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Nonlinear Dynamics for the Translocation of fd Virus through Nanopores: Euler Buckling at the Nanoscale

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The translocation of biopolymers such as DNA through nanopores has received a great deal of attention due to applications such as sequencing DNA or sorting polymers by size. In this presentation I will discuss results from a joint experimental-theoretical project examining the translocation of the filamentous fd virus through nanopores. The fd virus is relatively stiff with a persistence length on the order of its contour length. This is in contrast to typical translocation scenarios where the polymer is many Kuhn lengths in size. Experimental results for fd uncover complex nonlinear dynamics: the translocation speed increases superlinearly with the driving force, the mobility is force-dependent and transitions between scaling regimes with increasing virus length, and the variation in the translocation velocity increases dramatically with increasing driving force. All of these results can be explained by a simple physical picture in which the virus mechanically buckles as it is pushed through the pore and into the fluid on the opposite side of the membrane. This model is explored via Langevin dynamics simulations of the system. Consistent agreement between simulations and experiments verifies the underlying physics thus giving insight into heretofore unexplained experimental results. These findings demonstrate that for the translocation of semi-flexible polymers, the behaviour of the trans portion of the polymer —which is ignored in standard models —has a large impact on the translocation dynamics.

Author: DE HAAN, Hendrick (University of Ontario Institute of Technology)

Presenter: DE HAAN, Hendrick (University of Ontario Institute of Technology)

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