TECHNISCHE
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Soft Matter Theory
Problem Set 14 — Theory of DNA unzipping

hand-out Wed 01.02.06, return Wed 08.02.06

1) Unzipping a double helix with an external force: Consider an optical tweezer experiment at a long DNA double helix in Y-conformation, i.e. unzipped on one end. One of the two single strands of the molecule is attached to a hard substrate, while another one is pulled with a constant force F away from the surface. Calculate the critical unzipping force, and equilibrium number of unzipped monomers for the case of Gaussian single strands and binding energy per monomer w in the zipped state (a homopolymer case). Build a schematic melting diagram in terms of the applied force and temperature.

2) Unwrapping a DNA globule: Consider now a globular state of DNA molecule (for example, a toroidal globule), ends of which are pulled apart by optical tweezers. Calculate the length of condensed and free parts of the chain at a given fixed end-to-end distance z, if the chain persistence length is l_p, contour length L, and the attraction energy (due to presence of spermidine) is $-w$ per unit length. Consider the free ends as worm-like chain with and the force-extension relation

$$f(z) = \frac{k_B T}{l_p}\left[\frac{z}{L} - \frac{1}{4} + \frac{1}{4(1-z/L)^2}\right]$$