Modeling project: DNA packaging in a virus

Physics of Complex Systems M2 – Biophysics

Viruses are very simple objects by biological standards, made of a rigid protein box, the "capsid", in which DNA is packaged, ready to be ejected in order to infect the next cell. In the specific case of bacteria-infecting virus bacteriophage $\phi 29$, an molecular motor known as the "portal motor" packages the $\simeq 19000$ base-pairs double-stranded DNA genome in a preassembled, roughly spherical, 20 nm-radius capsid. This motor is located right at the point where DNA enters the capsid in the left-hand-side panel of Fig. 1. While this packaging initially happens quickly ($\approx 100\,\mathrm{bp}\cdot\mathrm{s}^{-1}$), as more and more of the genome is packaged the process slows down to much smaller speeds at the end of the packaging process as packing the DNA ever more densely inside the capsid becomes more and more difficult. Using the optical tweezers setup pictured on the left-hand-side of Fig. 1, it is possible to estimate the internal force resisting DNA packaging at each point of the packaging process, as displayed on the right-hand-side of Fig. 1.

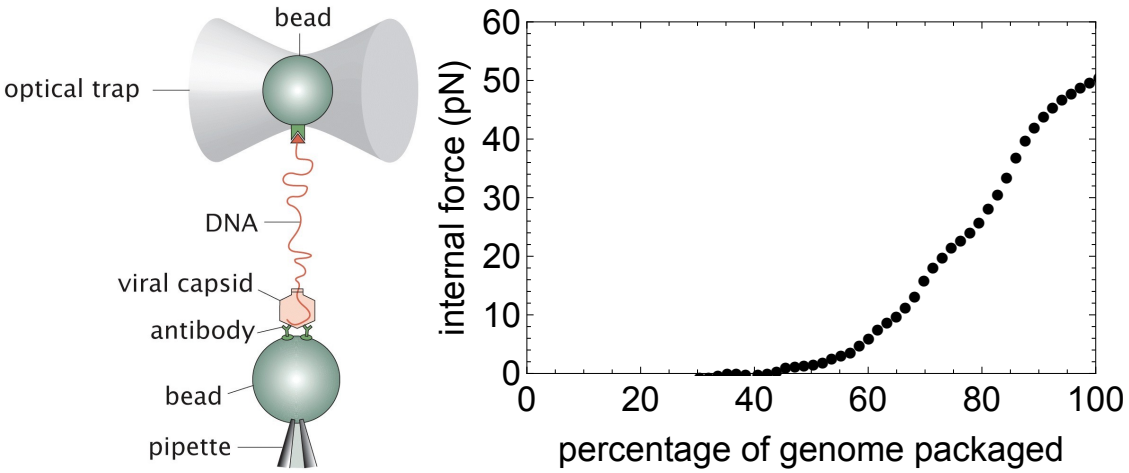

Figure 1: Optical tweezers measurement of the force during DNA packaging. *Left:* Experimental setup. The viral capsid is attached to one bead using antibodies and the viral genome is attached to a second bead. This second bead is held in an optical trap and the forces are monitored as the DNA is reeled into the capsid by a portal motor that consumes the molecular fuel ATP. *Right:* Force exerted by the already-packed DNA and resisting further packaging as a function of genome present in in the capsid.