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Ionic effects on the DNA denaturation and DNA unzipping

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The double-stranded DNA (dsDNA) that is separated and unwound changes its structure to the single-stranded DNA (ssDNA) in response either to the thermal energy or to the external forces. For the former the thermally induced dsDNA-to-ssDNA transition, called DNA denaturation, occurs in the polymer chain reactions. For the latter the force induced dsDNA-to-ssDNA transition, called DNA unzipping, separates two strands and opens a room for RNA polymerase to transcribe the sequence of base pairs. In DNA denaturation increasing the temperature higher than melting temperature, $T > T_m$, results in ssDNA. In DNA unzipping pulling the strands with the force stronger than critical force, $F > F_c$, also results in ssDNA. In the temperature-force phase diagram the critical force $F_c(T)$ is a boundary between the low temperature, small force phase of dsDNA and the high temperature, large force phase of ssDNA. The Na^+ concentration dependence of T_m and $F_c(T)$ is studied by using the correspondence between the statistical mechanics and the time imaginary quantum mechanics. In the language of quantum mechanics the ssDNA emerges naturally as a delocalized state. Both melting temperature T_m and critical force $F_c(T)$ are found to rise with increasing the Na^+ concentration in qualitative agreement with the calorimetric experiments measuring T_m and the single molecule experiments measuring F_c. The enhancement of DNA stability in the presence of Na^+ ions establishes a notion of the electrostatic stiffening.

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