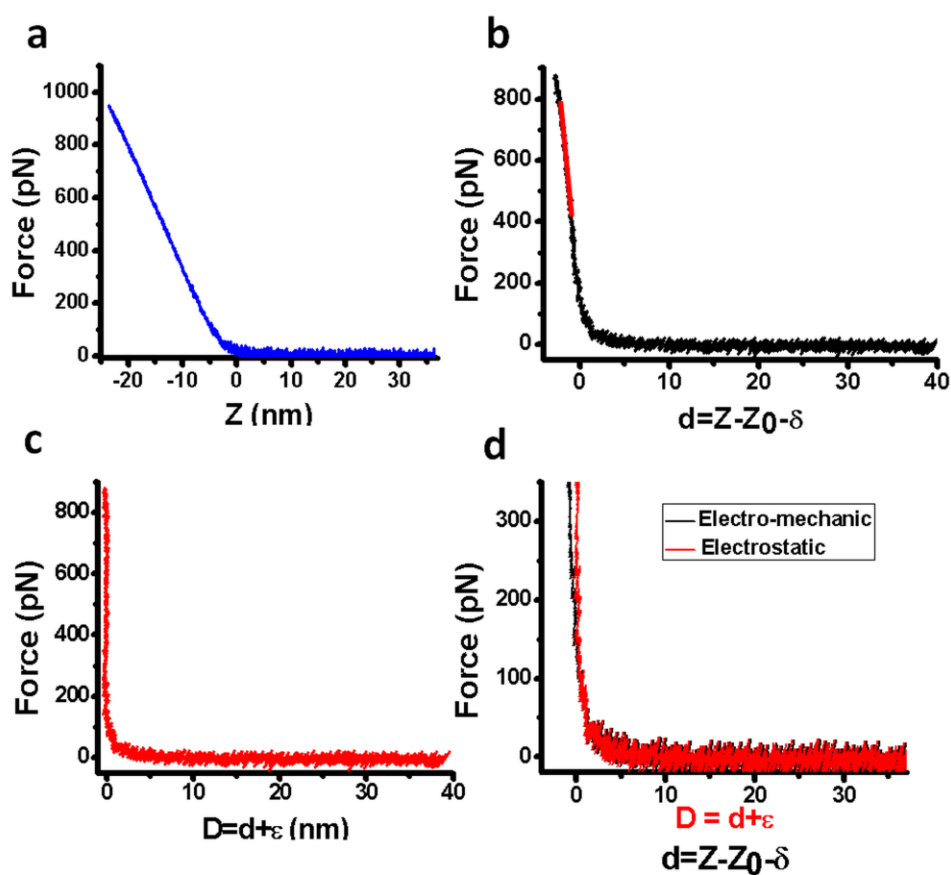


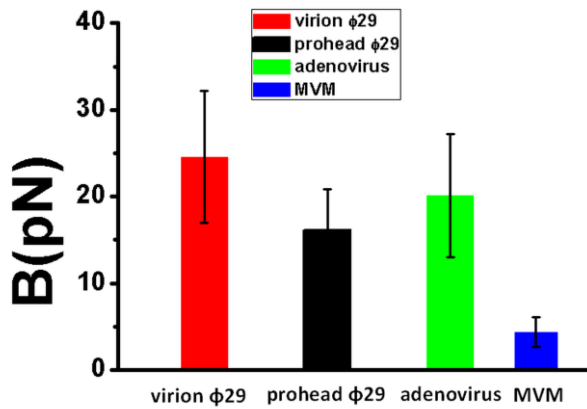
## Supplementary Information

### Quantitative nanoscale electrostatics of viruses

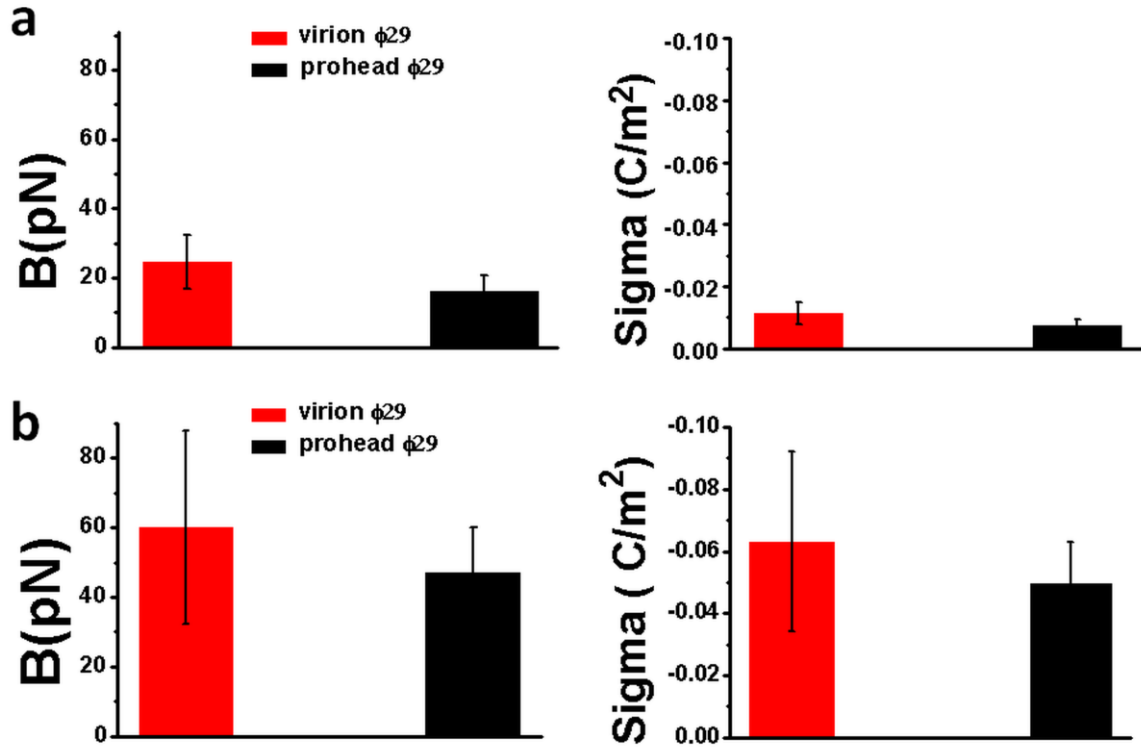
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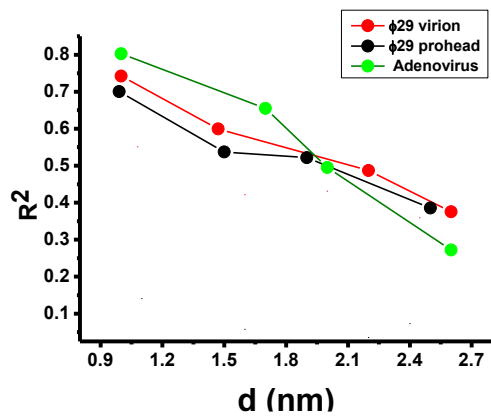
**Fig. S1:** Conversion of (a) the recorded F-Z curve performed on  $\phi 29$  virion during the experiment into (b) effective gap distance  $d = Z - Z_0 - \delta$  and (c) in the real tip-virus gap distance  $D = d + \epsilon$ . (d) A comparison between the F-d and F-D curves performed on viral particle.



**Fig. S2:** Viral particle identification by quantifying the electrostatic force interaction coefficient  $B$ . Classification of the electromechanical force (*Mean  $\pm$  Standard Deviation*) of the viral particles under 2 mM NaCl pH=7.8 buffer conditions: 12 particles of  $\phi$ 29 virion (red bar), 7 particles of  $\phi$ 29 prohead (black bar), 8 particles of adenovirus (green bar), and 11 particles of MVM (blue bar).



**Fig. S3:** Viral particle identification by quantifying the electrostatic interaction force and surface charge density from Eq. (2). (a) Classification of the electromechanical force (*Mean  $\pm$  Standard Deviation*) of bacteriophage viral particles in 2 mM NaCl pH=7.8 buffer condition: 12 particles of  $\phi 29$  virion (red bar) and 7 particles of  $\phi 29$  prohead (black bar). Surface charge density estimation (*Mean  $\pm$  Standard Deviation*) from the electromechanical force ( $-0.0114 \pm 0.0035 C/m^2$  for virion and  $-0.0074 \pm 0.0020 C/m^2$  for prohead). (b) Same measurements as in (a) obtained at 10 mM NaCl pH=7.8 buffer conditions: 10 particles of  $\phi 29$  virion (red bar) and 6 particles of  $\phi 29$  prohead (black bar), respectively.



**Fig. S4:**  $R^2$  as function of the fitting distance for  $\phi 29$  virion,  $\phi 29$  prohead and adenovirus using the approximation of the double exponential DLVO approximation based on the Parsegian-Gingell model (see main text).

Equation 2	Virion $\phi 29$ (12)	Prohead $\phi 29$ (7)	Adenovirus (8)	MVM (11)
$\text{Sigma}_{\text{from fitting}} \text{ (C/m}^2\text{)}$	$-0.0114 \pm 0.0035$	$-0.0074 \pm 0.0020$	$-0.0085 \pm 0.0020$	$-0.0023 \pm 0.0014$
$\text{Sigma}_{\text{from fitting}} \text{ (e}_0\text{/nm}^2\text{)}$	$-0.071 \pm 0.022$	$-0.046 \pm 0.012$	$-0.053 \pm 0.012$	$-0.014 \pm 0.008$
Outer Radius $R_{\text{out}}$ (nm)	21	21	42.4	12.5
Charge $_{\text{from Sigma} \times \text{Surface Area virus}} \text{ (e}_0\text{)}$	$-394 \pm 121$	$-255 \pm 69$	$-1197 \pm 272$	$-28 \pm 16$

**Table S1:** Summary of estimated charge and surface charge density (sigma) using the full Parsegian-Gingell and Eq. (2) under 2 mM NaCl pH = 7.8 salt concentration solutions.

Equation 4	Virion $\phi 29$ (12)	Prohead $\phi 29$ (7)	Adenovirus (8)	MVM (11)
$\text{Sigma}_{\text{from fitting}} \text{ (C/m}^2\text{)}$	$-0.0115 \pm 0.0025$	$-0.00766 \pm 0.00155$	$-0.00886 \pm 0.00171$	$-0.00342 \pm 0.00264$
$\text{Sigma}_{\text{from fitting}} \text{ (e}_0\text{/nm}^2\text{)}$	$-0.072 \pm 0.015$	$-0.0478 \pm 0.0097$	$-0.055 \pm 0.012$	$-0.0213 \pm 0.0165$
Outer Radius $R_{\text{out}}$ (nm)	21	21	42.4	12.5
Charge $_{\text{from Sigma} \times \text{Surface Area virus}} \text{ (e}_0\text{)}$	$-397 \pm 83$	$-264 \pm 53$	$-1249 \pm 272$	$-42 \pm 32$

**Table S1:** Summary of estimated charge and surface charge density (sigma) using Eq. (4) under 2 mM NaCl pH = 7.8 salt concentration solutions.