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### **Strongly Non-equilibrium Dynamics of Nanochannel Confined DNA**

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Nanoconfined DNA exhibits a wide-range of fascinating transient and steady-state non-equilibrium phenomena. Yet, while experiment, simulation and scaling analytics are converging on a comprehensive picture regarding the equilibrium behavior of nanochannel confined DNA, non-equilibrium behavior remains largely unexplored. In particular, while the DNA extension along the nanochannel is the key observable in equilibrium experiments, in the non-equilibrium case it is necessary to measure and model not just the extension but the molecule's full time-dependent one-dimensional concentration profile. Here, we apply controlled compressive forces to a nanochannel confined molecule via a nanodozer assay, whereby an optically trapped bead is slid down the channel at a constant speed. Upon contact with the molecule, a propagating concentration "shockwave" develops near the bead and the molecule is dynamically compressed. This experiment, a single-molecule implementation of a macroscopic cylinder-piston apparatus, can be used to observe the molecule response over a range of forcings and benchmark theoretical description of non-equilibrium behavior. We show that the dynamic concentration profiles, including both transient and steady-state response, can be modelled via a partial differential evolution equation combining nonlinear diffusion and convection. Lastly, we present preliminary results for dynamic compression of multiple confined molecules to explore regimes of segregation and mixing for multiple chains in confinement.