Charged Fluids

Interaction between charged plates, with neutralizing counterions

Debye-Hückel screened Coulomb interaction:

\[ \delta F_{DH}(H) = \frac{A\sigma^2}{\epsilon} H \times e^{-H/\lambda} \quad \lambda = \sqrt{\frac{\epsilon H k_B T}{2\sigma e}} \]

Poisson-Boltzmann (charge condensation) interaction:

\[ \delta F_{PB}(H) = k_B T \times \frac{A}{\ell_B H} \times \frac{\pi}{2} \quad \ell_B = \frac{e^2}{\epsilon k_B T} \]

Corrections due to reduced charge fluctuations near surfaces:

\[ \delta F_{FI}(H) = -k_B T \times \frac{A}{H^2} \times \left[ \frac{\zeta(3)}{16\pi} + \frac{\pi}{4} \left( \frac{\pi}{4} + \frac{1}{2} \right) + \frac{\pi}{4} \ln \left( 2\ell_B \sigma H \right) + \cdots \right] \]