Electromagnetic Field Theory

Week 6

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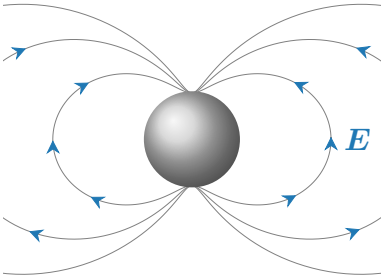
Outline

1. Energy in Electrostatics
2. Virtual Work Method
3. Forces Acting on Polarized Particle
4. Ferroelectricity



Energy of a Set of Charges

Electrostatic energy of a group of charges

$$W = \frac{1}{8\pi\epsilon_0} \sum_{\substack{i,j \\ i \neq j}} \frac{q_i q_j}{|\boldsymbol{r}_i - \boldsymbol{r}_j|}.$$

Energy

Electrostatic energy evaluated for a charge density distribution.

- From charge density

$$W = \frac{1}{8\pi\epsilon_0} \int_V \int_{V'} \frac{\rho(\boldsymbol{r})\rho(\boldsymbol{r}')}{|\boldsymbol{r} - \boldsymbol{r}'|} \,\mathrm{d}V \,\mathrm{d}V'$$

- from potential

$$W = \frac{1}{2} \int_V \rho(\boldsymbol{r})\varphi(\boldsymbol{r}) \,\mathrm{d}V,$$

item from electric field

$$W = \frac{1}{2} \int_V \varepsilon(\boldsymbol{r})|\boldsymbol{E}(\boldsymbol{r})|^2 \,\mathrm{d}V.$$

Energy in Capacitor

$$W = \frac{1}{2} C U^2$$

Virtual Work Method

Force acting in electrostatics

$$F = -\frac{\mathrm{d}W}{\mathrm{d}x}.$$

Forces Acting On a Dipole

Uniform field: Torque

$$\boldsymbol{N} = \boldsymbol{p} \times \boldsymbol{E}.$$

Non-uniform field: Torque & drift

$$\boldsymbol{N} = (\boldsymbol{p} \times \boldsymbol{E}) + (\boldsymbol{r} \times \boldsymbol{F}).$$

Electrets and Ferroelectricity

- Electrets (Permanent polarization)
- Ferroelectricity (Spontaneous polarization)
  - Ferroelectrics
  - Pyroelectrics
  - Piezoelectrics
  - ...

Questions?

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