PhD Thesis

Equilibrium Statistics of Channel-confined DNA

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This thesis is devoted to the study of DNA molecules in nanochannels. In the last ten years, a large number of studies have been conducted wherein DNA molecules were confined to channels with a width of about 100 nm. These studies are motivated both by biotechnical applications, and by the potential for using nanochannels as a model system for studying the physics of confined DNA. The results of this thesis increase our understanding of the equilibrium statistics of such channel-confined DNA.

The results can be divided into three parts. In the first, we derive novel predictions for the extension statistics of channel-confined polymers. Specifically, we map out a phase diagram of scaling regimes for a polymer in a rectangular channel. Further, in an important special case known as the extended de Gennes regime, we show that the configurational statistics are equivalent to those of a one-dimensional model known as the weakly self-avoiding random walk. Exact results for that model yield rigorous predictions for the confined polymer.

In the second part we report experimental measurements of the extension statistics of confined DNA. We find that the measurements agree very well with theoretical predictions, except at low ionic strengths.

Finally, the third part of the thesis concerns the melting of DNA, i.e. the partial disassociation of its two strands at elevated temperatures. We solve a simple model of DNA melting and show that, within this model, channel confinement makes the transition to the molten state less abrupt, despite the fact that the order of the phase transition is unchanged by confinement.