

Energy in EM wave

Light waves carry energy but how?

Electric Fields

- Recall Capacitor Energy:

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

- Energy Density (U/Volume):

$$u_E = \frac{1}{2} \epsilon_0 E^2$$

- Average Energy Density:

$$\begin{aligned} \overline{u_E} &= \frac{1}{2} \left(\frac{1}{2} \epsilon_0 E_0^2 \right) \\ &= \frac{1}{2} \epsilon_0 E_{\text{rms}}^2 \end{aligned}$$

Magnetic Fields

- Recall Inductor Energy:

$$U = \frac{1}{2} L I^2$$

- Energy Density (U/Volume):

$$u_B = \frac{1}{2} B^2 / \mu_0$$

- Average Energy Density:

$$\begin{aligned} \overline{u_B} &= \frac{1}{2} \left(\frac{1}{2} B_0^2 / \mu_0 \right) \\ &= \frac{1}{2} B_{\text{rms}}^2 / \mu_0 \end{aligned}$$

In EM waves, E field energy = B field energy! ($\overline{u_E} = \overline{u_B}$)

$$u_{\text{tot}} = u_E + u_B = 2u_E = \epsilon_0 E_{\text{rms}}^2$$