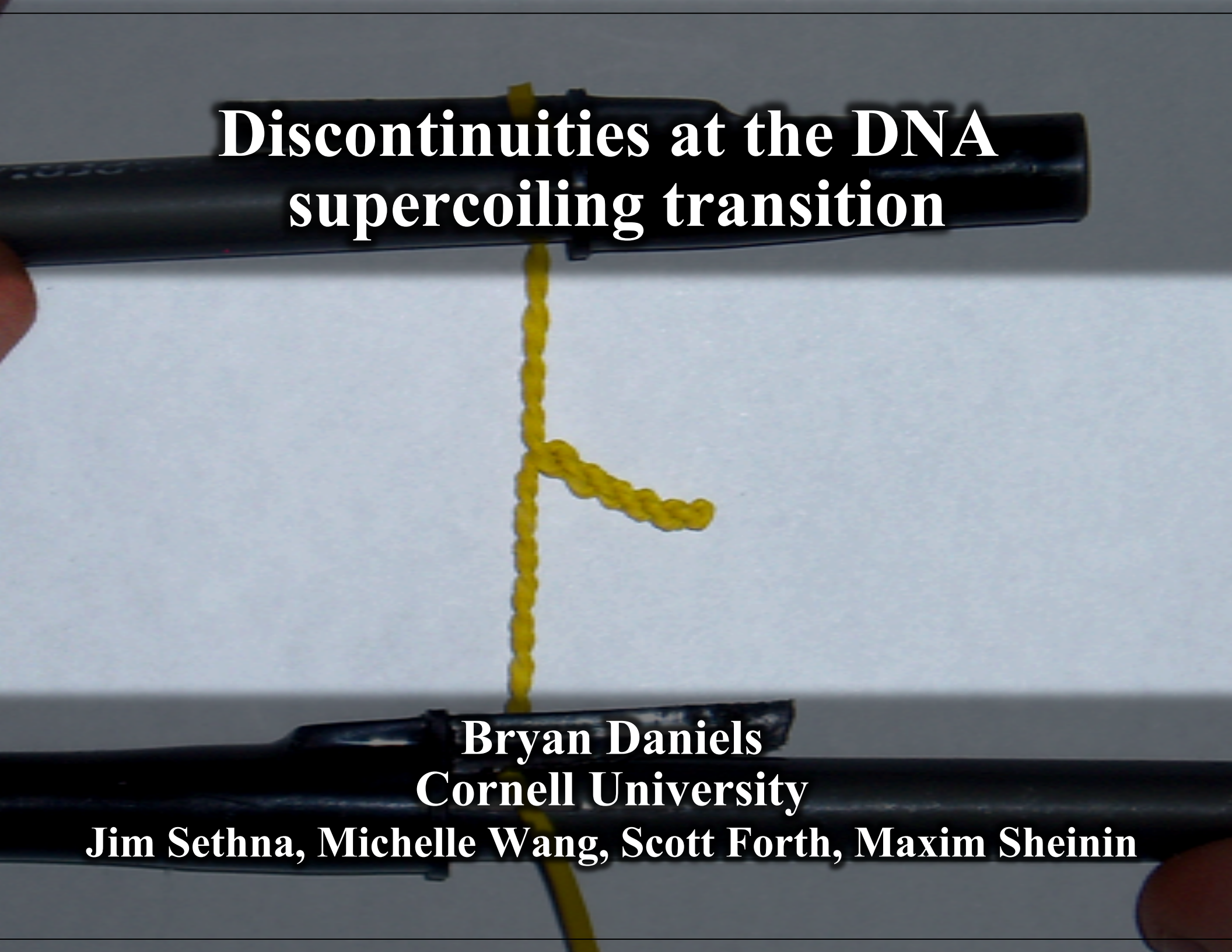
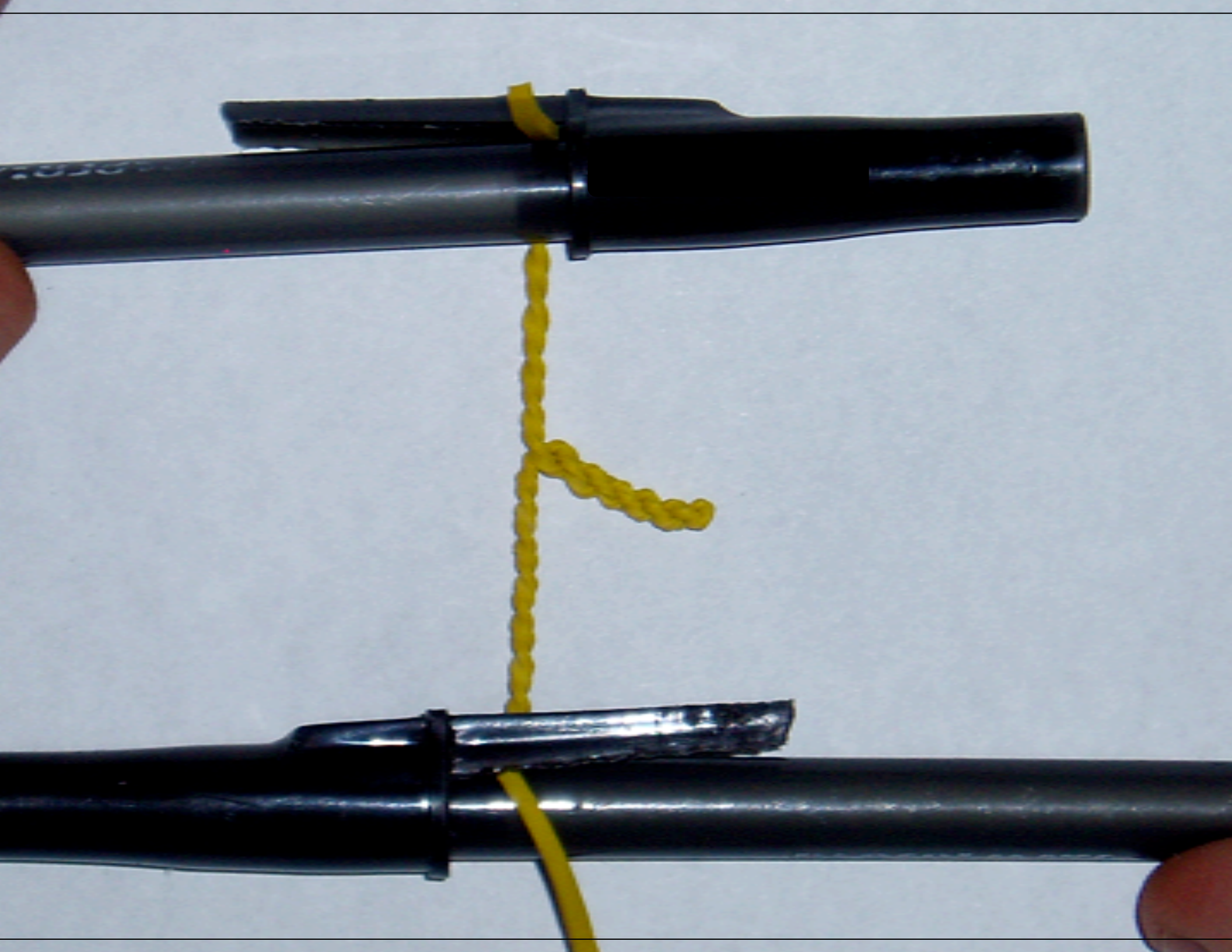
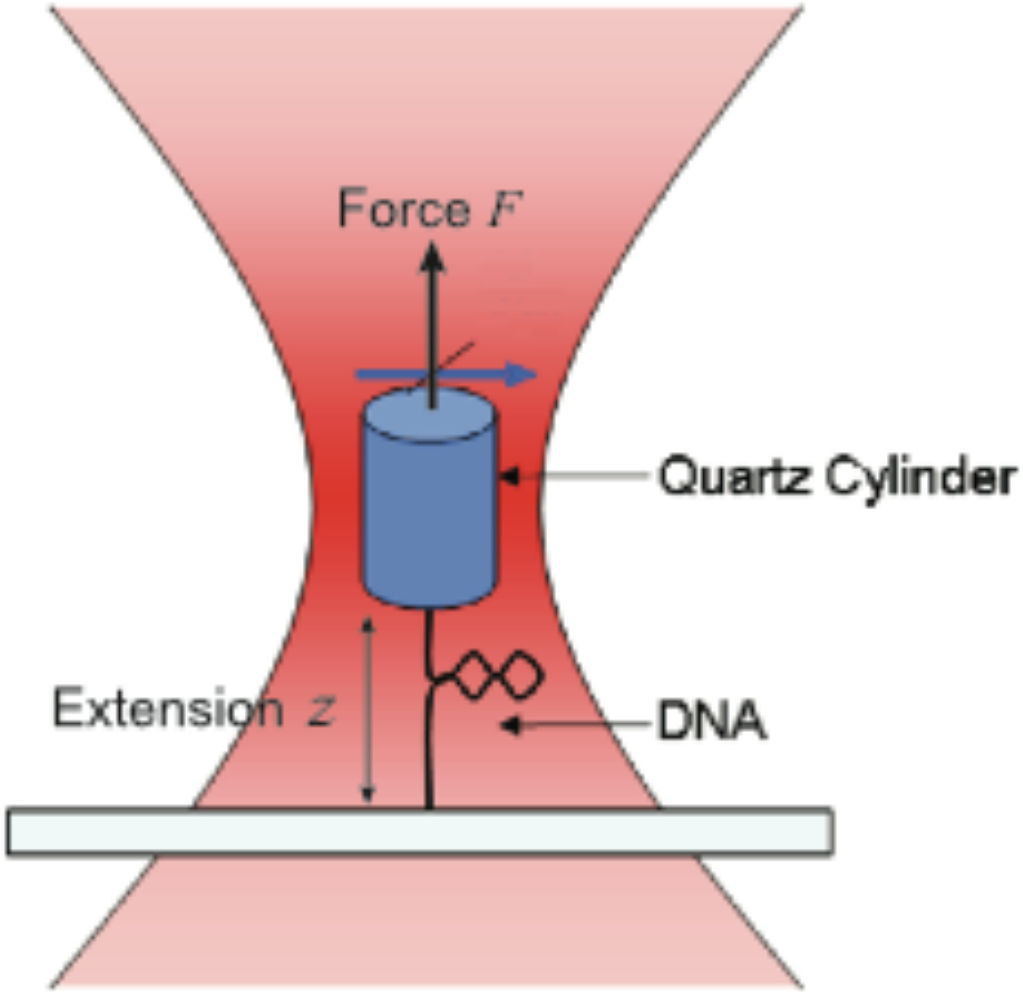


Discontinuities at the DNA supercoiling transition

Bryan Daniels
Cornell University
Jim Sethna, Michelle Wang, Scott Forth, Maxim Sheinin



Twisting DNA

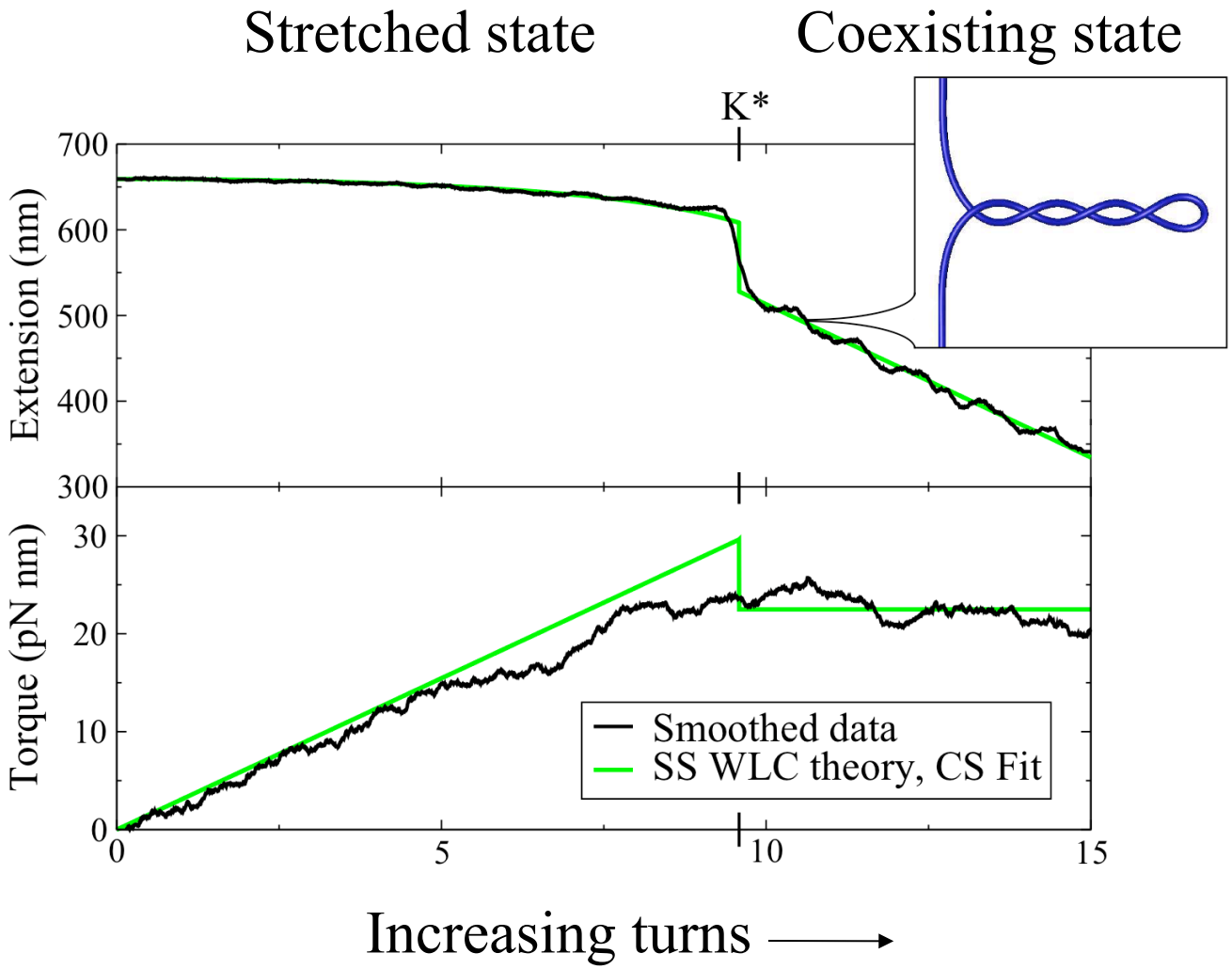


Discontinuities at the transition

- Sudden and reversible formation of twisted structure
- What determines the magnitudes of jumps?

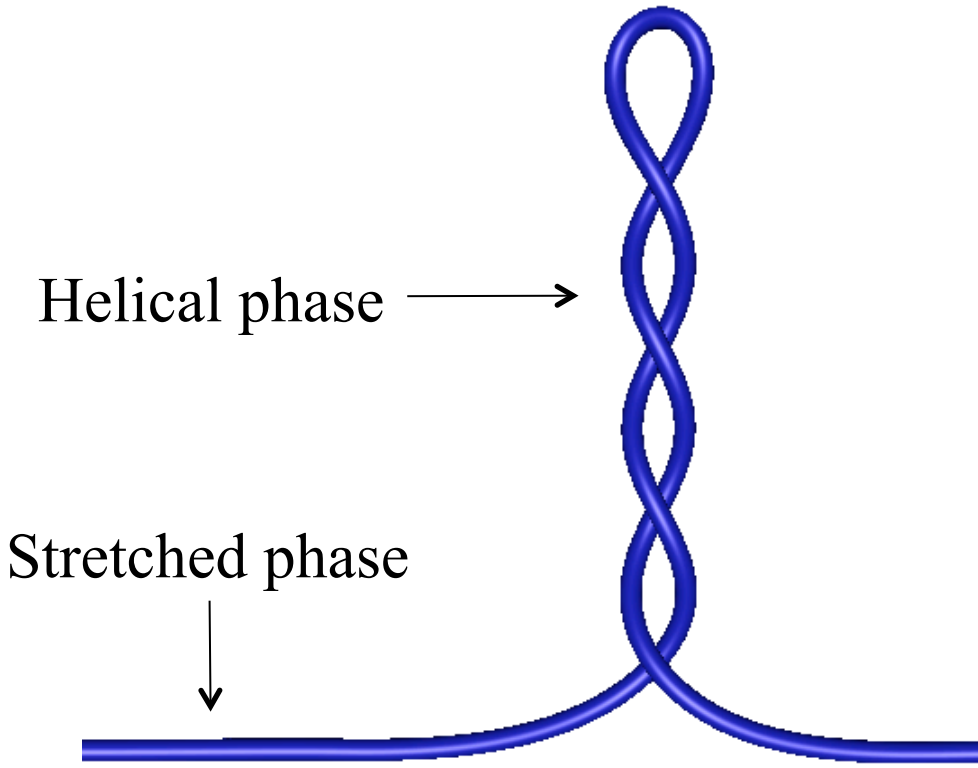
Length-dependence ?

Torque jump ?



Two-phase coexistence ⇒ Linearity

- In coexisting state, increasing twist linearly converts stretched to helical DNA (Marko model)
- Like liquid-gas coexistence
- Extra parts create a nucleation barrier (our model): “first order phase transition” with discontinuities



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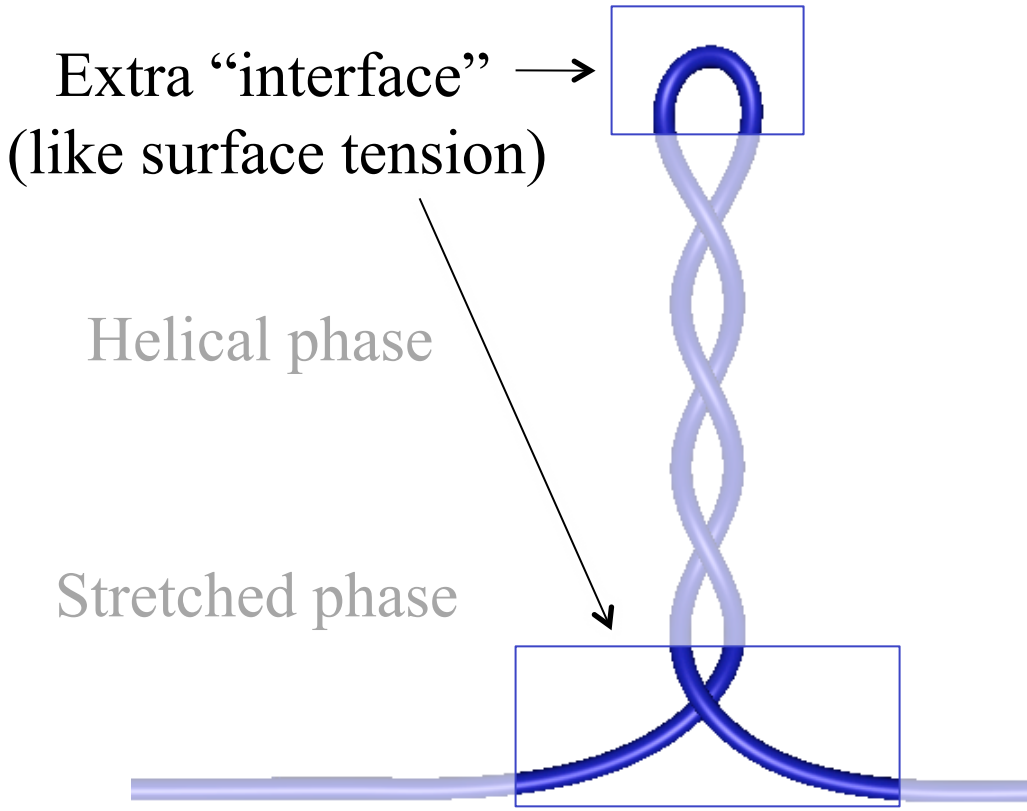
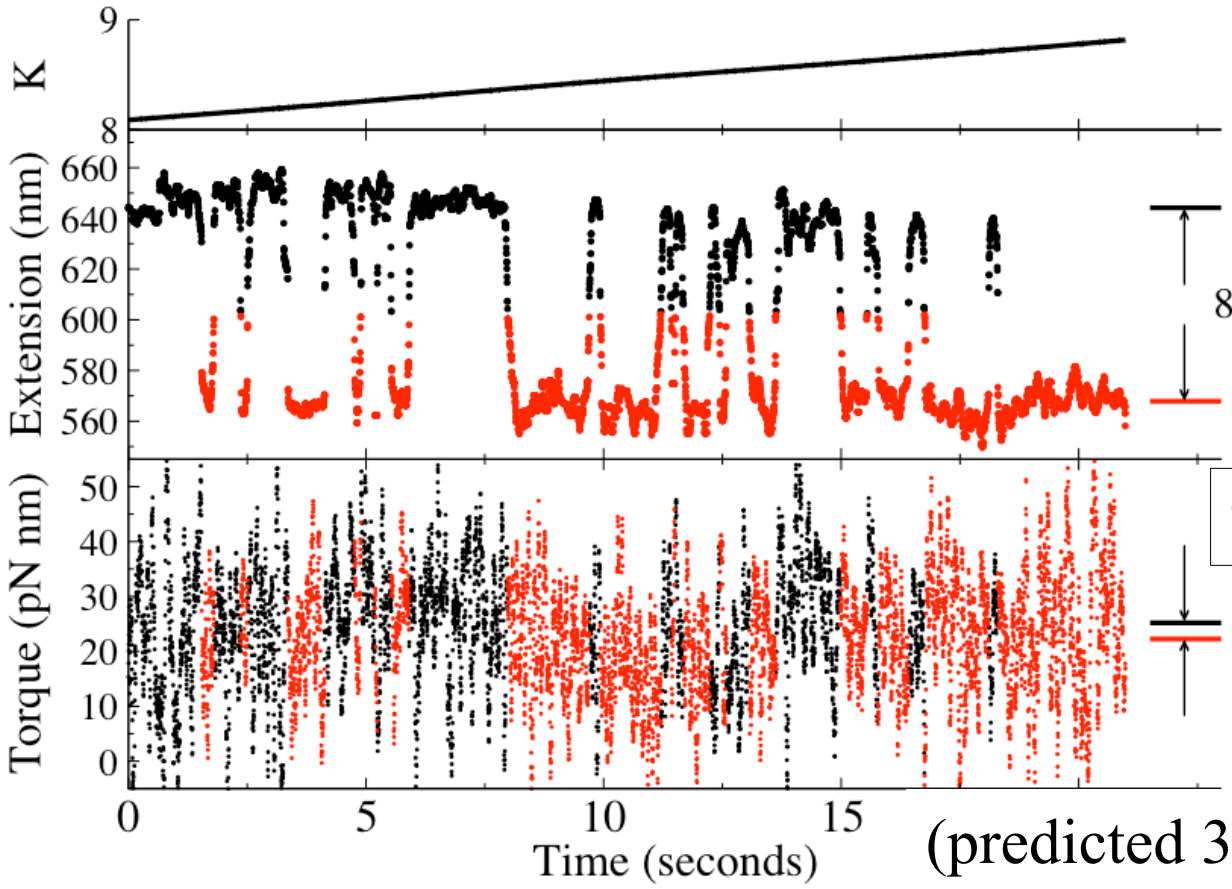


“Phase transition” smearing

- Thermal hopping smears the transition
- Can directly measure torque jump using binned averaging; agrees with prediction



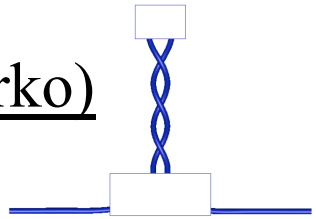
Torque jump ✔

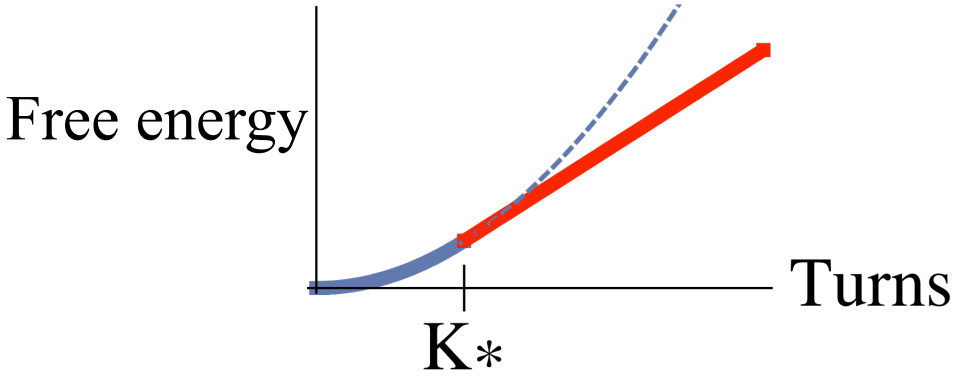
3 ± 0.7 pN nm

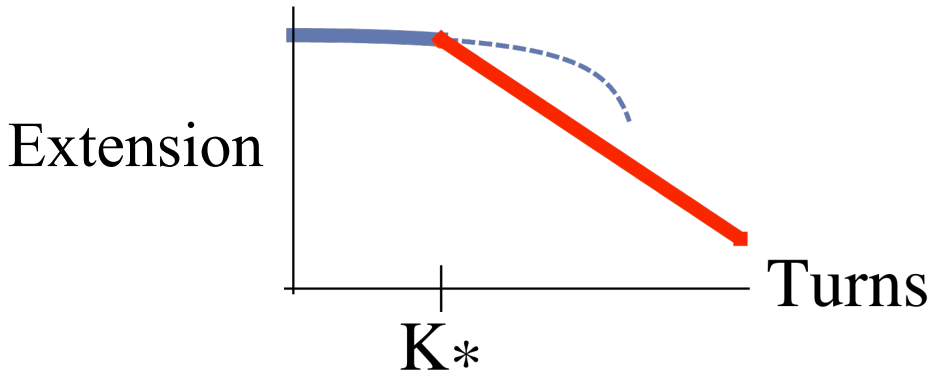
(predicted 3.9 ± 2.6 pN nm)

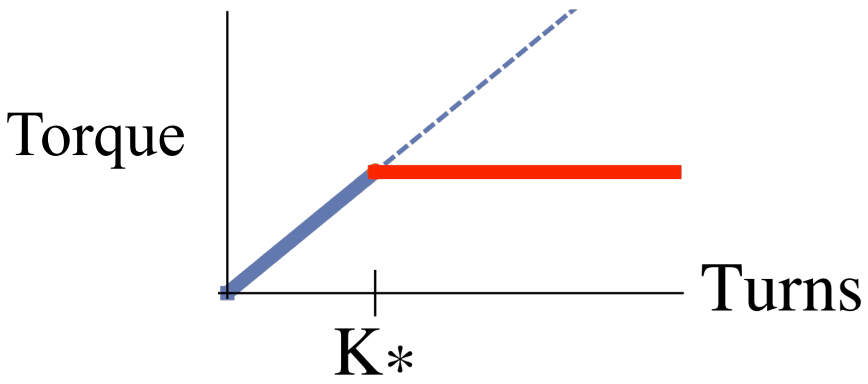
Without interface (Marko)

[Linear]



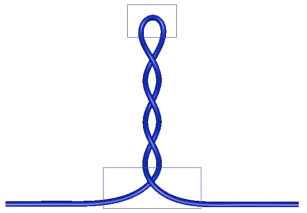


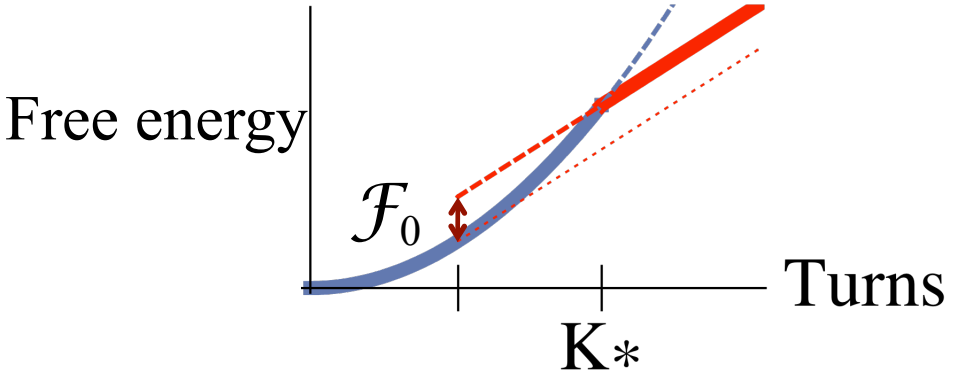


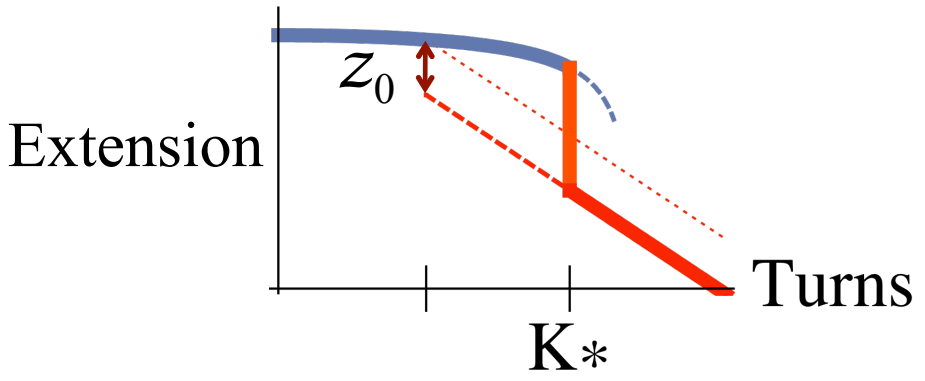


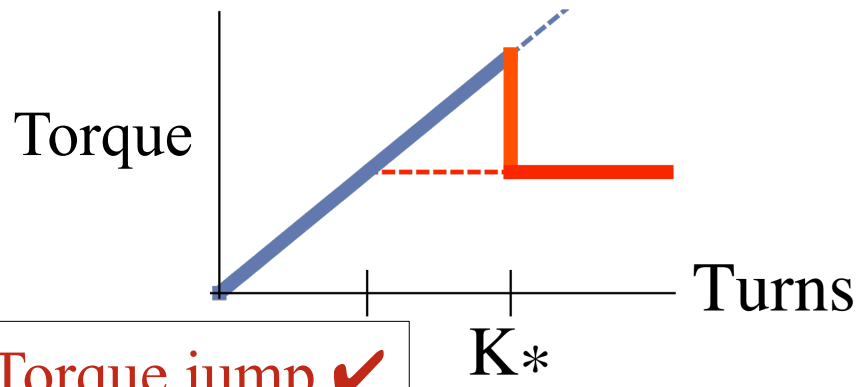
With interface (us)

[Linear + intercepts]







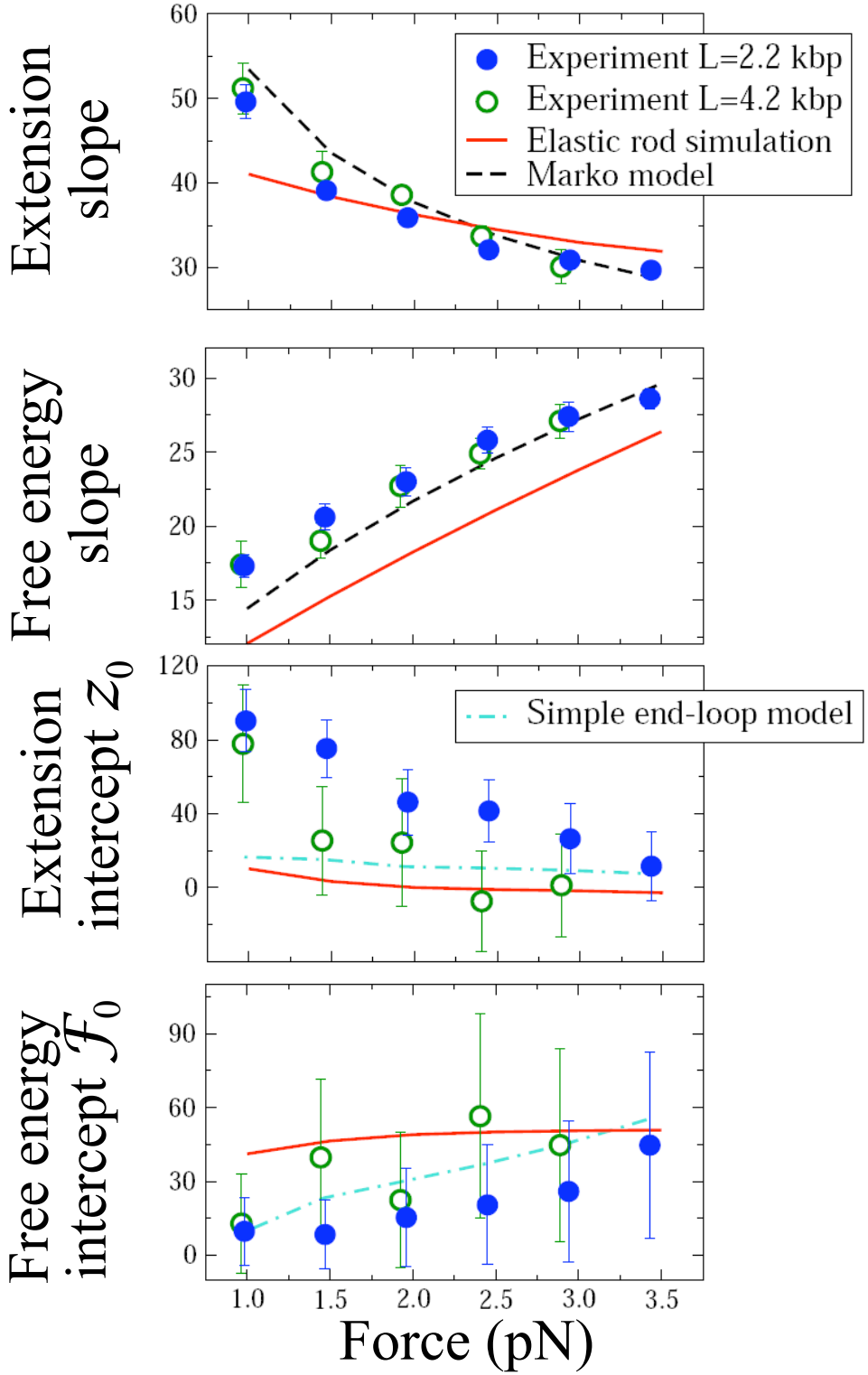


Torque jump ✔

Coexisting state theory

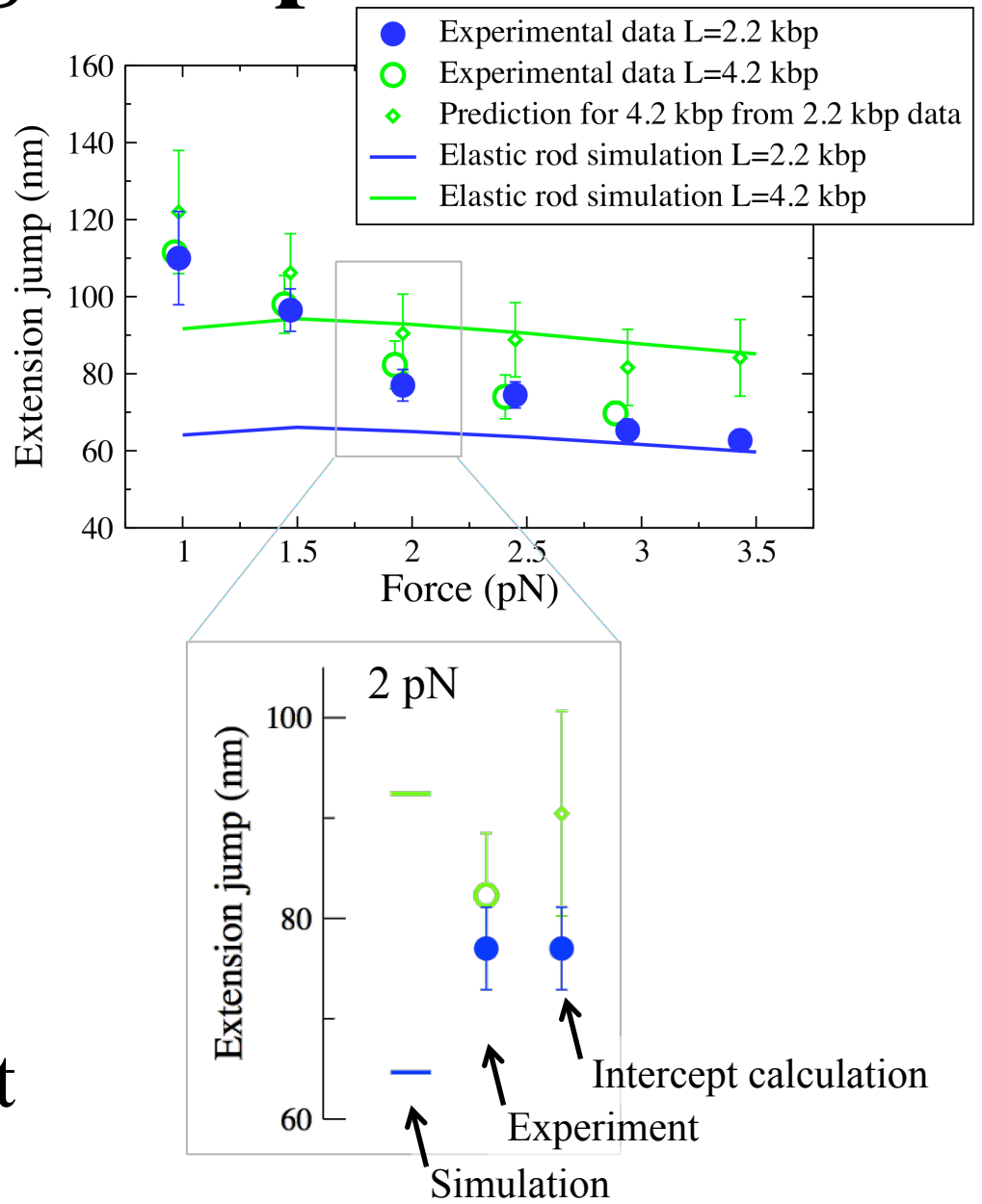
- We can measure slopes and intercepts vs. force from experiment and simulation
- These predict extension and torque jumps
  - Experiment ⇒

    Length-dependence ✔
  - Can also test DNA models



Predicted length-dependence

- Simulation showed large length-dependence of extension jump
- Data measured using 2.2 kbp predict the extension jump using 4.2 kbp
  - Gives smaller length-dependence, consistent with exp't



Conclusions

- Two-phase coexistence model ⇒ torque jump and length-dependence
- Predicted torque jump can be measured
- Small length-dependence of extension jump consistent with measured parameters
- Next: What is wrong with the DNA model?

Extension and torque jumps as a function of coexisting state parameters

$$\Delta z = z_0 + q\sqrt{\frac{L\mathcal{F}_0}{2\pi^2 C}} - L\left(\xi(\tau) - \xi(\tau + \sqrt{2C\mathcal{F}_0/L})\right)$$

$$\Delta\tau = \sqrt{\frac{2C}{L}\mathcal{F}_0}$$

With interface (us)

[Linear + intercepts]