Lecture 31 outline: 10/30/2020

- Only 13 lectures left! Ch 5 next week
- HW 8 due 11/11, HW 9 due 11/20.
  - Application – Insulated wire

  Questions:
  - What about polarizability tensor?
  - Why does torque on a dipole matter?
  - What equations apply in all circumstances?
  - How do these things get measured?
  - How do bound charges get into material. They bound!
  - Why aren't bound charges different from other charges?
  - Curl of polarization isn't zero … WHAT?
  - Isn't this just like magnetism? (Edelman)

Application: Charged wire with plastic insulator

What about polarizability tensor?

$$\vec{p} = \begin{pmatrix} \alpha_{xx} & \alpha_{xy} & \alpha_{xz} \\ \alpha_{yx} & \alpha_{yy} & \alpha_{yz} \\ \alpha_{zx} & \alpha_{zy} & \alpha_{zz} \end{pmatrix} \begin{pmatrix} E_x \\ E_y \\ E_z \end{pmatrix}$$

Why does torque on a dipole matter?

Answer 1: High dielectric materials

Answer 2: Motors!

Range of applicability of equations.

$\vec{P} = N \alpha \vec{E}$ True for gasses. Need "Clausius-Mossoti" for solids.

$\vec{P} \stackrel{\text{def}}{=} N \vec{p}$

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

$\vec{P} \stackrel{\text{def}}{=} \epsilon_0 \chi_E \vec{E}$

$\epsilon \stackrel{\text{def}}{=} \epsilon_0 (1 + \chi_E)$

$\epsilon_r \stackrel{\text{def}}{=} (1 + \chi_E)$

$\vec{D} = \epsilon \vec{E} \quad \vec{D} = \epsilon_r \epsilon_0 \vec{E}$

True for linear isotropic dielectrics

$\vec{N} = \vec{p} \times \vec{E}$

$\vec{F} = (\vec{p} \cdot \nabla) \vec{E}$

$\vec{D} = \epsilon_0 \vec{E} + \vec{P}$

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

$\rho_B = -\nabla \cdot \vec{P}$

$\nabla \cdot \vec{D} = \rho_{Free}$

True in all cases.

Q: How does dielectric constant get measured?

A: Slap some electrode on it and build
a capacitor out of it.

Q: How do bound charges get inside the dielectric?

A: They are already there, waiting for a spatially varying field.