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Velocity - Movement of Matter in Space and Time

Matter and Vacuum - refraction, max. phase velocity, max. group velocity

Lightspeed, max. group velocity :

$$\begin{aligned} c &= \frac{|\mathcal{E}|}{|\mathcal{B}|} = \frac{1}{\sqrt{\epsilon_0 \mu_0}} \left[\frac{F_{\mathcal{B}}}{F_{\mathcal{E}}} \right] = \frac{1}{\sqrt{\epsilon_0 \mu_0}} = \frac{\eta}{\sqrt{\epsilon \mu}} = \frac{\eta}{\sqrt{\epsilon_0 \epsilon_r \mu_0 \mu_r}} = \\ \eta \cdot c_{ph} &= \sqrt{v_{phase} \cdot v_{matter}} = \\ \frac{\omega}{k} &= \frac{\lambda}{\mathcal{J}} = \nu \lambda = -\frac{d\lambda}{d\nu} \nu^2 = \lambda^2 \frac{\mathcal{J}_\lambda}{\mathcal{J}_\nu} = \frac{\langle |\mathcal{S}| \rangle}{\langle w_{EM} \rangle} = v_{gr}^{max} \\ &\leq v_{ph} - \lambda \frac{d}{d\lambda} v_{ph} = \frac{d}{dk} \omega = v_{gr} \end{aligned} \tag{1}$$

where:

$F_{\mathcal{E}} = q\mathcal{E} \equiv$ Coulomb-Force (Electric, charge presence, localization in space)

$F_{\mathcal{B}} = q(v \times \mathcal{B}) \equiv$ Lorentz-Force (Magnetic, charge movement, localization in time)

$\left[\frac{F_{\mathcal{B}}}{F_{\mathcal{E}}} \right] = 1$

$\mathcal{J} \equiv$ Flux Density

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

$w_{EM} \equiv$ Energy Density ElectroMagnetic

$\eta \equiv$ [Refraction Index](#)

Refraction for identifying matter (property of matter):

$$\begin{aligned} \eta &\stackrel{opt.}{=} \frac{\sin(\alpha)}{\sin(\beta)} = \frac{\eta_\beta}{\eta_\alpha} \stackrel{prism}{=} \frac{\sin[\frac{1}{2}(\varpi + \varsigma_{min})]}{\sin[\frac{1}{2}\varpi]} \\ &\stackrel{phys.}{=} \sqrt{\epsilon_r \mu_r} = \frac{\lambda_\alpha}{\lambda_\beta} = \frac{v_{ph,\alpha}}{v_{ph,\beta}} = \frac{1}{2} \frac{\lambda}{d_r} \frac{n}{\cos(\beta)} = \sqrt{\left(\frac{n}{2} \frac{\lambda}{d_r} \right)^2 + \sin(\alpha)^2} \\ &\stackrel{dispersion}{=} \eta(\lambda) = \eta(\omega) \stackrel{anisotropy}{=} \eta(r) \end{aligned} \tag{2}$$

$$\text{Vacuum} \iff \eta = 1f = \text{FocalLength} \quad D = \text{RefractivePower}(\text{dioptry})$$

$n \equiv \text{order}$ (“quantum cycle”):

$$n = \frac{\nu}{c} \Delta s = \frac{\Delta \varphi}{2\pi} = 2\eta \frac{d_r}{\lambda} \sqrt{\eta^2 - \sin(\alpha)^2} = 2\eta \frac{d_r}{\lambda} \cos(\beta) = \frac{q}{e_0} \in \mathbb{N} \quad (3)$$

$$v^2 = \left(\frac{\nu \lambda}{\eta} \right)^2 = \left(\frac{\omega}{k\eta} \right)^2$$

$$\left(\frac{\eta}{c} \right)^2 = \epsilon \mu \quad \epsilon = \epsilon_0 \epsilon_r \quad \mu = \mu_0 \mu_r$$

where:

$\{\alpha, \beta\} :=$ [radiation orientation](#) angles

$d_r = r_{x+1} - r_x :=$ distance in space

$\alpha :=$ irradiation angle, incoming radiation direction, from source/sender (Einstrahlungswinkel zur Normalen auf Grenzfläche des Mediums)

$\beta :=$ refraction angle for bented transmitted radiation A_t orientation in matter (Durchstrahlungswinkel zur Normalen aus Grenzfläche ins Medium)

$\epsilon_0 :=$ Dieelectric Constant (conductiv electric charge)

$\mu_0 :=$ Magnetic Constant (permeability in vacuum)