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What's Wrong with the Wormlike Chain

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DNA bending on length scales shorter than a persistence length (50 nm) plays an essential role in the translation of genetic information from DNA to cellular function. Although the Wormlike Chain model successfully describes the bending of DNA on length scales longer than a persistence length, recent DNA cyclization experiments reveal that this model underestimates the probability of spontaneous sharp bending. Indeed, at the scales most relevant for biological processes, recent experiments give cyclization rates three orders of magnitude greater than that predicted by the Wormlike Chain model.

In this talk, we reconcile the successes of the Wormlike Chain model in describing the long-length-scale mechanics of DNA, with its failure to describe bending on biologically relevant length scales. We present an exact statistical mechanics model for a polymer which can undergo a kinking transition and explicitly show that this high-curvature softening of the polymer constitutive relation can dramatically increase the probability of high curvature configurations while leaving the long-length-scale mechanics of the polymer virtually unchanged [P. Wiggins, R. Phillips, & P. Nelson: cond- mat/0409003, Phys Rev E in press]. Next, we present a new technique for describing stiff polymers which can be exploited to compute near-exact result for many polymer observables. We use these techniques and short-length-scale AFM measurements to construct a quantitative model for DNA bending mechanics applicable on the length scales relevant for many biological processes. This new model predicts the softening observed in short-contour-length cyclization measurements.