

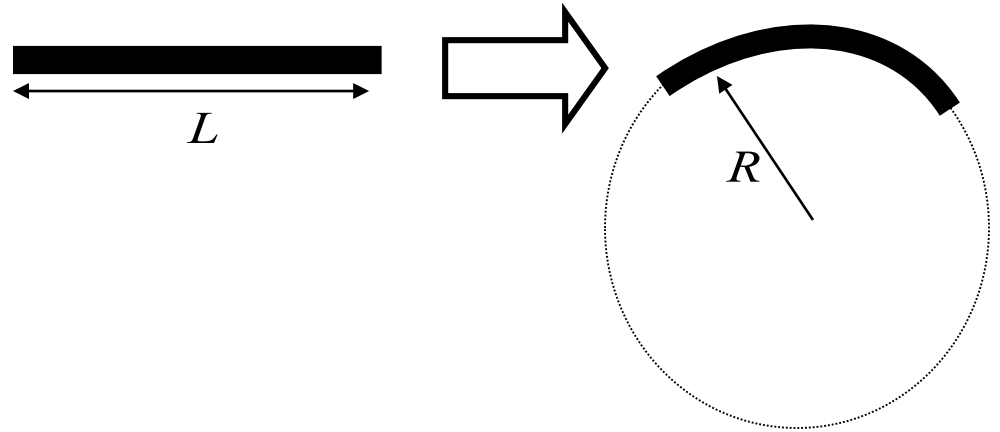
Life at Low D

Lecture II: Virtual Lab

Bend Energy

$$U_{Bend} = \frac{EI}{2} \frac{L}{R^2}$$

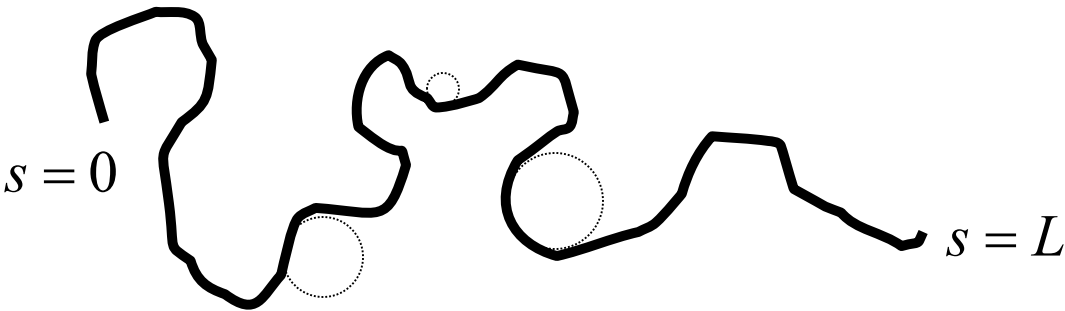
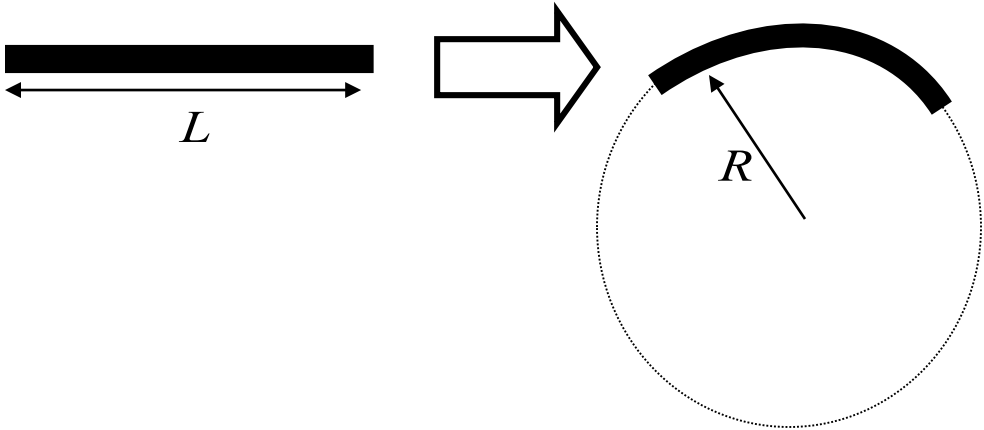
Energy required to bend filament of Length L into circular arc of Radius, R



Bend Energy

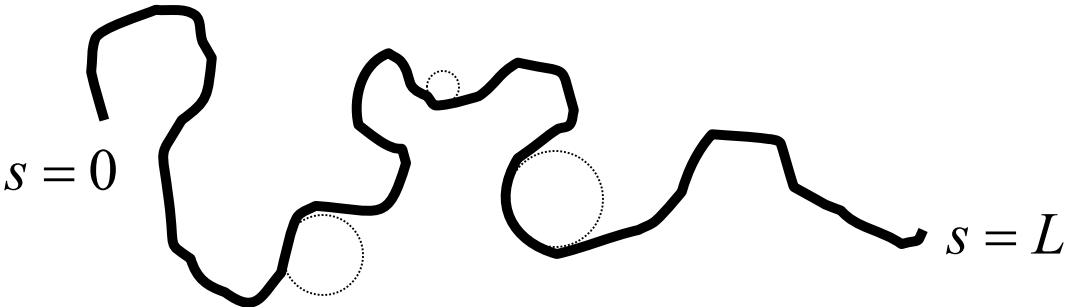
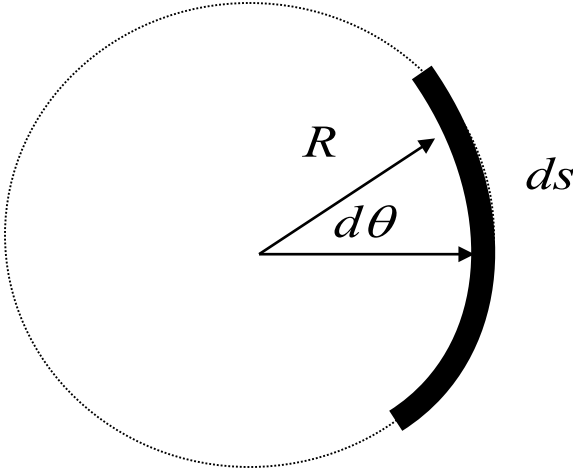
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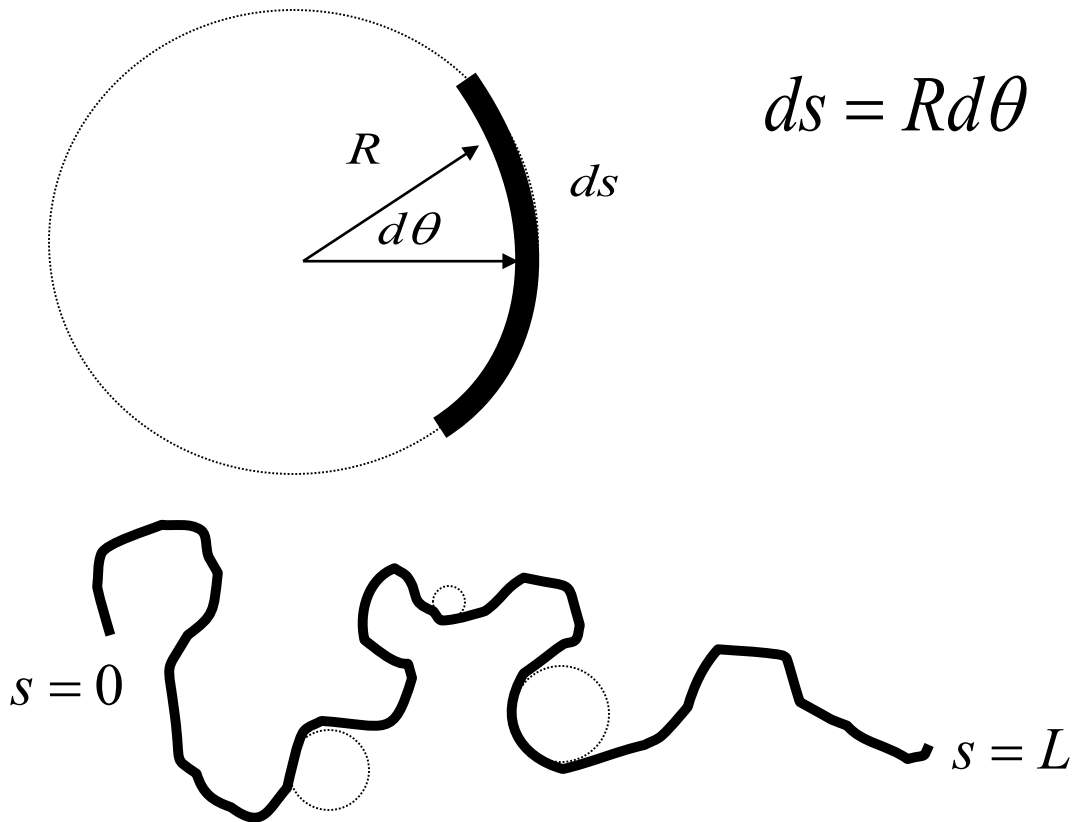
$$U_{Bend} = \sum_{all\ arcs} U_{Bend}^o = \frac{EIL}{2} \int_0^L \frac{1}{R^2(s)} ds$$

Bend Energy



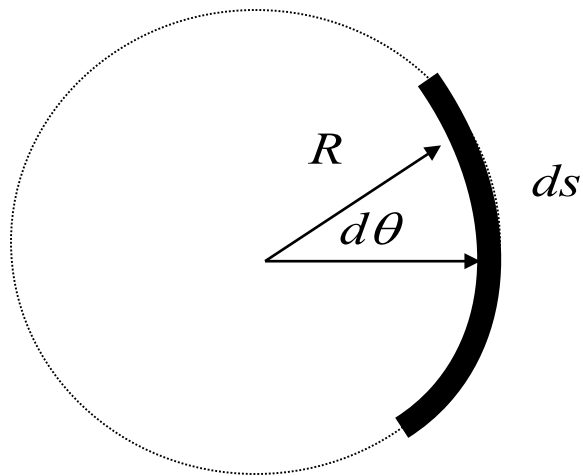
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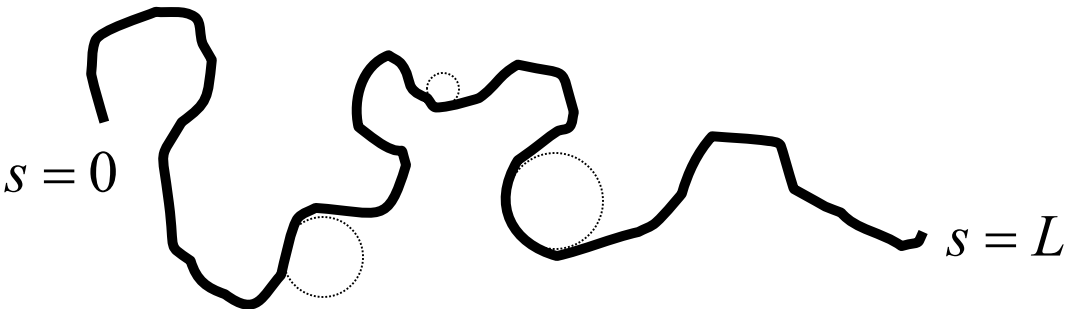


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Bend Energy

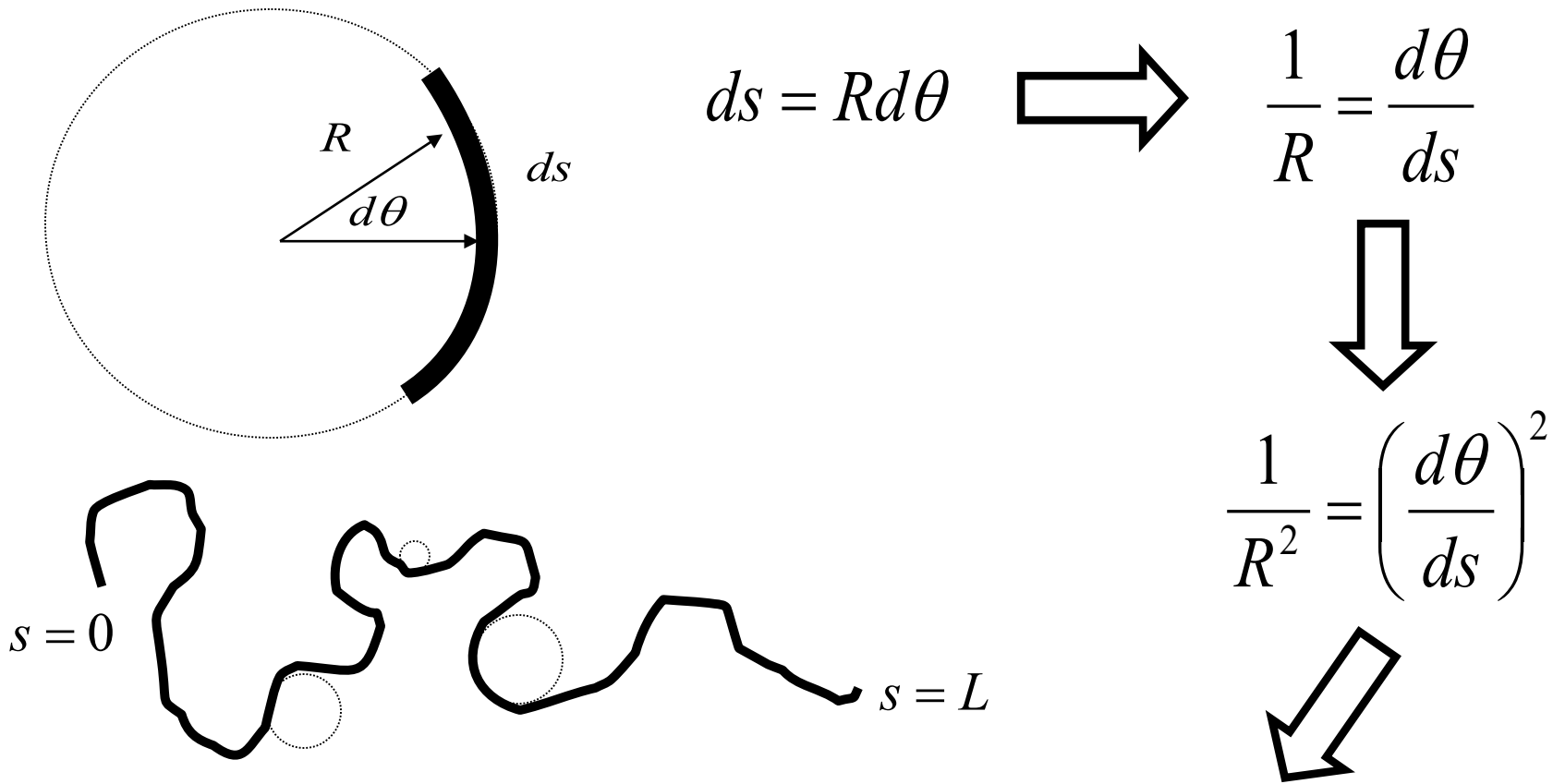


$$ds = R d\theta \quad \Rightarrow \quad \frac{1}{R} = \frac{d\theta}{ds}$$



$$U_{Bend} = \sum_{all\ arcs} U_{Bend}^o = \frac{EIL}{2} \int_0^L \frac{1}{R^2(s)} ds$$

Bend Energy

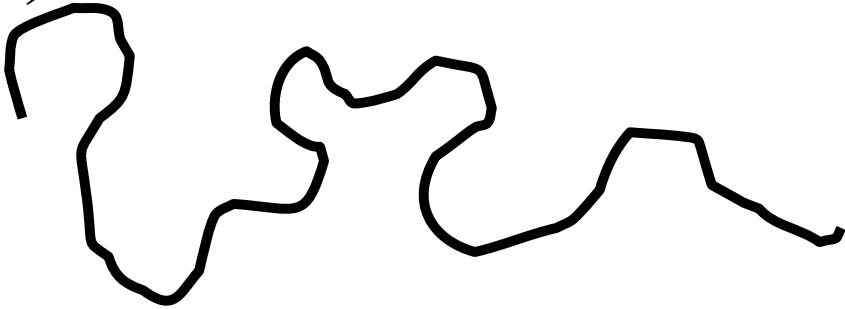


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Bend Energy

$$U_{Bend} = \frac{EIL}{2} \int_0^L \left(\frac{d\theta}{ds} \right)^2 ds$$

(1)



(2)

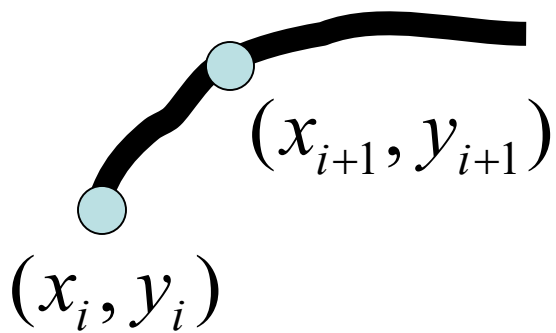
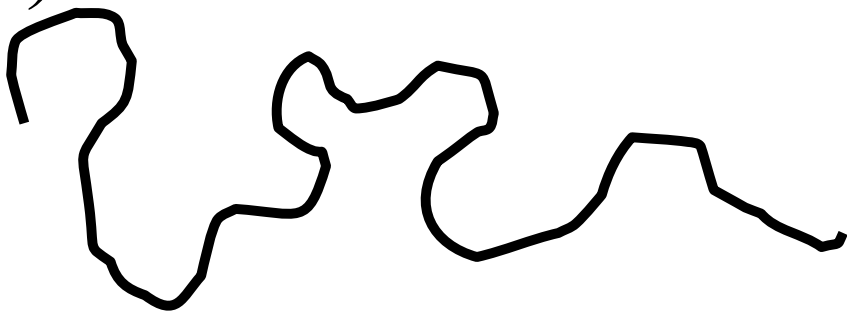


$$U_{Bend}(1) \gg U_{Bend}(2)$$

Bend Energy

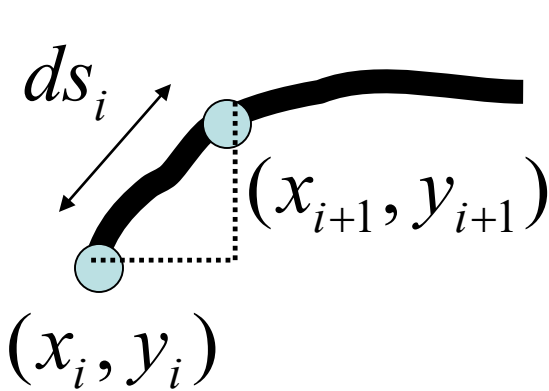
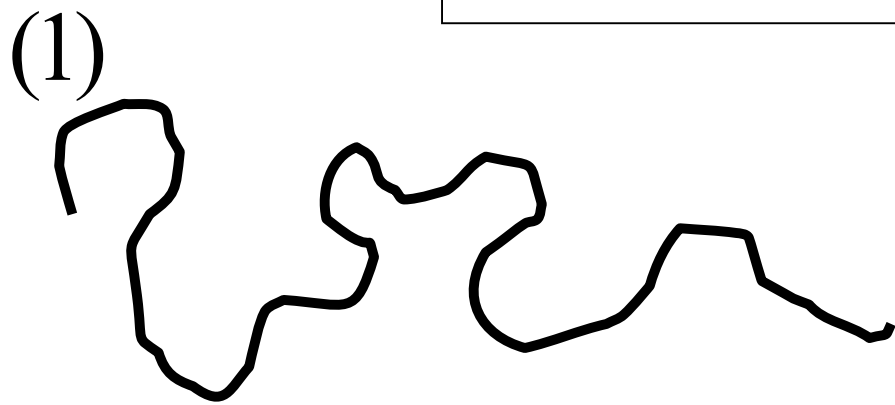
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(1)



Bend Energy

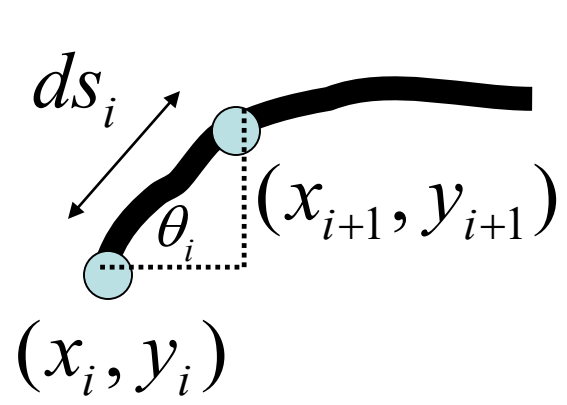
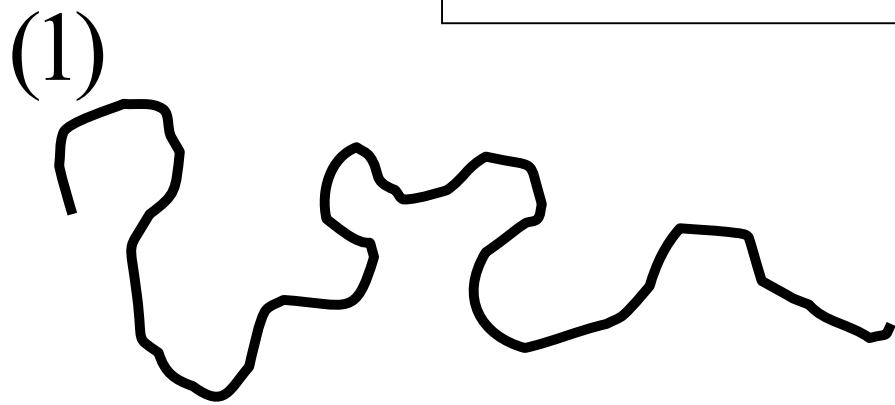
$$U_{Bend} = \frac{EIL}{2} \int_0^L \left(\frac{d\theta}{ds} \right)^2 ds$$



$$ds_i = \sqrt{(x_{i+1} - x_i)^2 + (y_{i+1} - y_i)^2}$$

Bend Energy

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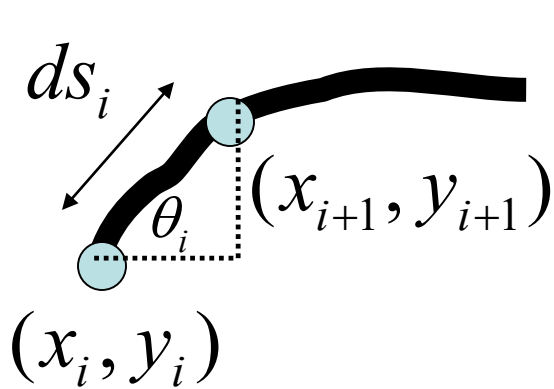
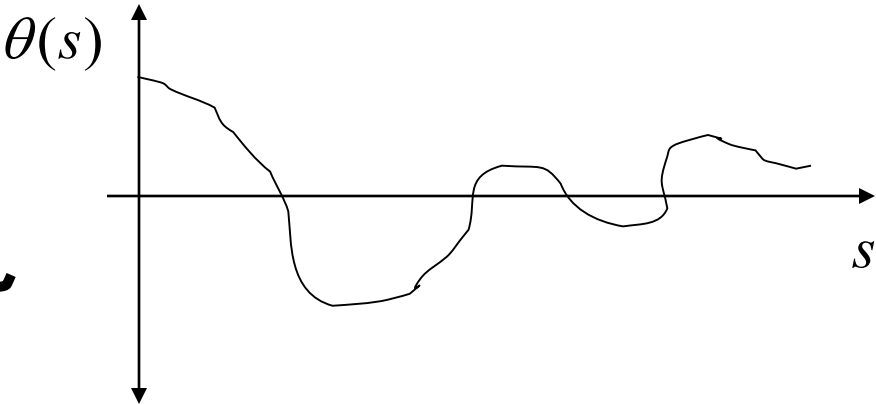
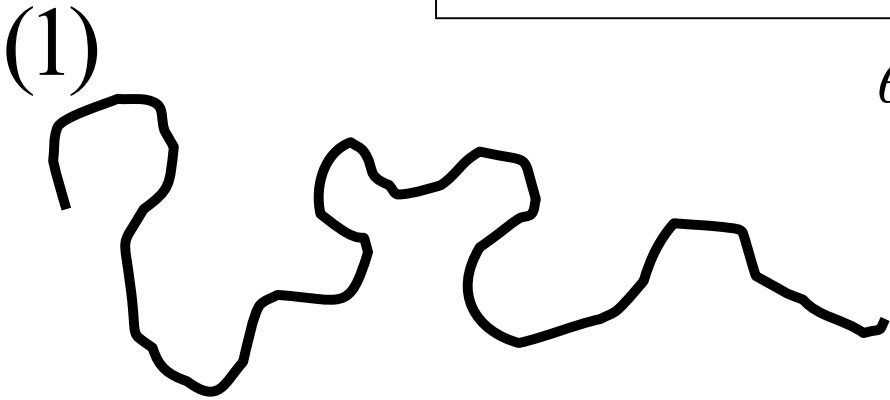


$$ds_i = \sqrt{(x_{i+1} - x_i)^2 + (y_{i+1} - y_i)^2}$$

$$\tan[\theta_i] = \frac{y_{i+1} - y_i}{x_{i+1} - x_i}$$

Bend Energy

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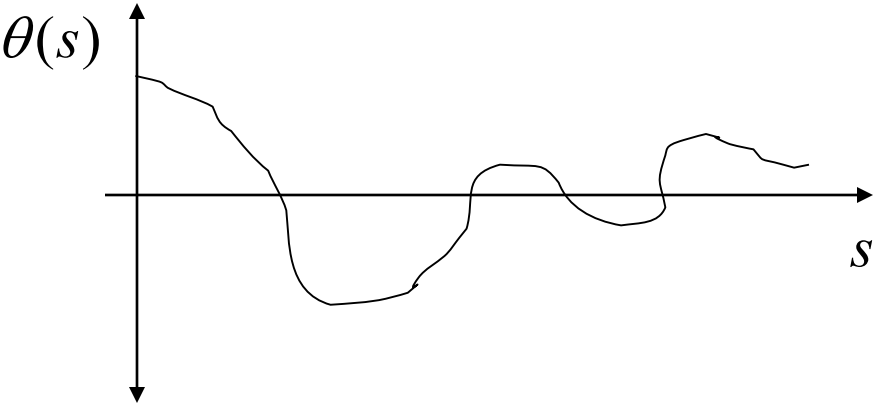
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Bend Energy

$$U_{Bend} = \frac{EIL}{2} \int_0^L \left(\frac{d\theta}{ds} \right)^2 ds$$

$$\theta(s) = \sqrt{\frac{2}{L}} \sum_n \theta(q) \cos\left(\frac{n\pi}{L} s\right)$$

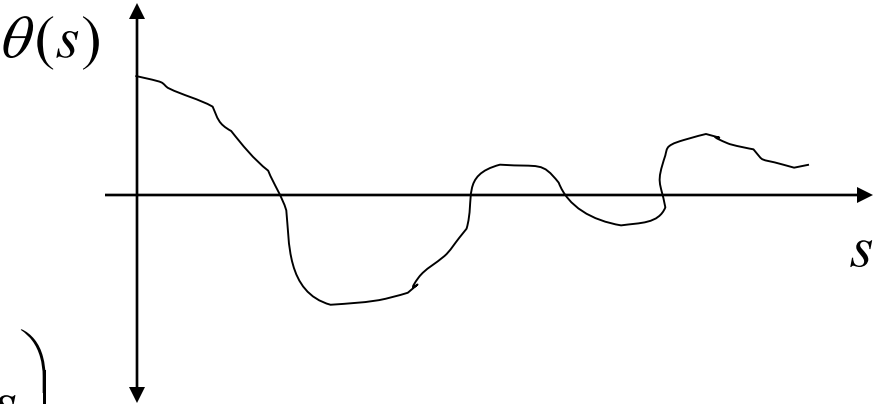


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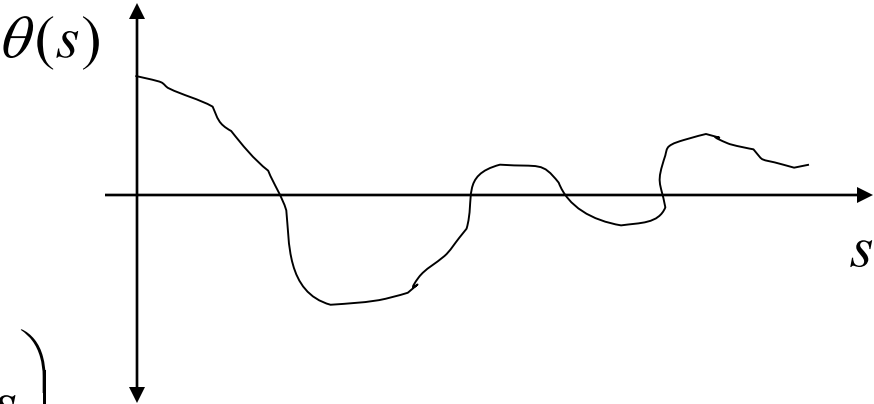
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$$\left(\frac{d\theta}{ds}\right)^2 = \frac{2}{L} \sum_m \sum_n \theta(q) \left(\frac{n\pi}{L}\right) \sin\left(\frac{n\pi}{L} s\right) \theta(k) \left(\frac{m\pi}{L}\right) \sin\left(\frac{m\pi}{L} s\right)$$



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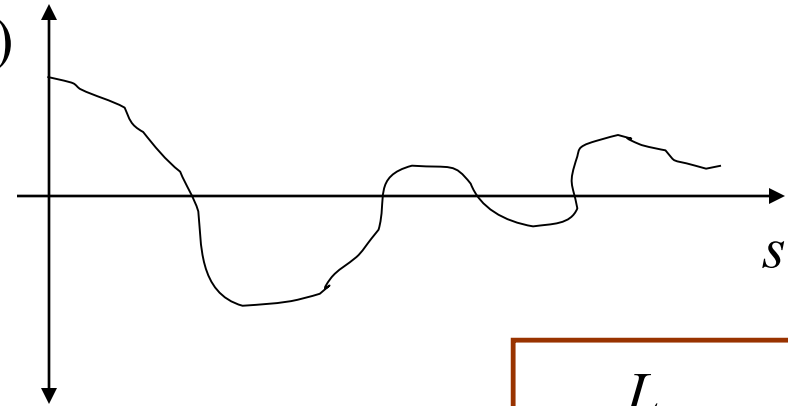
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$$\int_0^L \left(\frac{d\theta}{ds}\right)^2 ds = \frac{2}{L} \sum_{n,m} \theta(q) \theta(k) \left(\frac{n\pi}{L}\right) \left(\frac{m\pi}{L}\right) \int_0^L \sin\left(\frac{m\pi}{L} s\right) \sin\left(\frac{n\pi}{L} s\right) ds$$

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$$= \frac{L}{2} \delta_{mn}$$

$$\left(\frac{d\theta}{ds} \right)^2 = \frac{2}{L} \sum_m \sum_n \theta(q) \left(\frac{n\pi}{L}\right) \sin\left(\frac{n\pi}{L}s\right) \theta(k) \left(\frac{m\pi}{L}\right) \sin\left(\frac{m\pi}{L}s\right)$$

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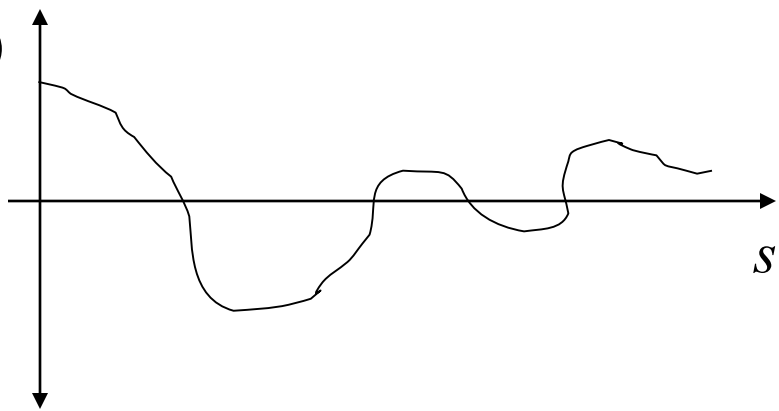
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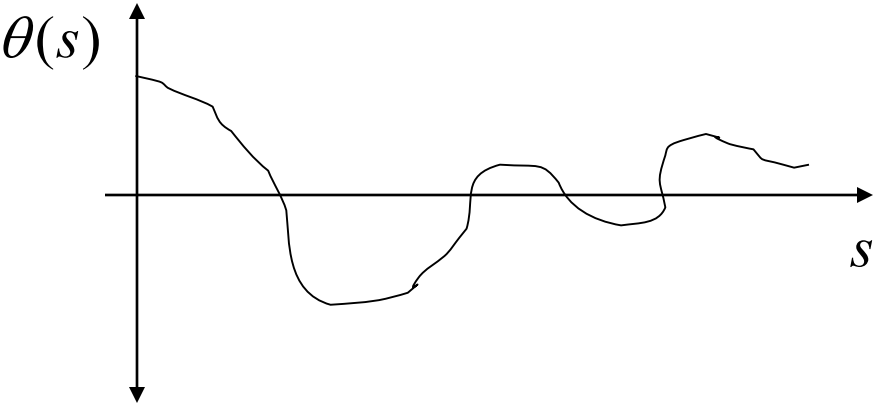
$$\int_0^L \left(\frac{d\theta}{ds} \right)^2 ds = \sum_n q^2 \theta^2(q)$$

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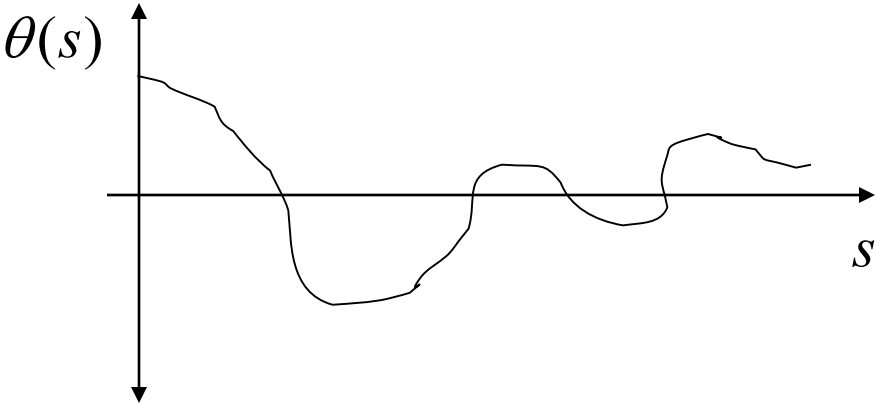
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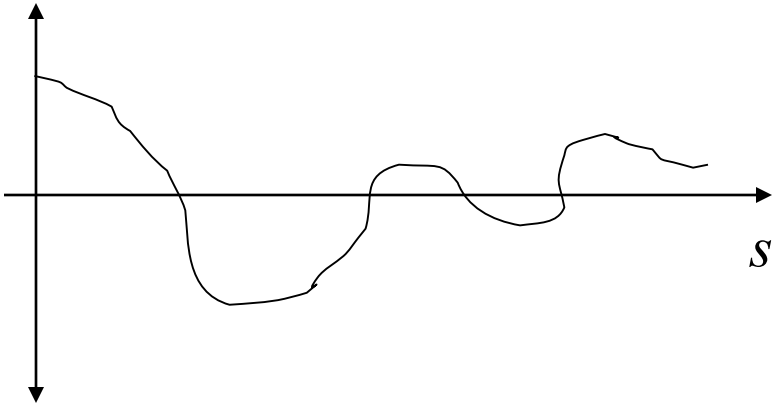
$$\frac{1}{2} k_B T = \frac{EIL}{2} q^2 \langle \theta^2(q) \rangle$$



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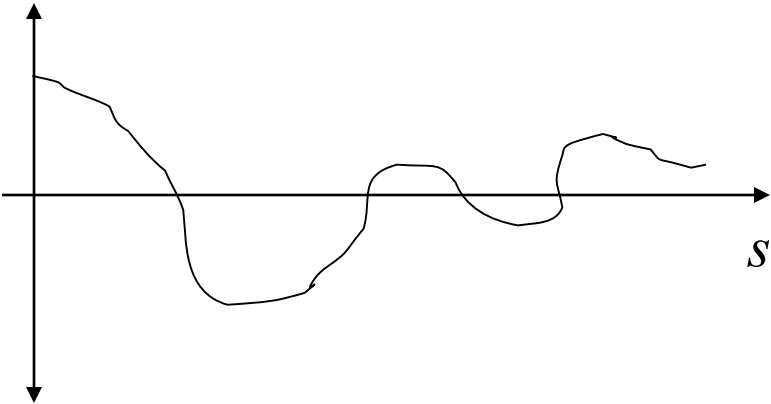
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$$\langle \theta^2(q) \rangle = \left(\frac{k_B T}{EI} \right) \frac{1}{L q^2}$$

Bend Energy

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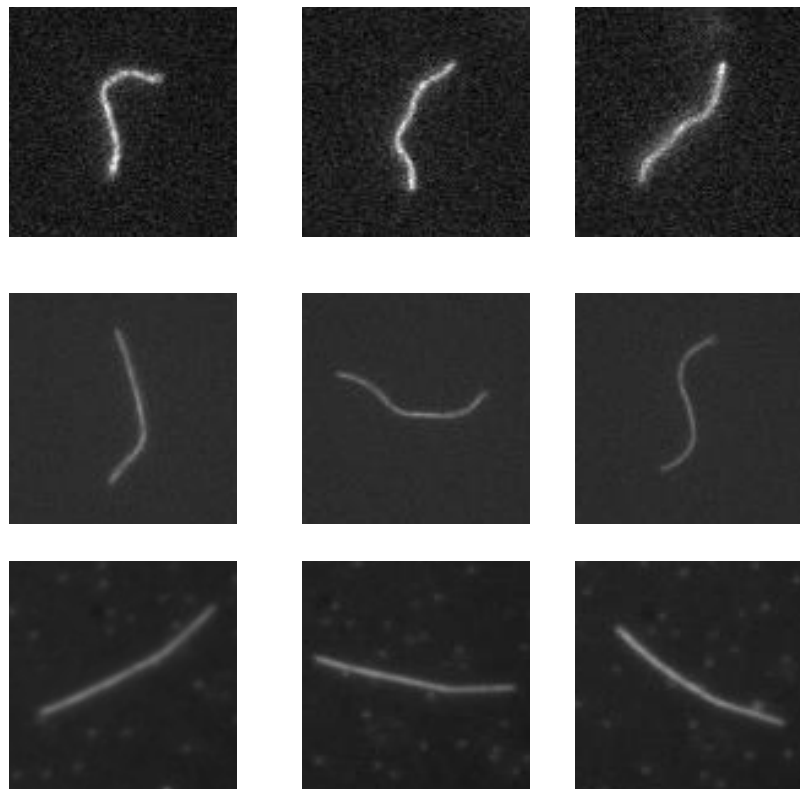
$$\langle \theta^2(q) \rangle = \frac{1}{\xi} \frac{1}{L q^2}$$

Persistence Length

$$\langle \theta^2(q) \rangle = \frac{1}{\xi} \frac{1}{Lq^2} \quad \Rightarrow \quad \xi = \frac{1}{\langle \theta^2(q) \rangle} \frac{1}{Lq^2}$$

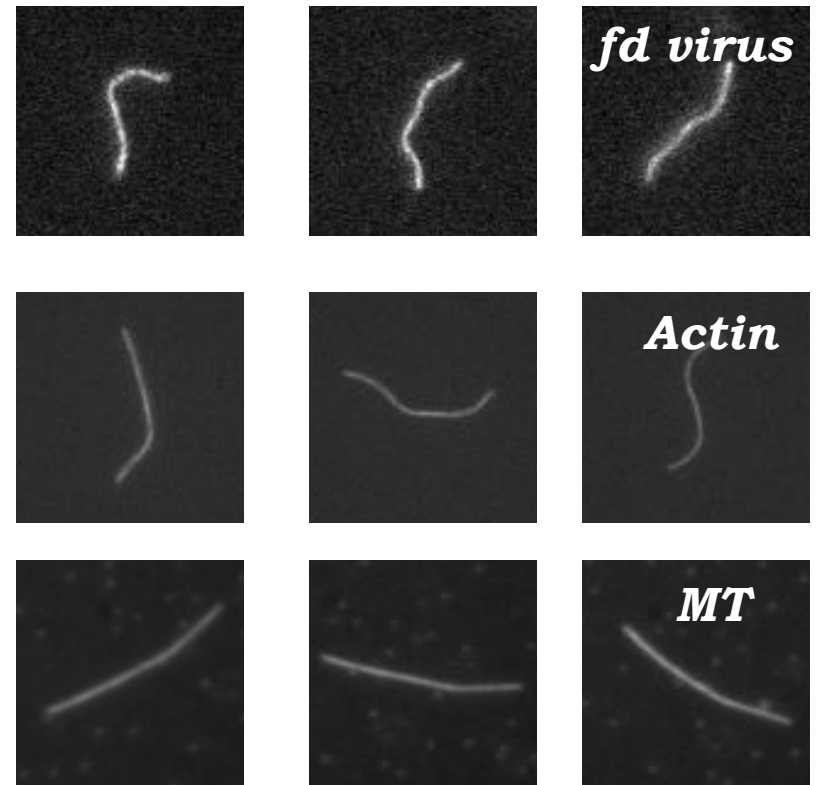
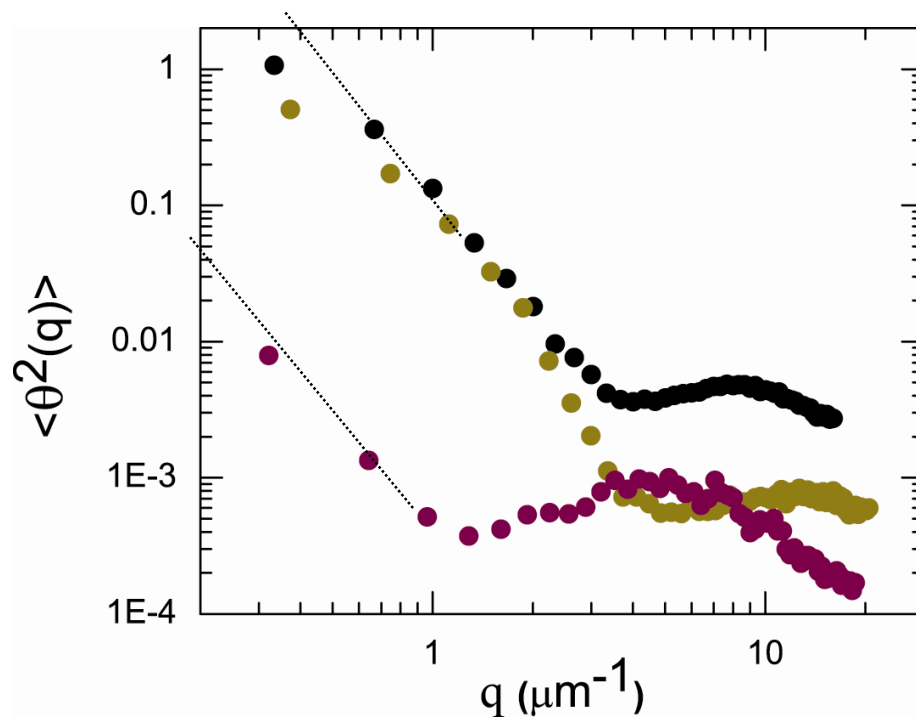
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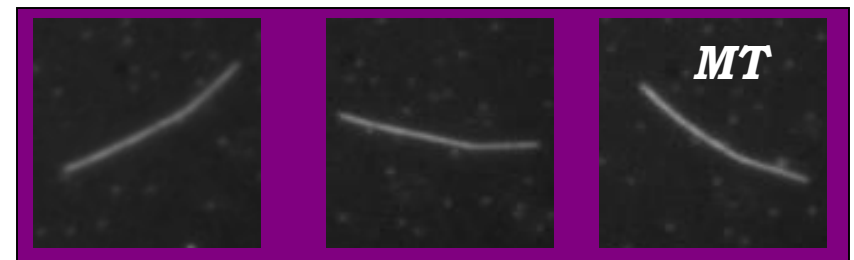
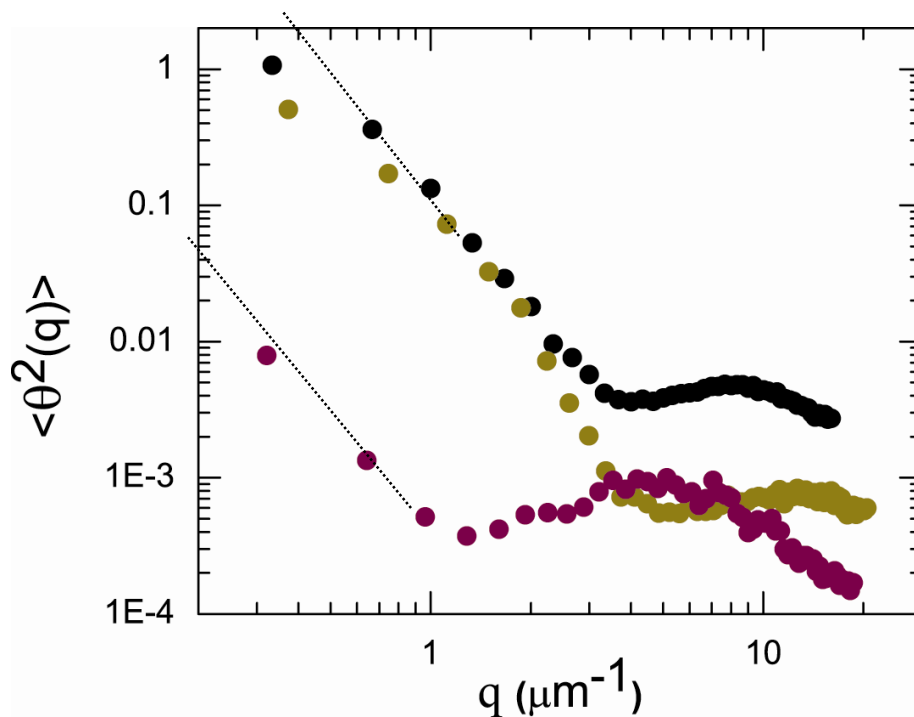
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$$\xi_{fd} = 7.3 \pm 2.1 \mu m$$



$$\xi_{actin} = 13.9 \pm 1.9 \mu m$$



$$\xi_{MT} = 1.6 \pm .0.3 mm$$

