6.2: Dielectric Constant and Screening

Charge interactions are suppressed in a polarizable medium, which depends on the dielectric constant. The potential energy for interacting charges is long range, scaling as r^{-1}.

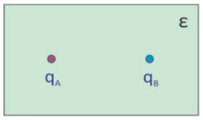
$$U(r) = \frac{q_A q_B}{4\pi} \frac{1}{\varepsilon r}$$

You can think of ε as scaling the potential interaction distance $U \propto (\varepsilon r)^{-1}$. Here we equate the dielectric constant and the relative permittivity $\varepsilon_r = \varepsilon / \varepsilon_0$, which is a unitless quantity equal to the ratio of the sample permittivity ε to the vacuum permittivity ε_0.

The dielectric constant is used to treat the molecular structure and dynamics of the charge environment in a mean sense, to give you a sense of how the polarizable medium screens the interaction of charges. Making use of a dielectric constant implies a separation of the charges of the system into a few important charges and the environment, which encompassed countless countess charges and their associated degrees of freedom.

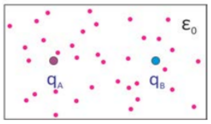
Two treatments of the electrostatic force that charge *b* exerts on charge *a* in a dense medium:

Continuum



$$f_A = \frac{1}{4\pi\varepsilon_0} \frac{q_a q_b}{\varepsilon_r r^2}$$

Explicit Charges



$$\begin{aligned} f_A &= \frac{1}{4\pi\varepsilon_0} \left[\frac{q_a q_b}{r^2} + \sum_{i=1}^{N} \frac{q_a q_i}{r_{ai}^2} \right] \\ &= \frac{1}{4\pi\varepsilon_0} \frac{q_a q_b}{r^2} \left[1 + \sum_{i=1}^{N} \frac{q_i}{q_b} \frac{r^2}{r_{ai}^2} \right] \end{aligned}$$

i: charged particles of the environment