Table of contents

Intensity (density, concentration)

Irradiance, Intensity is impact at receiver (observer in distance b):

$\mathcal{I} \equiv$ Irradiation, Intensity, "straight impact" at receiver (observer surface orthogonal to ray beam, $\mathcal{A}_b \perp R$)

$\Phi \equiv$ Power (Flux) $= \frac{W}{t} = \frac{F \cdot x}{t} = \frac{dE}{dt} = mva = pa$

$\mathcal{S} \equiv$ Poynting-Vector, Radiation

$\mathcal{A}_b \equiv$ Area surface at observer (receiver)

$\mathcal{A}_g \equiv$ Area surface at source (sender)

$\Omega_g \equiv$ Solid Angle at source (sender)

$\Omega_b \equiv$ Solid Angle at observer (receiver)

$\mathcal{J} \equiv$ Flux Density (Radiant Intensity), "angular emission" at source (sender)

$\mathcal{L} \equiv$ Radiance

$R \equiv$ Distance, ray beam length

$$\mathcal{I} = \mathcal{I}_\alpha = \langle w_{EM} \rangle \cdot c = \langle w_{EM} \cdot c_{ph} \rangle = \frac{1}{2}\frac{c}{\eta}\epsilon \mathcal{E}_0^2 = \frac{1}{2} c_{ph} \epsilon_0 \mathcal{E}_0^2 = \frac{1}{\mu_0} |\mathcal{E} \times \mathcal{B}| = \langle |\mathcal{E} \times \mathcal{B}| \rangle = \langle |\mathcal{S}| \rangle = \langle \Phi \rangle = \frac{d\Phi}{d\mathcal{A}_b} = \frac{d\Phi}{d\Omega_g} \tag{1}$$

$$\mathcal{I}_0 \overset{\mu_r=1}{=} c\epsilon_0 \left(\frac{\mathcal{E}(\vartheta)}{e^{t(\omega t - kr)}} \frac{sin(\frac{1}{2}\Delta\varphi)}{sin(\frac{N}{2}\Delta\varphi)} \right)^2 = \mathcal{I}_{A_r} + \mathcal{I}_{A_t} = \mathcal{I}_\vartheta + \mathcal{I}_\beta = \mathcal{I}_{A_t,max} = \mathcal{I}_{\beta_t,max} = \mathcal{E}_0^2 \tag{2}$$

$$\mathcal{I}_{max} \overset{\mu_r=1}{=} \mathcal{I}_{\alpha=0=\beta} = \mathcal{I}(0) = N^2 \mathcal{I}_0 \overset{\mu_r=1}{=} (N\mathcal{E}_0)^2 \tag{3}$$

Transmitted Intensity (Airy-Function) in refraction:

$$\mathcal{I}_{\beta_t} = \mathcal{I}_{A_t} = \frac{1}{1 + \frac{4a_r^2}{(1-a_r^2)^2} sin^2(\frac{\Delta\varphi}{2})} = \frac{1}{1 + \mathcal{F} \cdot sin^2(\frac{\Delta\varphi}{2})} \tag{4}$$

$$\mathcal{J}_{A_t}(\Delta\varphi) = \mathcal{E}^*\mathcal{E} = \mathcal{E}_0^2 \frac{\left(1-\left(\frac{\mathcal{E}_{0,\vartheta}}{\mathcal{E}_{0,\alpha}}\right)^2\right)^2}{\left(1-\left(\frac{\mathcal{E}_{0,\vartheta}}{\mathcal{E}_{0,\alpha}}\right)^2\right)^2} \frac{1}{1+\frac{4\left(\frac{\mathcal{E}_{0,\vartheta}}{\mathcal{E}_{0,\alpha}}\right)^2}{\left(1-\left(\frac{\mathcal{E}_{0,\vartheta}}{\mathcal{E}_{0,\alpha}}\right)^2\right)^2}\sin^2(\frac{\Delta\varphi}{2})} = \mathcal{E}_0^2 \frac{(1-a_r^2)^2}{(1-a_r^2)^2} \frac{1}{1+\frac{4a_r^2}{(1-a_r^2)^2}\sin^2(\frac{\Delta\varphi}{2})} = \mathcal{E}_0^2 \mathcal{J}_{A_t} = \tag{5}$$

$$\mathcal{J}_{\beta_t,min} = \mathcal{J}_{A_t,min} = \mathcal{J}_{A_t,max} \cdot \frac{1}{1+\frac{4a_r^2}{(1-a_r^2)^2}} = \mathcal{J}_{\beta_t,max} \cdot \frac{1}{1+\mathcal{F}} = \frac{\mathcal{E}_0^2}{1+\mathcal{F}} \tag{6}$$

Absorbed Intensitiy:

$$\mathcal{J} = \mathcal{J}_{\beta_a} = \mathcal{J}_0 e^{-al} \overset{\mu_r=1}{=} \frac{\mathcal{E}_0^2}{e^{al}} \qquad a = \text{absorbtion coefficient} \qquad l = \text{direction} \tag{7}$$

Reflected Intensity:

$$\mathcal{J}_\vartheta \overset{\mu_r=1}{=} c\epsilon_0 \langle \mathcal{E}(\vartheta)^2 \rangle = \mathcal{J}_0 \frac{sin^2\left(\frac{N}{2}\Delta\varphi\right)}{sin^2\left(\frac{1}{2}\Delta\varphi\right)} = \mathcal{J}_0 \frac{sin^2\left(N\pi\frac{d}{\lambda}sin(\vartheta)\right)}{sin^2\left(\pi\frac{d}{\lambda}sin(\vartheta)\right)} \tag{8}$$

Difracted Intensity:

$$\mathcal{J}_\theta \overset{\mu_r=1}{=} c\epsilon_0 \langle \mathcal{E}^2 \rangle = \underbrace{\mathcal{J}_0}_{Max.} \underbrace{\left(\frac{sin(\beta)}{\beta}\right)^2}_{Modulation} \underbrace{\left(\frac{sin(N\alpha)}{sin(\alpha)}\right)^2}_{Variation} \tag{9}$$

$\beta = k\frac{b}{2}sin(\theta) \qquad \alpha = k\frac{a}{2}sin(\theta)$

a = particle distance $\qquad b$ = particle size

Hypothesis:

$\left(\frac{\mathcal{J}}{R}\right)^2 = \mathcal{J} \cdot \mathcal{J}$

$\Rightarrow$ ray length (reach)

$R = \sqrt{\frac{\mathcal{J}}{\mathcal{J}}}$