Lecture 32 outline: 11/02/2020

- HW 8 due 11/11, HW 9 due 11/20.
- In person or remote? Wed. Remote for demos.

  Ch 4 Questions:

  - Why aren't bound charges different from other charges? (Privett)
  - Curl of polarization isn't zero … WHAT?
  - Isn't this just like magnetism? (Edelman)
  - Ch 5 Questions:

    Magnets snap together. How can you say B does no work? (Edelman)
  - What is relativistic Lorentz Force? (Smith)
  - Is f_electrostatic E? (Privett)
  - Why does Griffith's call water an insulator? (Sahd)

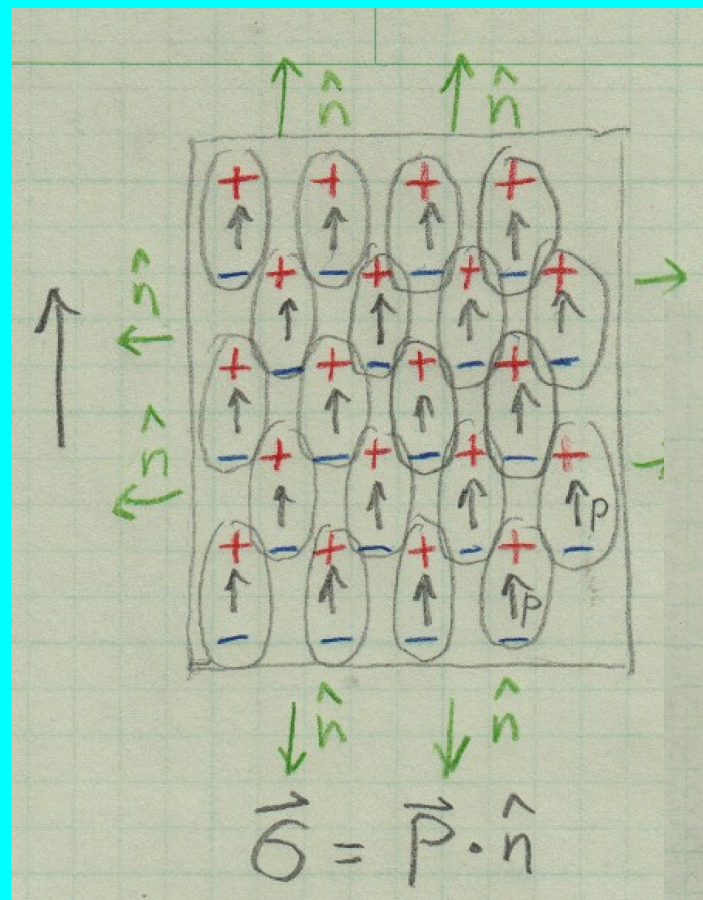
Q: Why aren't bound charges different from other charges??

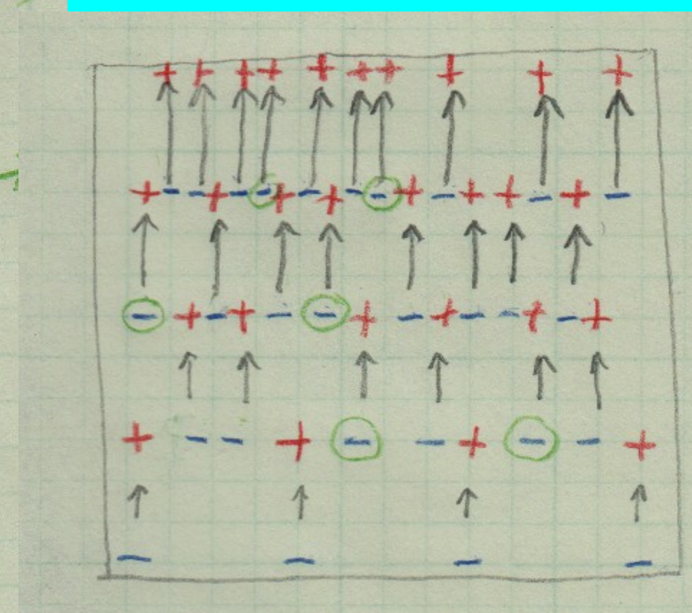
A: Because they make electric fields and exert forces on other charges

$$\nabla \cdot \vec{E} = \frac{\rho}{\epsilon_0}$$

$$\rho = \rho_{Free} + \rho_{Bound}$$

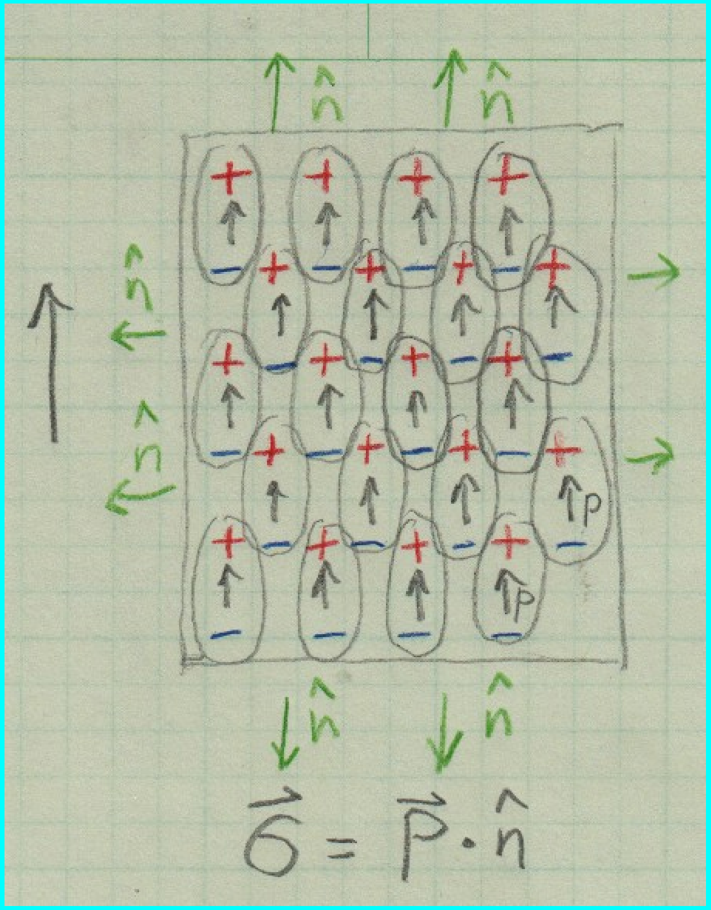
$$\rho_{Bound} = -\nabla \cdot \epsilon_0 \chi_E \vec{E}$$





Q: Curl of Polarization may be non-zero – What planet did that come from?

Consider an electret ...



Isn't this just like magnetism?

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

$\vec{M} \stackrel{\text{def}}{=} N\,\vec{m}$

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

$\vec{m} = I\,\vec{A}$

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

$\vec{M} \stackrel{\text{def}}{=} \chi_M \vec{H}$

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

$\mu \stackrel{\text{def}}{=} \mu_0 (1 + \chi_M)$

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

$\mu_r \stackrel{\text{def}}{=} (1 + \chi_M)$

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

$\vec{H} = \frac{\vec{B}}{\mu} \quad \vec{H} = \frac{\vec{B}}{\mu_r \mu_0}$

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

$\vec{N} = \vec{m} \times \vec{B}$

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

$\vec{F} = (\vec{m} \cdot \nabla)\vec{B}$

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

$\vec{H} = \vec{B}/\mu_0 - \vec{M}$

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

$\vec{K}_B = \vec{M} \times \hat{n}$

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

$\vec{J}_B = \nabla \times \vec{M}$

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

$\nabla \times \vec{H} = \vec{J}_{Free}$

Lecture 32 outline: 11/02/2020

- Maxwell's equations
- Ampere's law, source of magnetic fields.
  - Field of a wire
  - Units
- Lorentz Force, Cyclotron motion
  - e/m apparatus
- What is current?
- What is resistance and resistivity?
- What is the force on a current?

Maxwell's Equations

Gauss's Law

$$\oiint \vec{E}\cdot d\vec{a} = \frac{Q}{\epsilon_0}$$

$$\nabla\cdot\vec{E} = \frac{\rho}{\epsilon_0}$$

The "no monopole" equation

$$\oiint \vec{B}\cdot d\vec{a} = \mu_0 Q_{monopole} = 0$$

$$\nabla\cdot\vec{B} = 0$$

Ampere's Law

$$\oint \vec{B}\cdot dl = \mu_0 I$$

$$\nabla\times\vec{B} = \mu_0 \vec{J}$$

Faraday's Law

$$\varepsilon = -\frac{\partial}{\partial t}\int \vec{B}\cdot d\vec{a}$$

$$\nabla\times\vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

The “no monopole” Equation

$$\nabla \cdot \vec{B} = 0$$

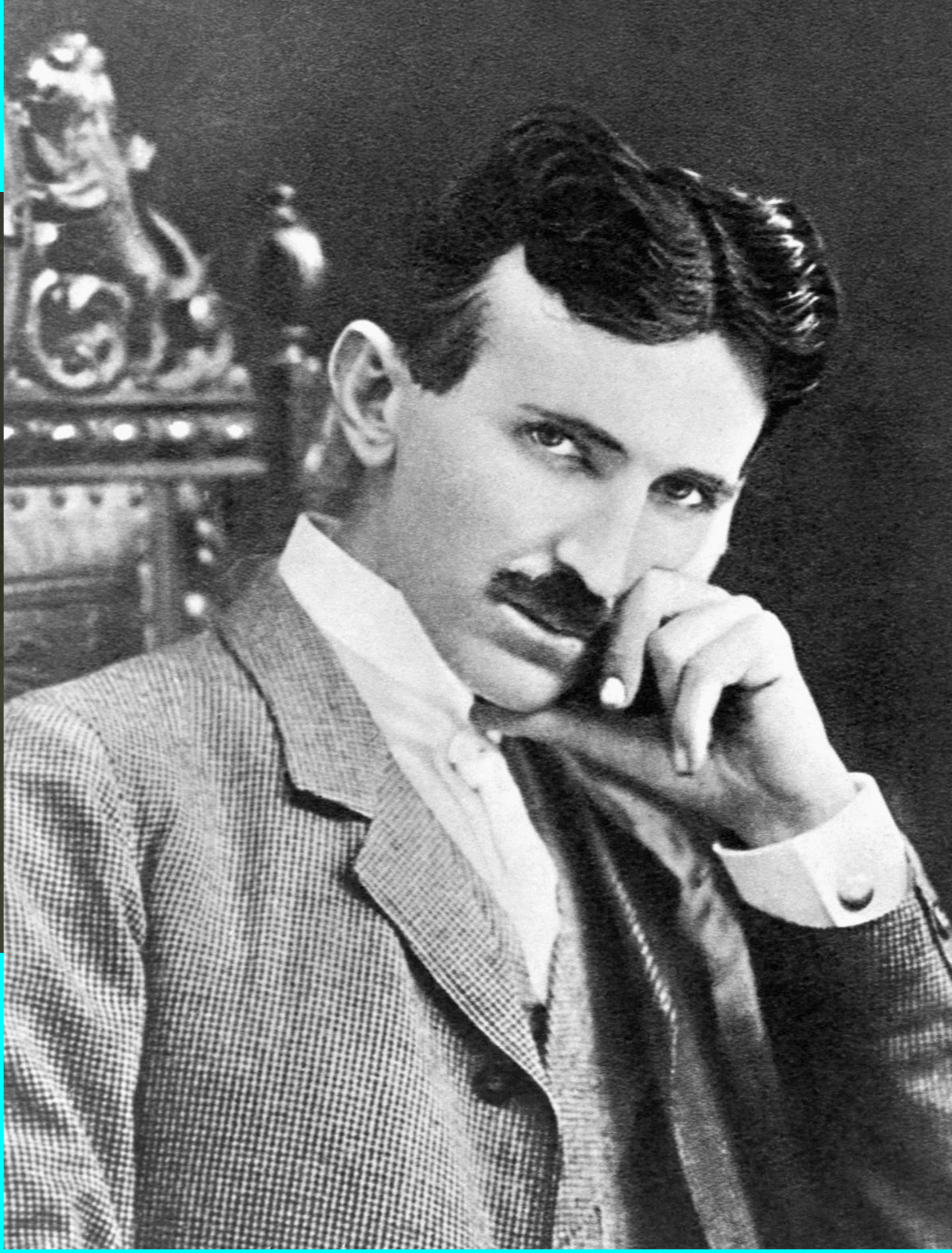
$$\oiint \vec{B} \cdot d\vec{a} = 0$$

Ampere's Law

$$\oint \vec{B} \cdot dl = \mu_0 I_{enclosed}$$

Field of a wire.

1 Tesla = 10,000 Gauss



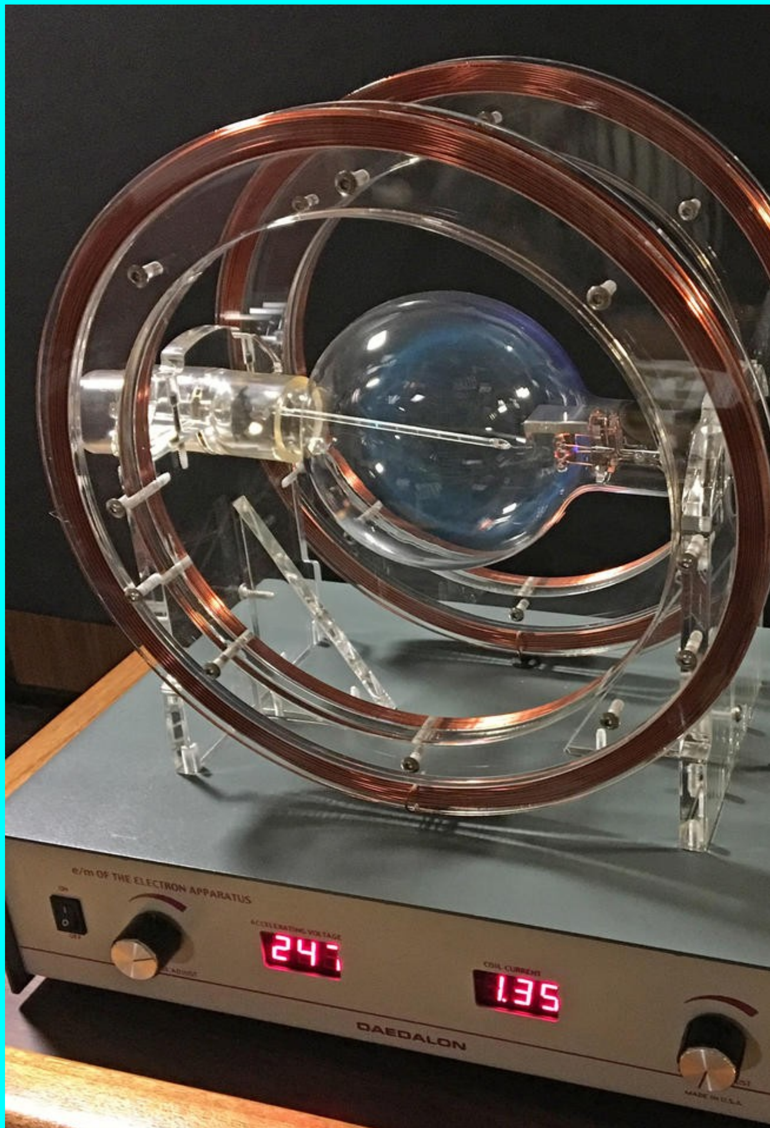
Lorentz Force

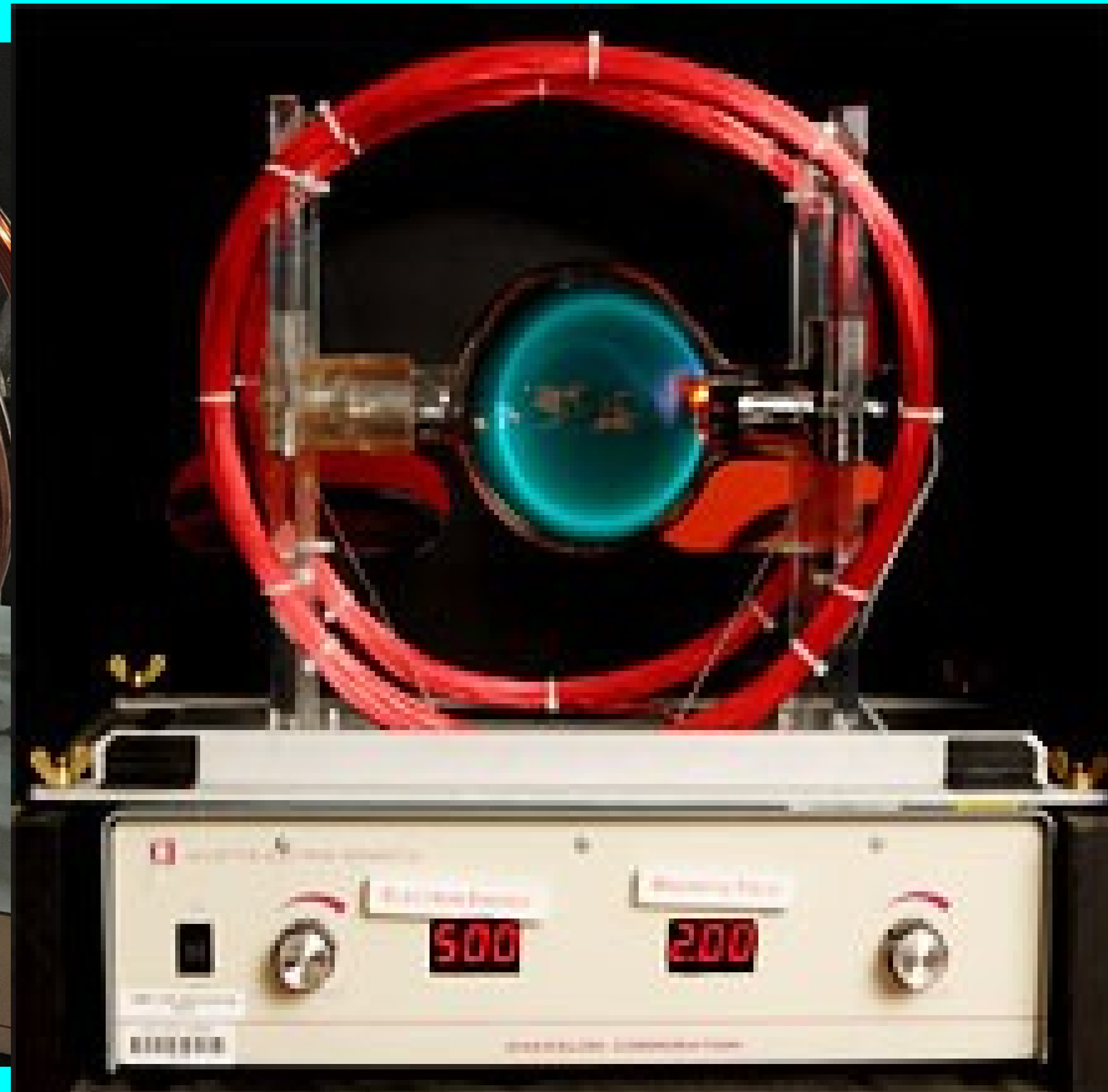
$$\vec{F} = q\vec{E} + q\vec{v} \times \vec{B}$$

B does no work?

Cyclotron motion

e/m apparatus





e/m apparatus

Cycloid motion