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Forces on DNA in a solid-state nanopore

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Amongst the variety of roles for nanopores in biology, an important one is enabling polymer transport, for example in gene transfer between bacteria and transport of RNA through the nuclear membrane. Recently, this has inspired the use of protein and solid-state nanopores as single-molecule sensors for the detection and structural analysis of DNA and RNA by voltage-driven translocation. The magnitude of the force involved is of fundamental importance in understanding and exploiting this translocation mechanism. Furthermore, solid-state nanopores can be seen as a model system for biological nanopores. We will discuss the forces acting on single DNA strands electrophoretically driven through a solid-state nanopore. The force was directly measured using optical tweezers [1]. The force depends linearly on the applied voltage for a wide range of salt concentrations (0.02M – 1M KCl) and nanopore diameters (6 nm – 80 nm). Interestingly, we find for small nanopores with a diameter less than 15 nm that the force on the DNA is independent of the salt concentrations. However, the force decreases significantly in the larger nanopores. We will qualitatively discuss our results using the Poisson-Boltzmann and Navier-Stokes equations for a simple geometry. The influence of hydrodynamic coupling between the nanopore walls and the DNA molecule is of crucial importance to understand the force on a DNA molecule in nanopores. [1] U. F. Keyser et al. Nature Physics 2, 473 (2006)