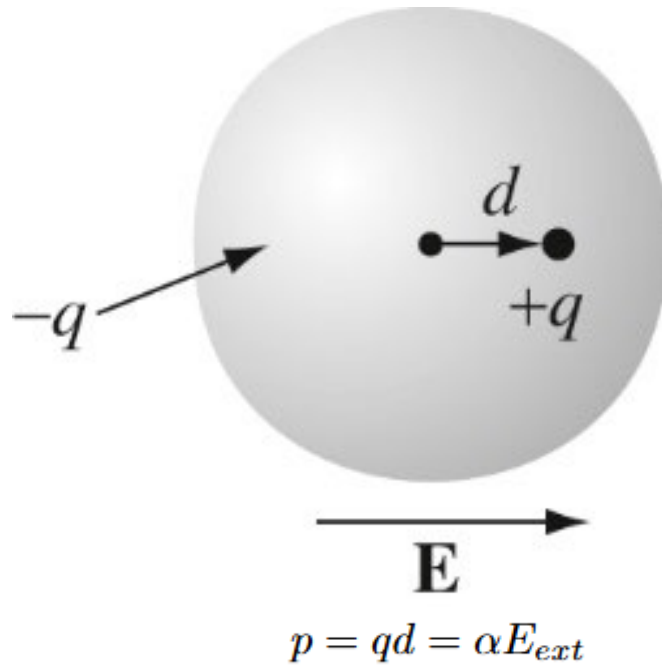


Lecture 19 Slides

Phys 313 Fall 2026

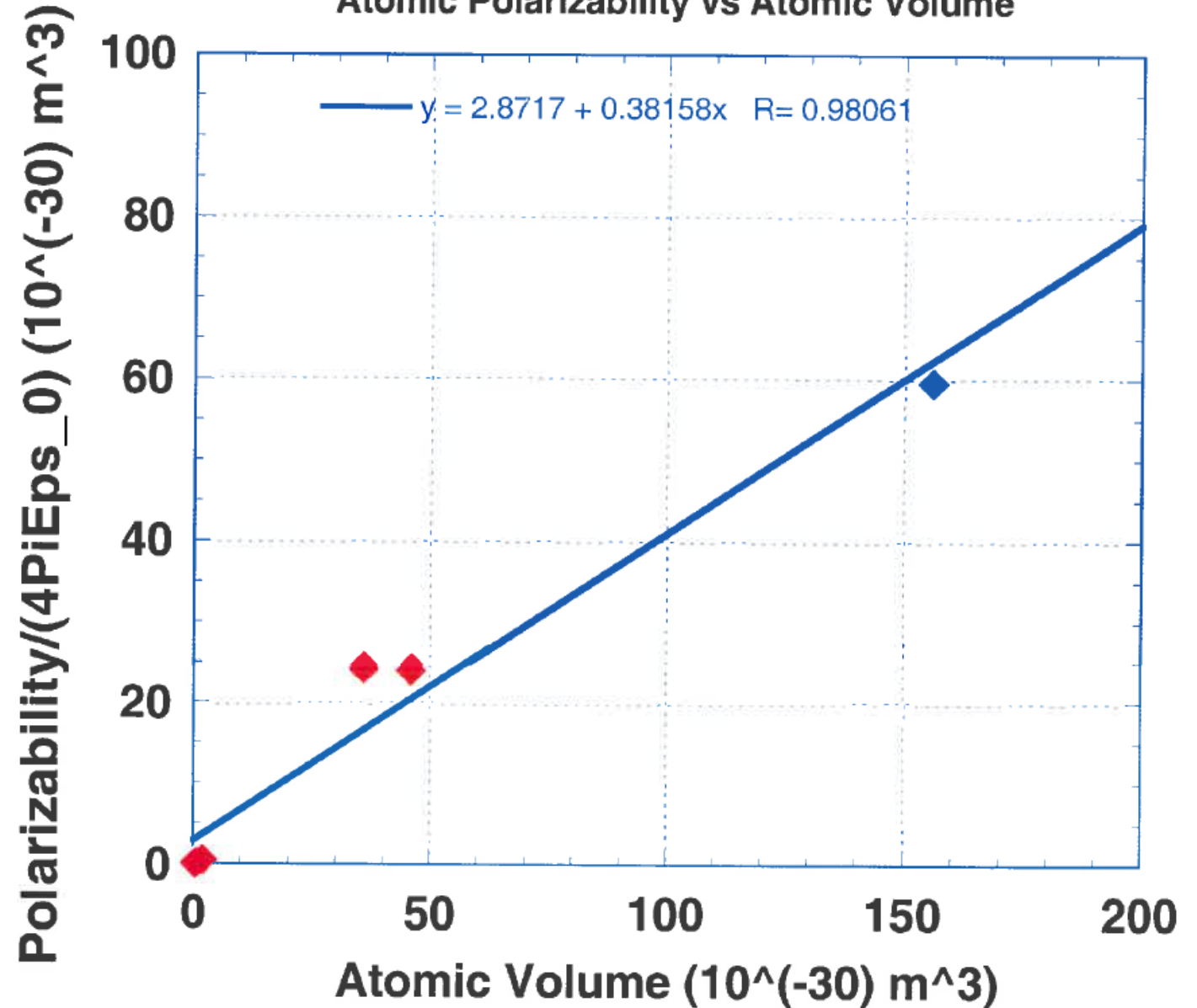
Atomic Polarizability



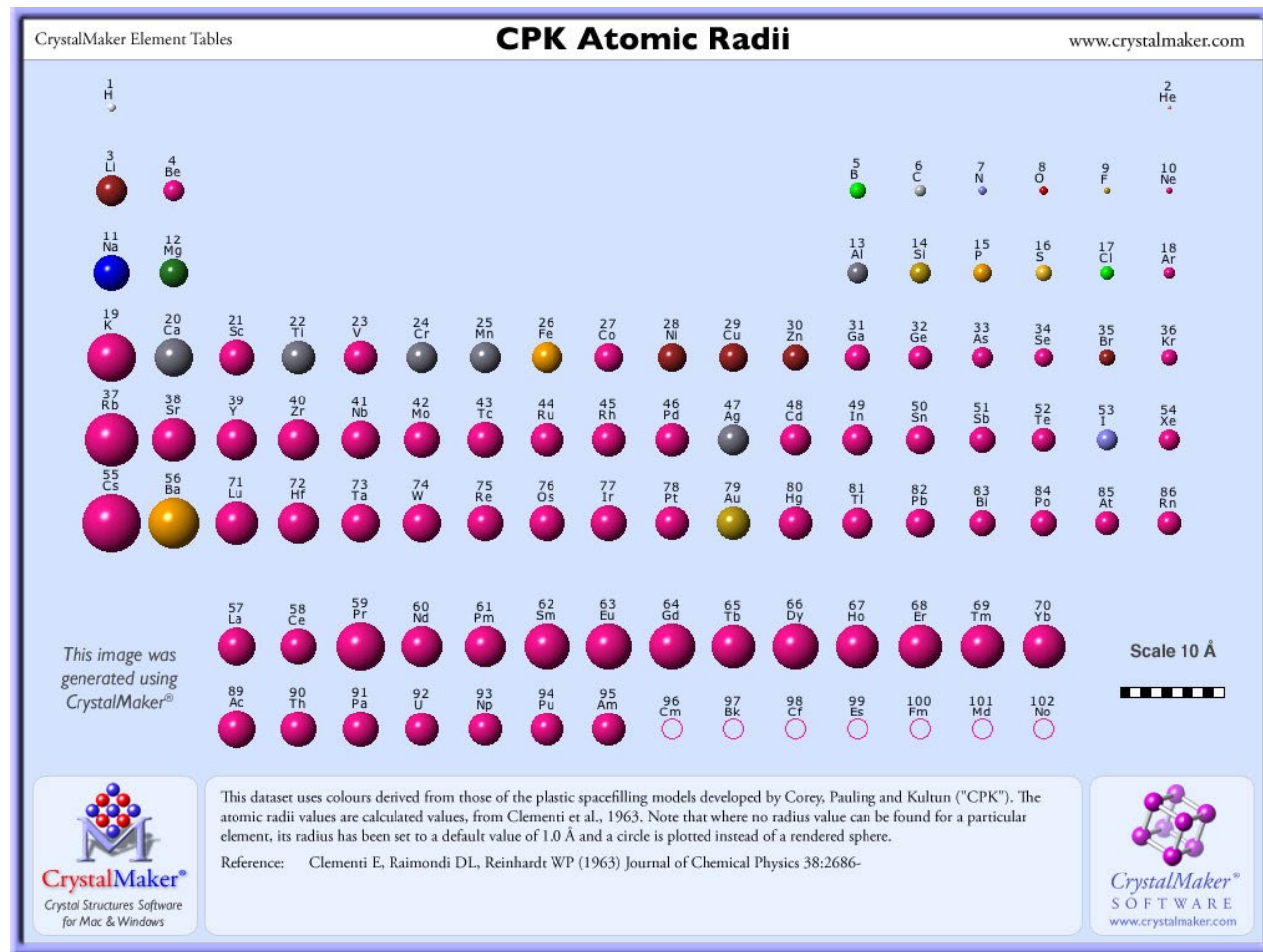
$$\alpha = 4\pi\epsilon_0 a^3 = \left(\frac{4}{3}\pi a^3\right) 3\epsilon_0 = 3\epsilon_0 V_{atom}$$

Atom	Volume* 10^{-30} m^3	Polarizability $\propto 4\pi\epsilon_0$ 10^{-30} m^3
H	2.1	0.667
He	0.5	0.205
Li	36	24.3
Ne	0.6	0.396
Na	46	24.1
Cs	156	59.6

Atomic Polarizability vs Atomic Volume



Atomic Polarizability



<https://crystallmaker.com/support/tutorials/atomic-radii/>

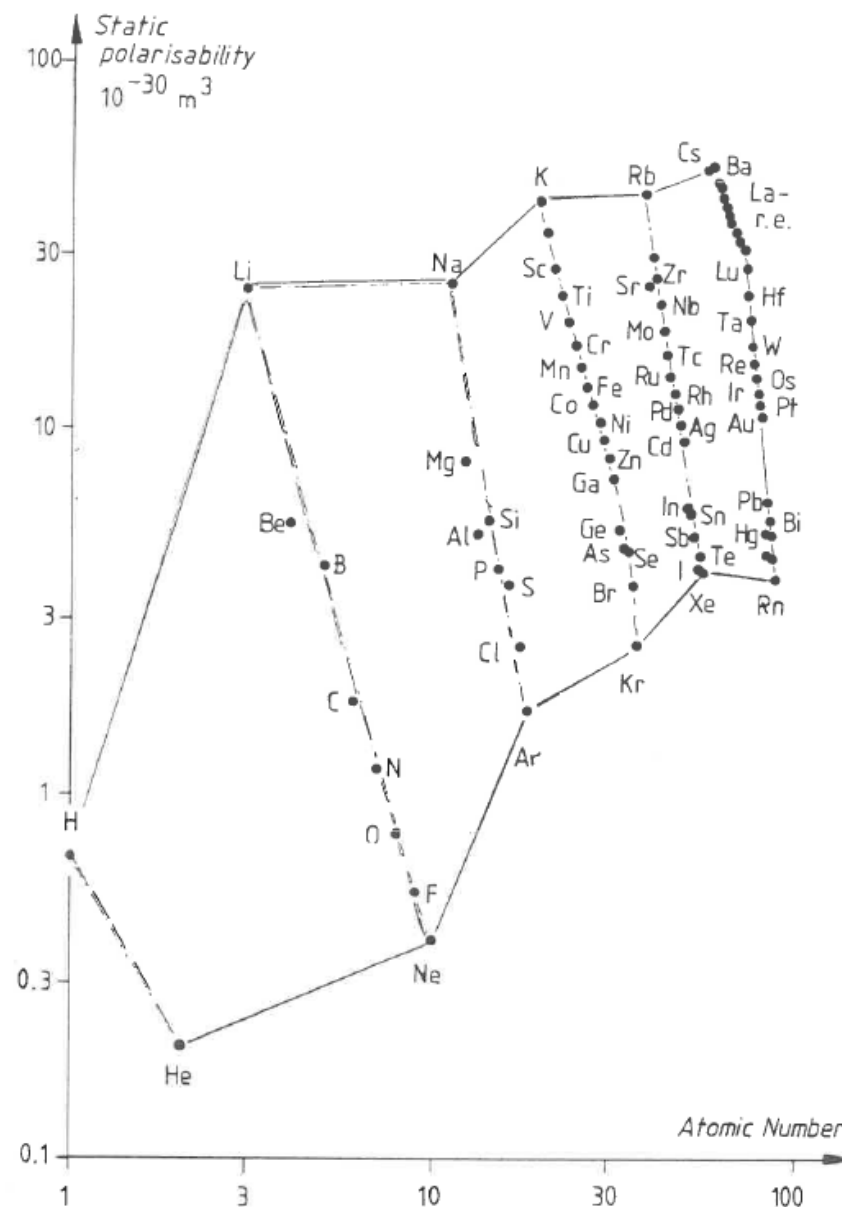
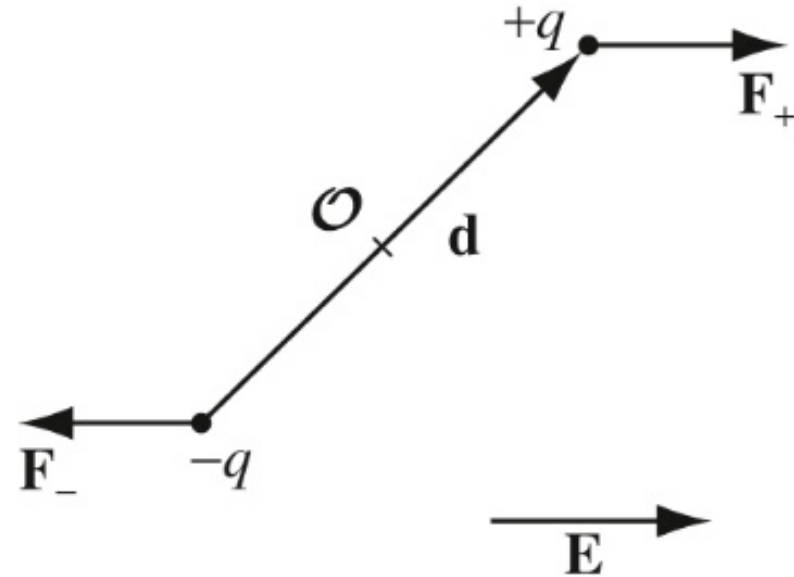
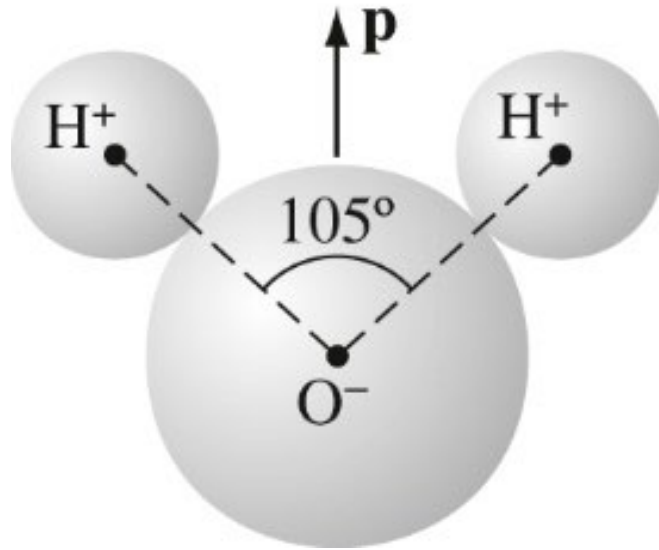


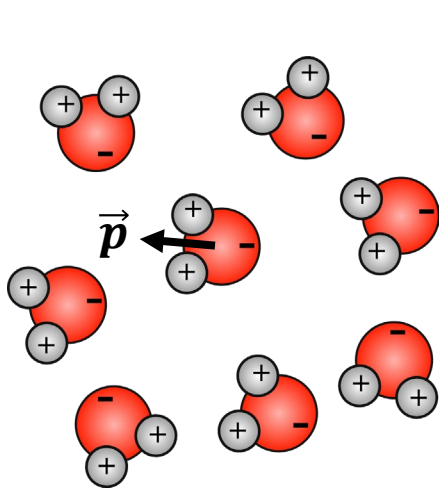
Figure 2.5 The logarithm of the static atomic polarisabilities plotted against the logarithm of the atomic number, showing the periodicity and regularity of the relationship. Data from Teachout and Pack (1971).

Electric Dipole Moment of Water Molecule

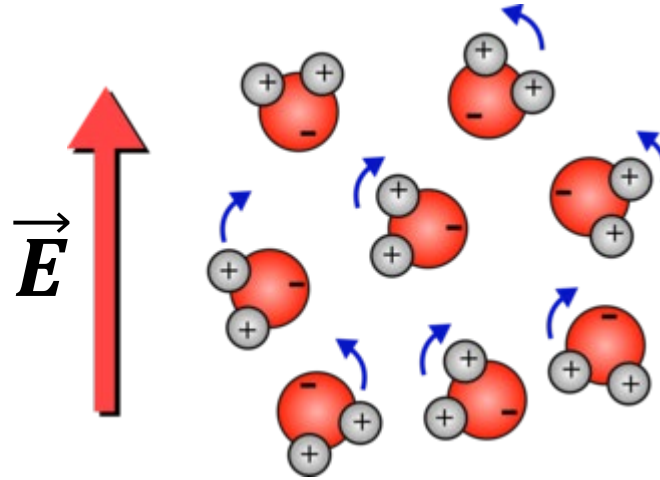
$$\vec{p} = q \vec{d}$$



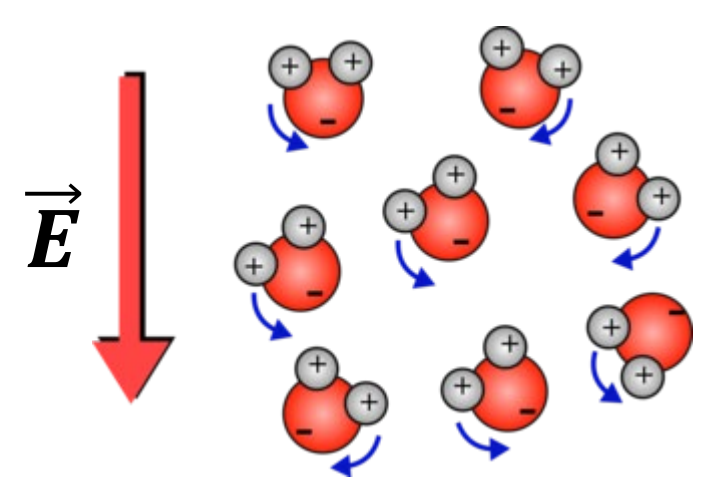
Microscopic Picture of How a Microwave Oven Works



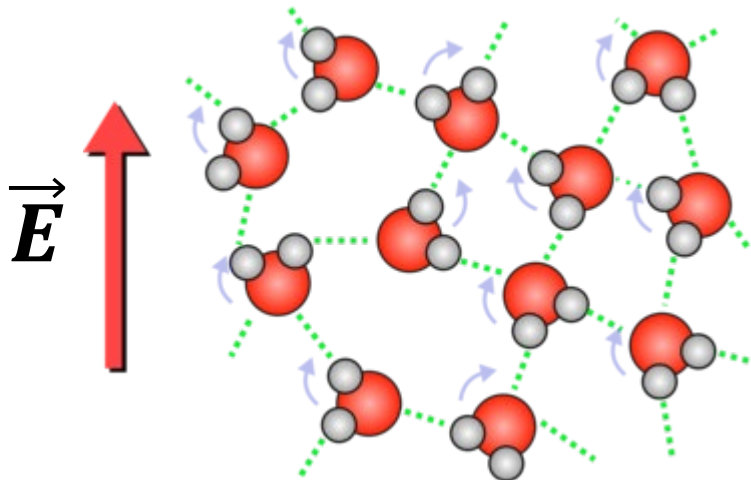
H₂O molecules in *liquid* water with random orientations for their electric dipole moments $\vec{p}$



Microwave electric field alternating at 2.45×10^9 times per second



All of this rotation transfers energy to the water and heats it up.

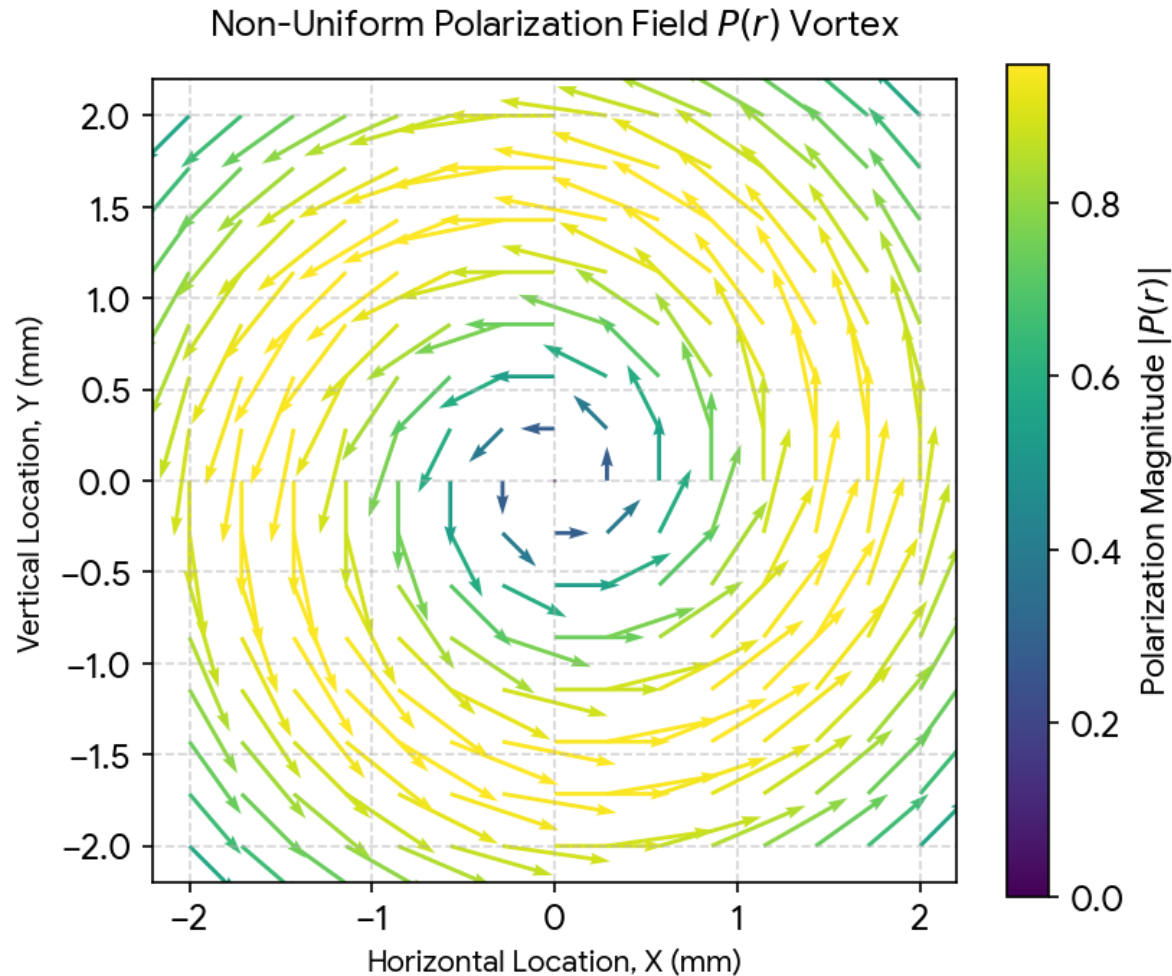


H₂O molecules in *solid* water (aka *ice*) have their electric dipoles $\vec{p}$ locked in place by the strong hydrogen bonding. Little heating!

Electric Polarization $\vec{P}$

$$\vec{P}(\vec{r}) = \frac{\textit{electric dipole moment}}{\textit{Volume}}$$

Example of a spatially-
varying electric polarization
 $\vec{P}(\vec{r})$



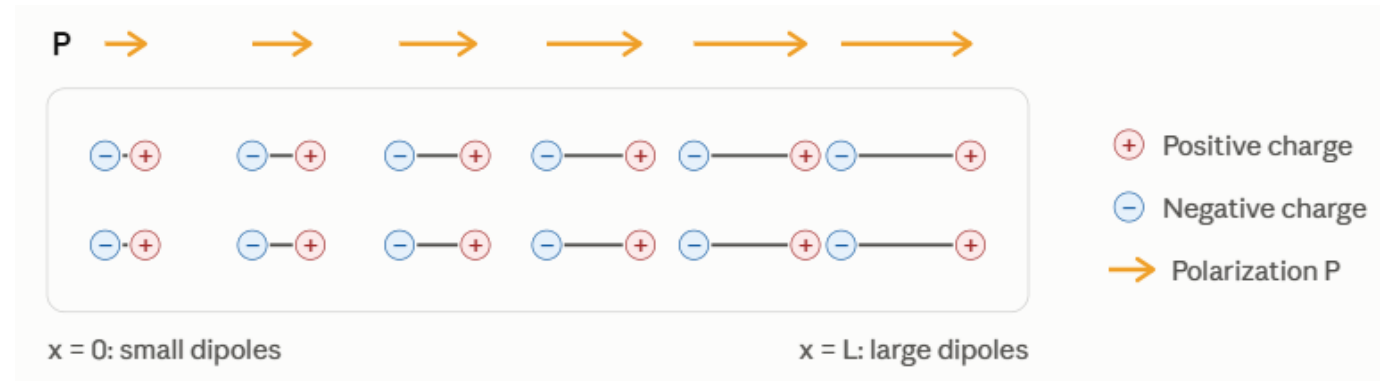
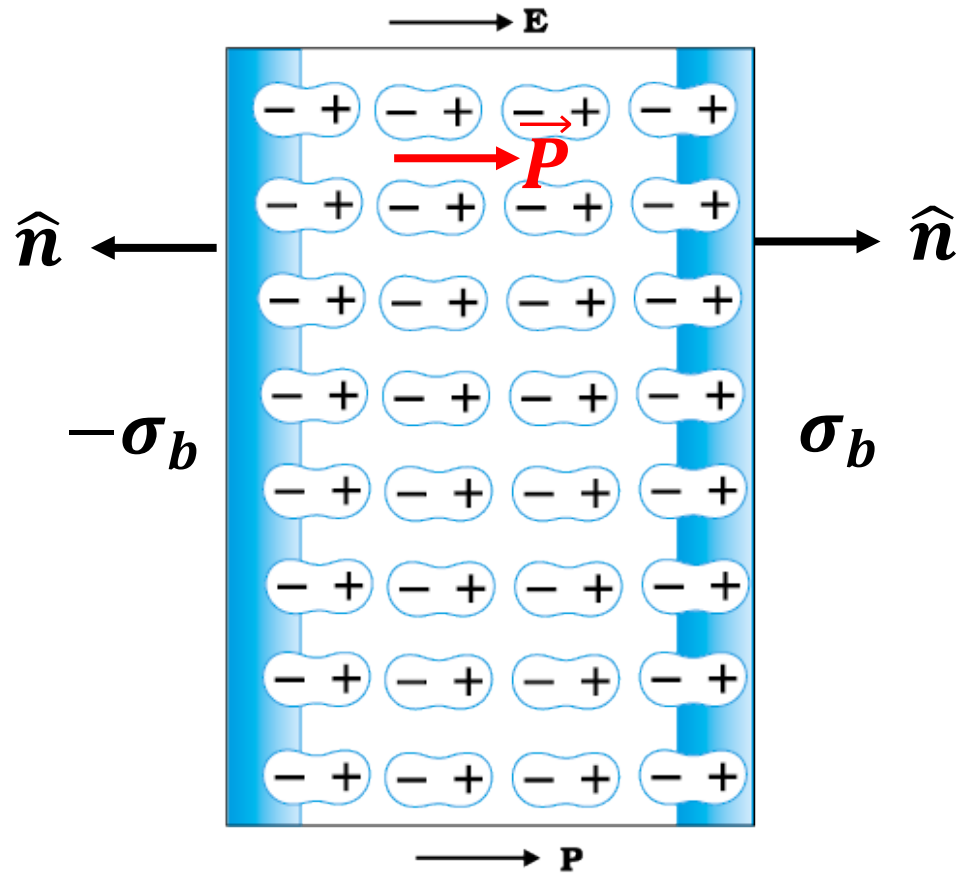
Bound Charge

$$\sigma_b = \vec{P} \cdot \hat{n}$$

surface bound charge

$$\rho_b = \vec{\nabla} \cdot \vec{P}$$

volume bound charge



$$\frac{\partial P_x}{\partial x} > 0 \text{ in this case}$$