Atomic polarizability

Example: a molecule *A* becomes polarized because of the presence of a molecule *B* with a permanent dipole moment p_B

$$\vec{p}_A = \alpha \vec{E}_B$$

Let's consider the case of A being on the axis of p_B (say the *z* axis):

$$\vec{p}_B = p_B \hat{\mathbf{z}}, \quad \vec{E}_B(A) = \frac{p_B}{2\pi\epsilon_0 z^3}\hat{\mathbf{z}}$$

$$\Rightarrow \quad \vec{p}_A = \alpha \frac{p_B}{2\pi\epsilon_0 z^3}\hat{\mathbf{z}}$$ (of course p_A and p_B are aligned)

So the force acting on the induced dipole A is:

$$\vec{F}_A = (\vec{p}_A \cdot \nabla)\vec{E}_B = \alpha \frac{p_B}{2\pi\epsilon_0\, z^3}\frac{\partial}{\partial z}\left(\frac{p_B}{2\pi\epsilon_0\, z^3}\right)\hat{\mathbf{z}} = -\frac{3\alpha p_B^2}{(2\pi\epsilon_0)^2\, z^7}\hat{\mathbf{z}}$$

always attractive

sizeable only at *very* short distance

consider the force on dipole B:

$$\overrightarrow{E_A}(B) = \frac{p_A}{2\pi\epsilon_0 z^3}\hat{z} = \alpha\frac{p_B}{(2\pi\epsilon_0)^2 z^6}\hat{z}$$

So the force acting on dipole B is:

$$\overrightarrow{F_B} = (\overrightarrow{p_B} \cdot \nabla)\,\overrightarrow{E_A}(B) = p_B\frac{\partial}{\partial z}\left[\alpha\frac{p_B}{(2\pi\epsilon_0)^2 z^6}\right]\hat{z}$$

$$= -\frac{6\alpha p_B^2}{(2\pi\epsilon_0)^2 z^7}\hat{z} = 2\overrightarrow{F_A}$$

How is this possible (Newton's Third Law)