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Dynamics of Linear and Circular DNA in Sub-Micron Channels[1]

YENG-LONG CHEN, JEN-FANG CHANG, Institute of Physics, Academia Sinica, PO-KENG LIN, WUNSHAIN FANN, Insitute of Atomic and Molecular Sciences, Academia Sinica — DNA dynamics in microchannels of height H may be categorized into three regimes: I. H > Rg, II. Rg > H > lp, and III. lp > H, where Rg and lp are the DNA radius of gyration and persistence length, respectively. Dynamics of DNA molecules in regime I has been extensively studied in recent theory and experiments. It has been shown that the intra-chain hydrodynamic interactions (HI) may strongly affect how DNA behaves under a microfluidic flow. In contrast, intra-chain HI is believed to be screened in regime III, as suggested by recent studies of Doyle et al. In this work, we investigate the role of HI in regime II and how it affects DNA of different conformation, specifically for linear and circular chains. In order to capture the intra-chain HI, we employ lattice Boltzmann simulations for the fluid, coupled with coarse-grained dynamics simulations for the DNA. We find that regime II confinement affects the chain conformation and shape differently for linear and circular chains due to the degrees of freedom for chain ends. The different chain conformations also lead to different chain dynamic.

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