Semiflexible biopolymers with locally fluctuating bending stiffness

In many biopolymers, their local bending stiffness fluctuates as they undergo conformational changes. For example, DNA-binding proteins attach and detach from DNA to regulate cellular functions, which can change the local bending stiffness of the polymer backbone. This can also happen due to internal conformational transitions, such as the DNA denaturation or the helix-coil transition in polypeptides. What these systems have in common is that the the change in their local flexibility is transient and reversible. In order to model the reversible conformational transitions of such biopolymers, we present the minimal but inclusive model of of a freely jointed chain with reversible hinges (rFJC). Using this model, we have analysed the elastic response of the biopolymer under tension. We have found that the rFJC is remarkably different from the usual freely jointed chain (uFJC). At small stretching forces, the rFJC is more compliant than the uFJC and the former has a size (mean square end-to-end distance) always greater than that of the latter. At strong stretching forces, in contrast, the rFJC is much stiffer than the uFJC. In this regime, the thermal undulations of the chain decay very rapidly with the stretching force, resulting in an almost fully extended state of the biopolymer. We also discuss the inequivalence between the fixed-force (Gibbs) and the fixed-extension (Helmholtz) statistical ensemble which is of direct relevance to a given experiment.

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