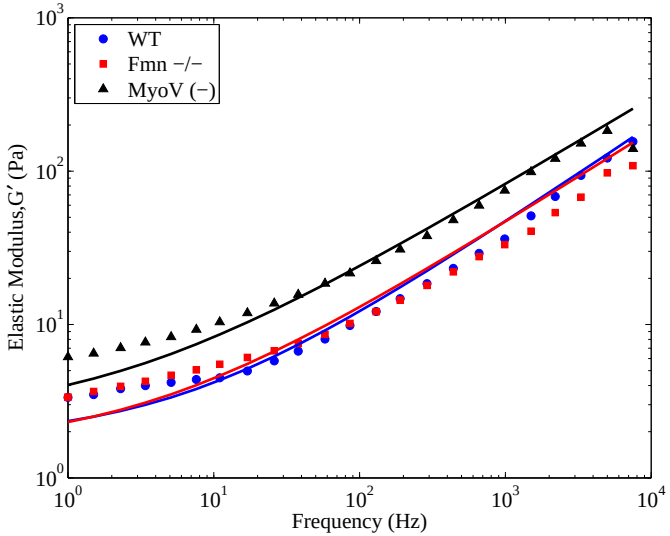

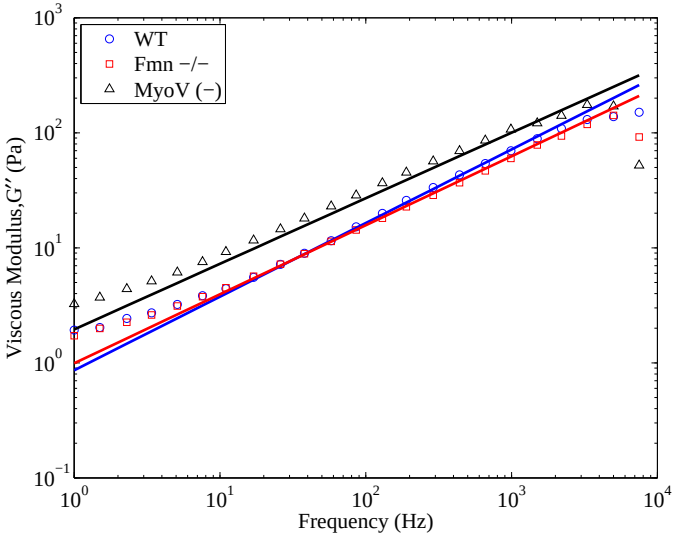

Complex modulus: $G^*(\omega) = G_0\left(1 + (i\omega\tau_\alpha)^\alpha\right)$, $\alpha \simeq 0.6$

Nonequilibrium mechanics in living oocytes

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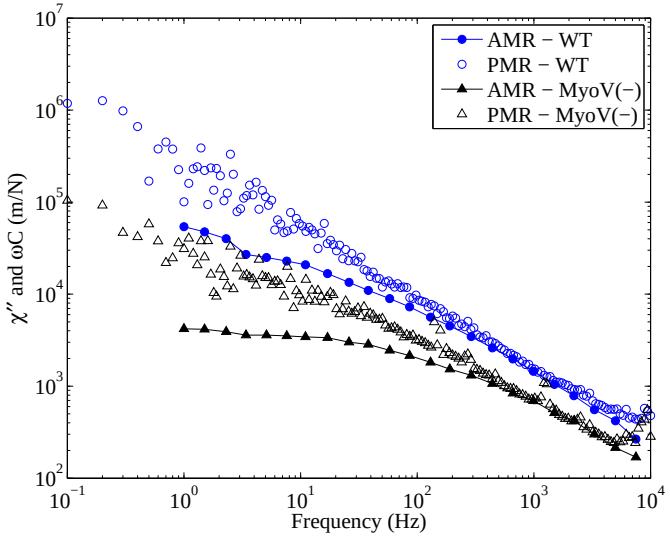

Fluctuation dissipation

$$\chi''(\omega) = \frac{\omega C(\omega)}{2k_B T}$$

Nonequilibrium mechanics in living oocytes

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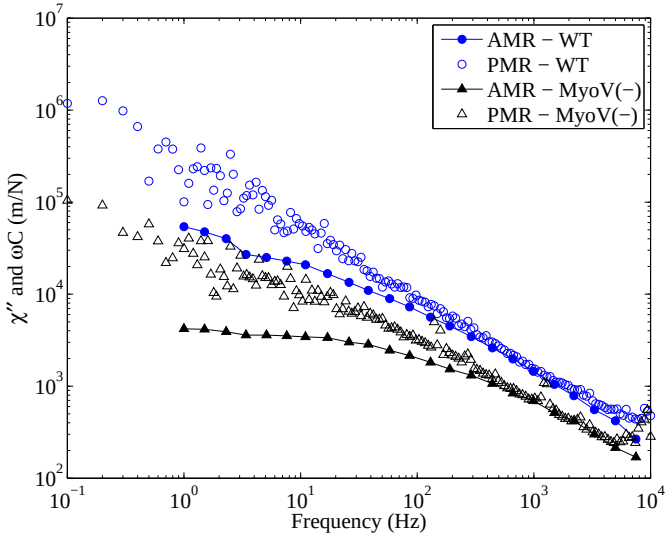

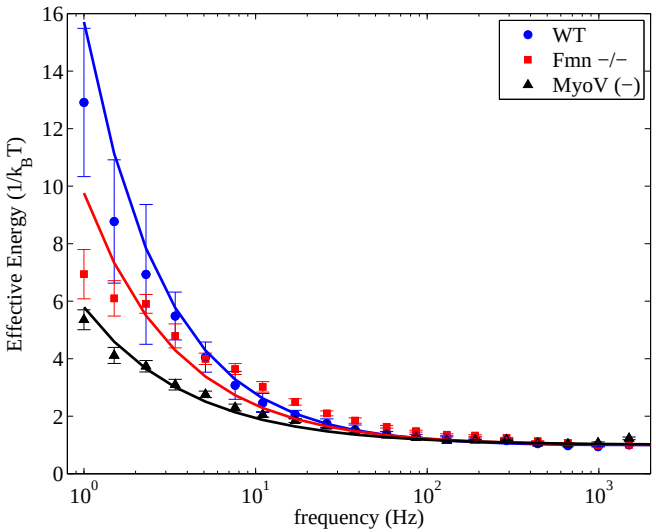

Fluctuation dissipation

$$\chi''(\omega) = \frac{\omega C(\omega)}{2k_B T}$$

$T_A = 5.5T$

$T_A = 5T$

$T_A = 3.8T$

Epithelial tissues as fluctuating active foams

Vishwajeet Mehandia, Daniel Riveline

Fluctuations of tricellular junctions