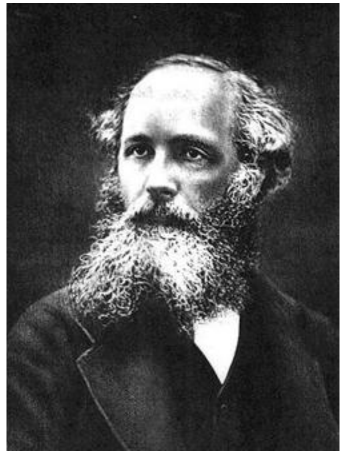
Richiami onde in mezzi omogenei, isotropi e lineari

Equazioni Maxwell nel vuoto



$$\vec{\nabla} \cdot \vec{E} = 0 \qquad \vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\vec{\nabla} \cdot \vec{B} = 0 \qquad \vec{\nabla} \times \vec{B} = \mu_o \varepsilon_o \frac{\partial \vec{E}}{\partial t}$$

Equazioni di Helmholtz

$$\nabla^2 \vec{E} = \mu_o \varepsilon_o \frac{\partial^2 \vec{E}}{\partial t^2} = -k^2 \vec{E}$$

$$\nabla^2 \vec{B} = \mu_o \varepsilon_o \frac{\partial^2 \vec{B}}{\partial t^2} = -k^2 \vec{B}$$

Scomposizione in armoniche

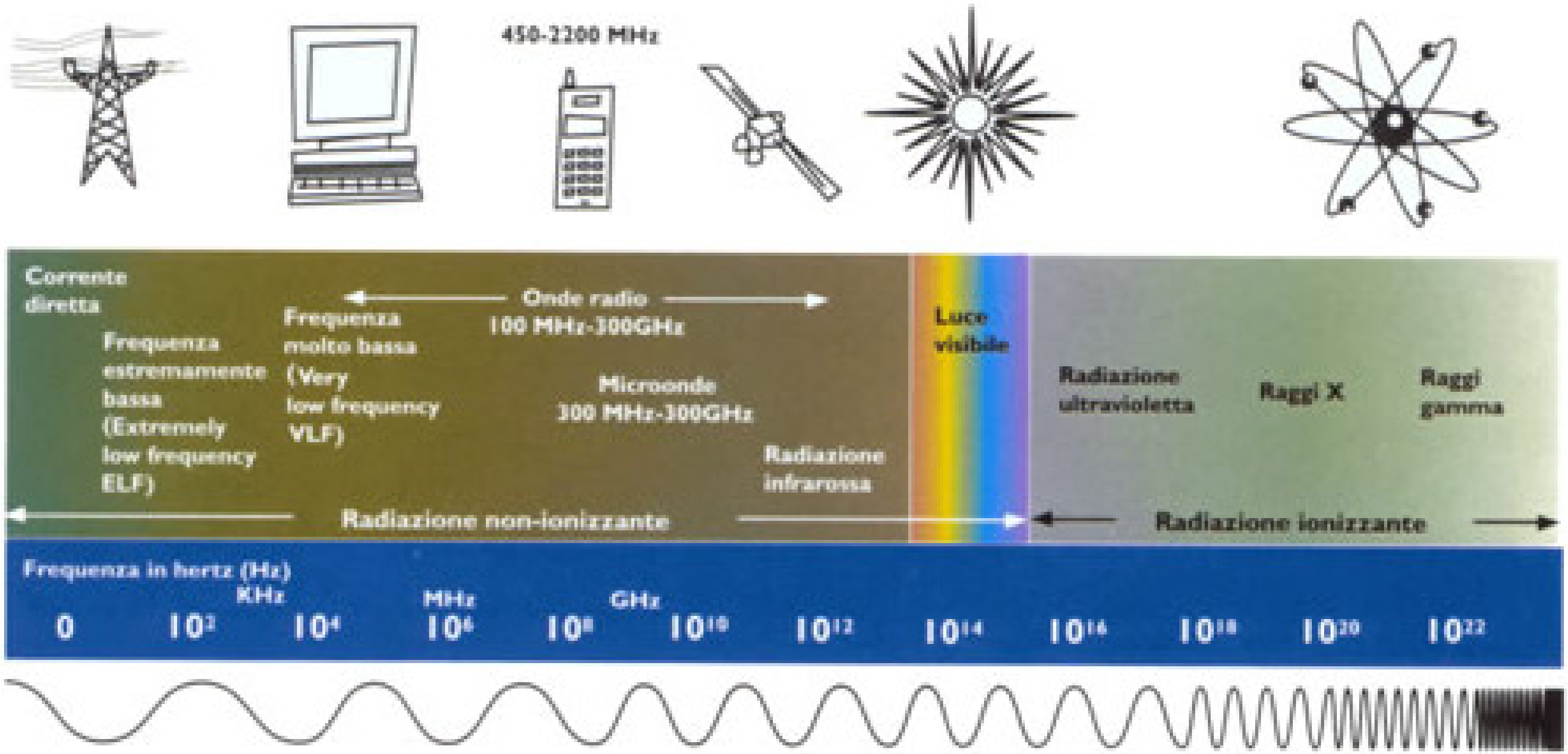
$$k = \frac{\omega}{c}$$

Relazione dispersione

$$\lambda = \frac{c}{\nu} \qquad \lambda = \frac{ch}{h\nu} = \frac{ch}{e}\frac{e}{h\nu} \qquad \lambda(nm) = \frac{1239.8}{h\nu(eV)}$$

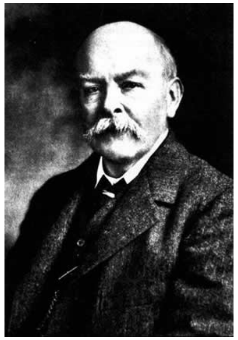
Onde elettromagnetiche

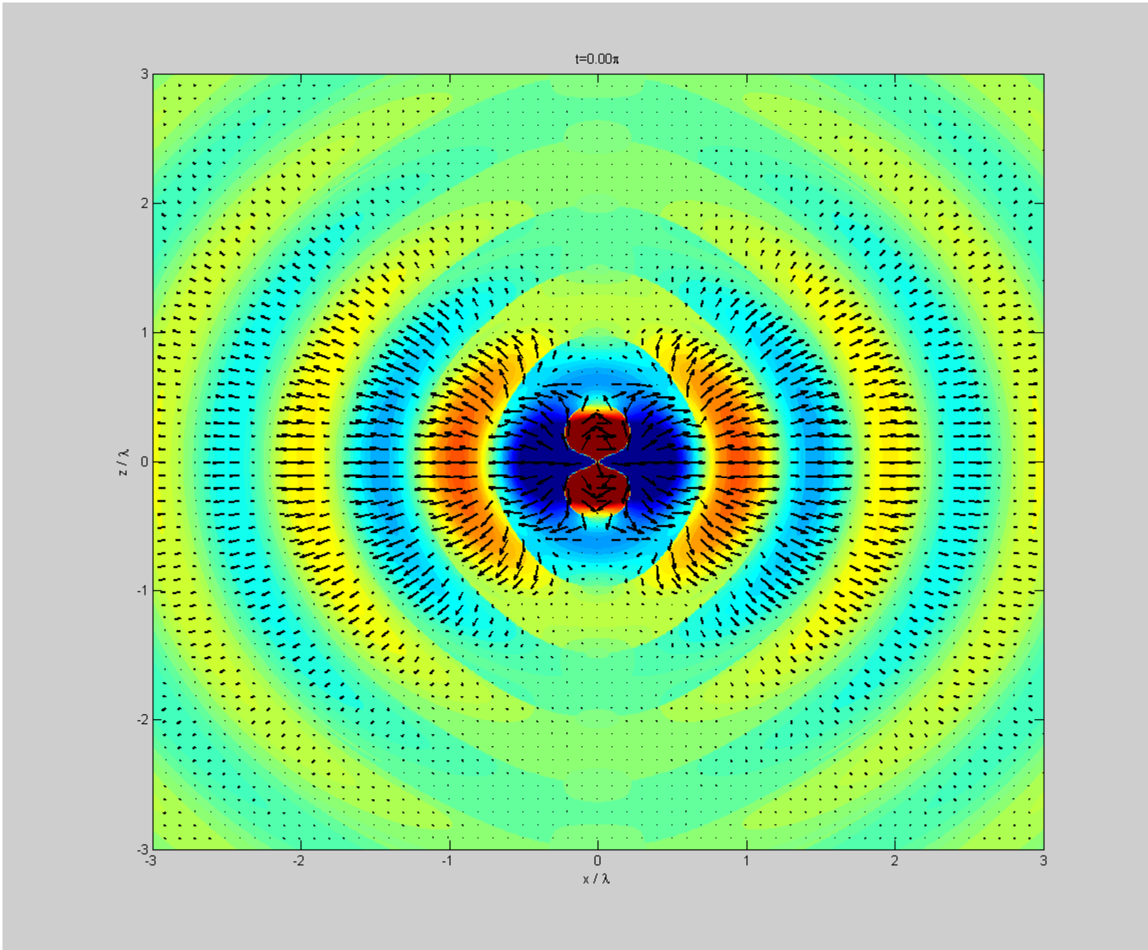
∃ ∀ ω



Vettore di Poynting

$$\vec{S} = \frac{\vec{E} \times \vec{B}}{\mu_o} = \varepsilon_o E^2 c \hat{k}$$

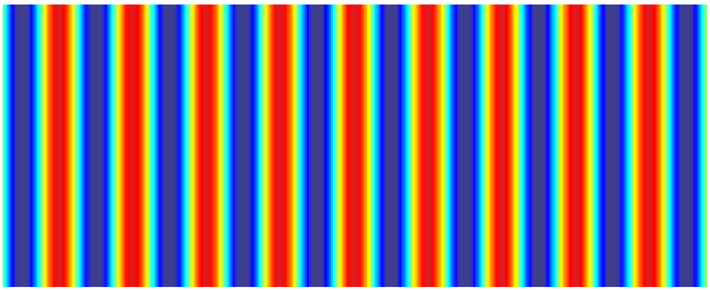


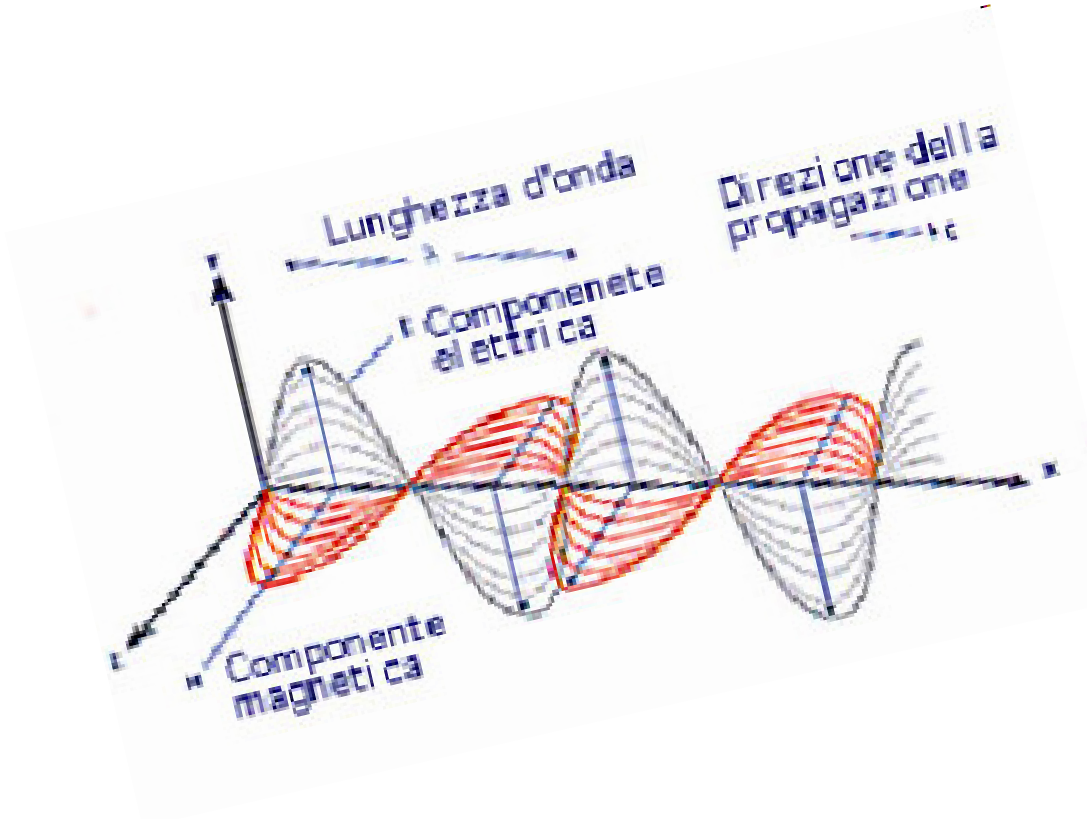


Onde piane

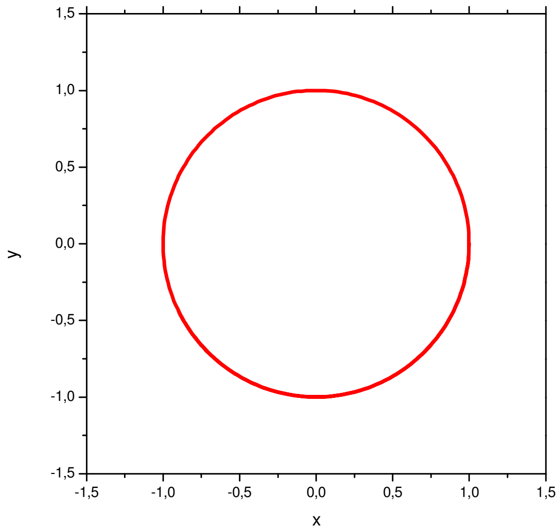
$$\vec{E} = \vec{E}_o e^{i(\vec{k}\cdot\vec{r}-\omega t)}$$

$$\vec{k}\cdot\vec{E} = 0 \qquad \vec{k}\times\vec{B} = \omega\vec{E}$$

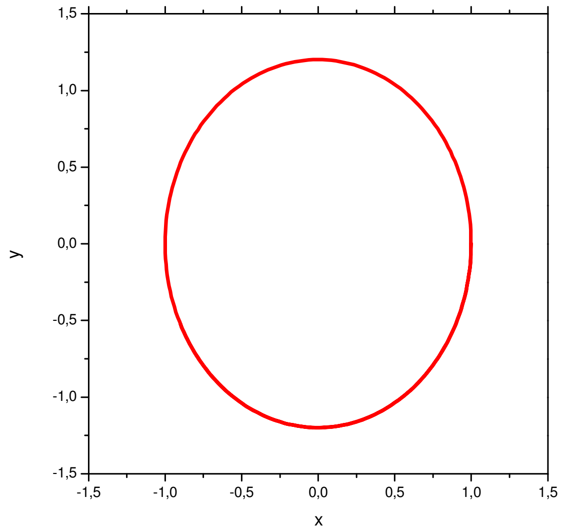




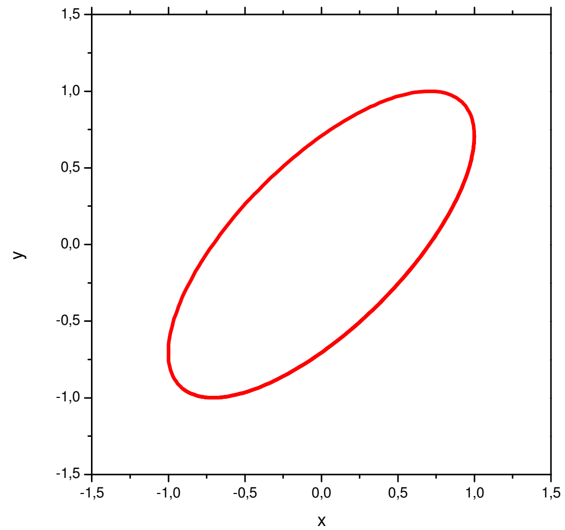
$$E_x = \cos(\omega t)$$
$$E_y = \cos(\omega t + \pi / 2)$$



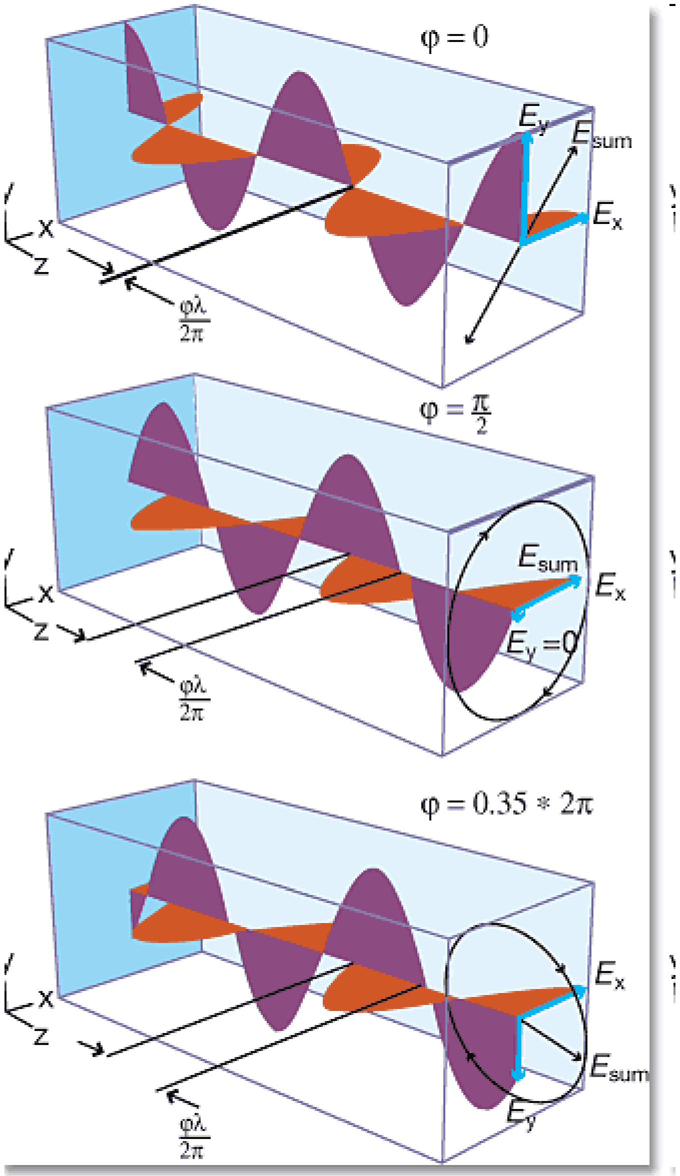
$$E_x = \cos(\omega t)$$
$$E_y = 1.2\cos(\omega t + \pi / 2)$$



$$E_x = \cos(\omega t)$$
$$E_y = \cos(\omega t + \pi / 4)$$



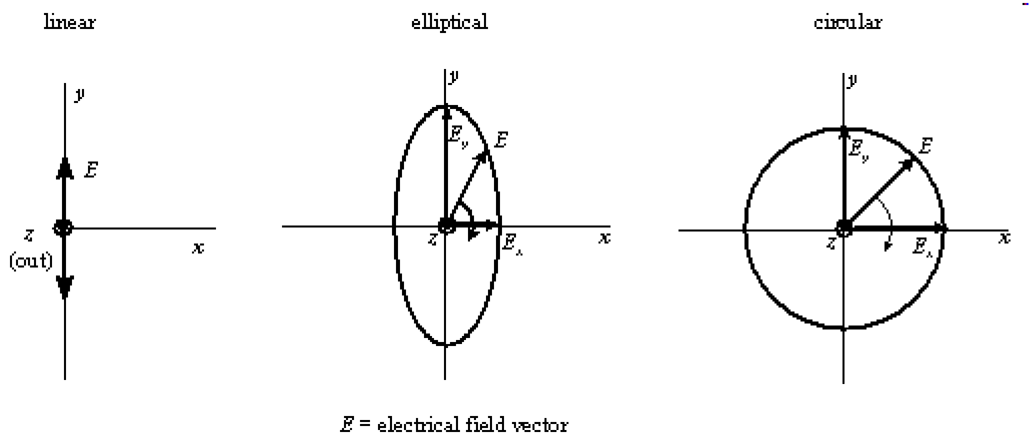
Onde piane: polarizzazione



$$\vec{E} = \vec{E}_o e^{i(\vec{k}\cdot\vec{r} - \omega t)} + c.c.$$

$$\vec{k} = k\hat{e}_z$$

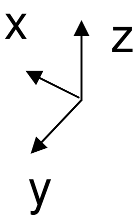
$$E_{o,x} = E_o \qquad E_{o,y} = E_o e^{i\varphi}$$

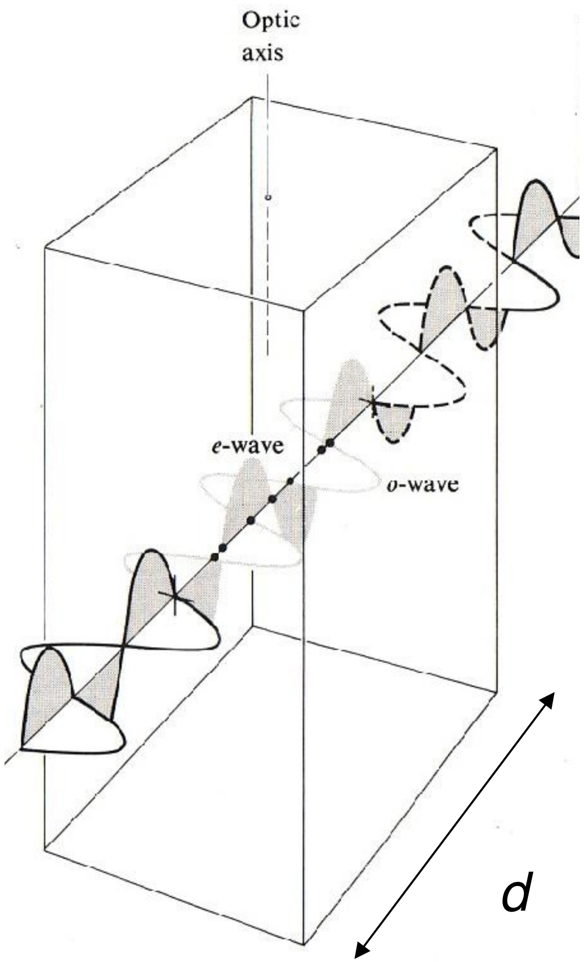


Lamine ritardanti

$$\vec{k}_e = \frac{\omega n_e}{c}\hat{e}_y$$

$$\vec{k}_o = \frac{\omega n_o}{c}\hat{e}_y$$





$$\varphi_e = \frac{\omega n_e}{c} d = \frac{2\pi n_e}{\lambda} d$$

$$\varphi_o = \frac{\omega n_o}{c} d = \frac{2\pi n_o}{\lambda} d$$

$$E_{in} = E_0\left(\hat{e}_x + \hat{e}_z\right)e^{j(ky-\omega t)}$$

$$E_{out} = E_0\left(\hat{e}_x e^{j\varphi_o} + \hat{e}_z e^{j\varphi_e}\right)e^{j(ky-\omega t)} =$$

$$= E_0\left(\hat{e}_x + \hat{e}_z e^{j(\varphi_e-\varphi_o)}\right)e^{j\varphi_o}e^{j(ky-\omega t)}$$

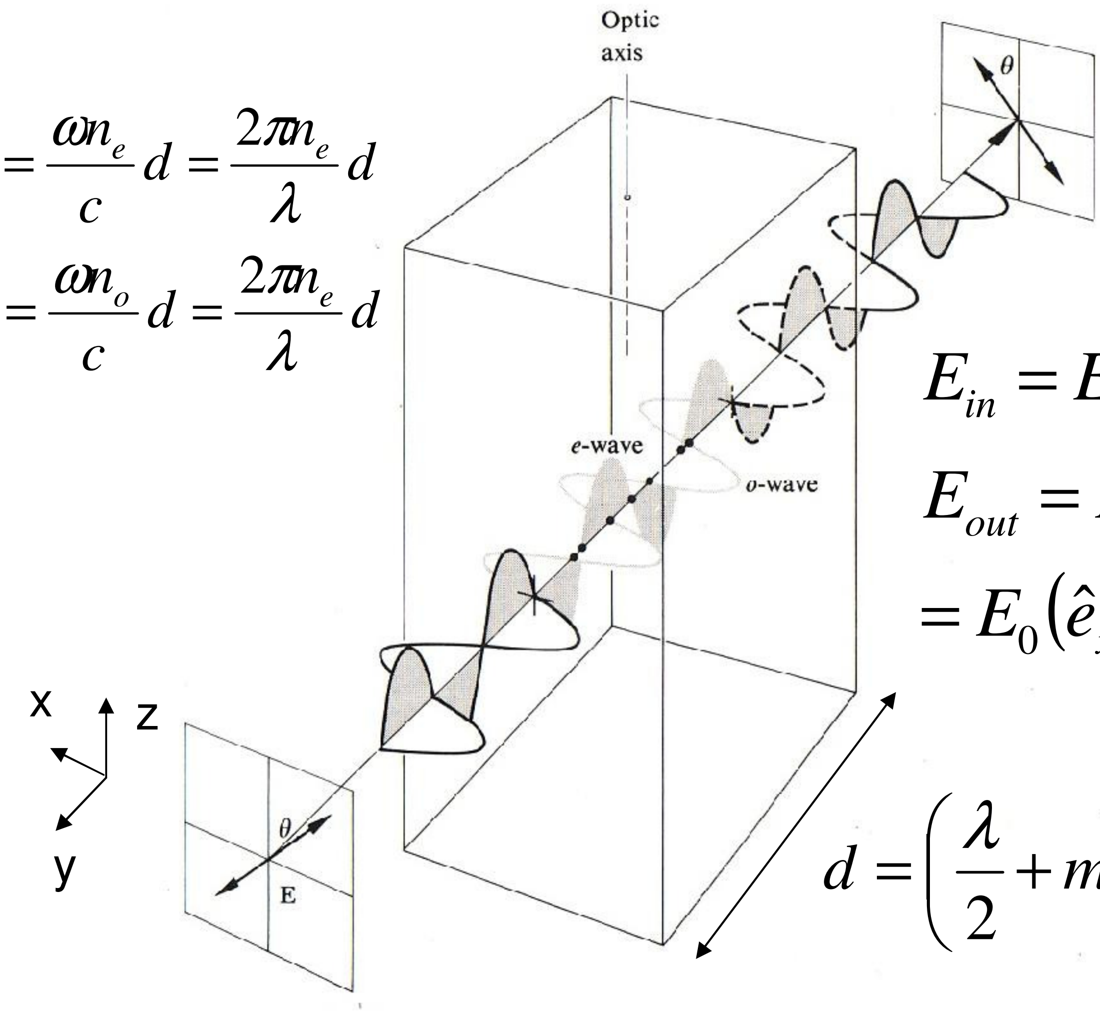
$$\varphi_e - \varphi_o = \frac{2\pi}{\lambda} d\left(n_e - n_o\right)$$

Lamine λ/2

$$\varphi_e - \varphi_o = \pi(2m+1)$$

$$\varphi_e = \frac{\omega n_e}{c} d = \frac{2\pi n_e}{\lambda} d$$

$$\varphi_o = \frac{\omega n_o}{c} d = \frac{2\pi n_e}{\lambda} d$$



$$E_{in} = E_0\left(\hat{e}_x + \hat{e}_z\right)e^{j(ky-\omega t)}$$

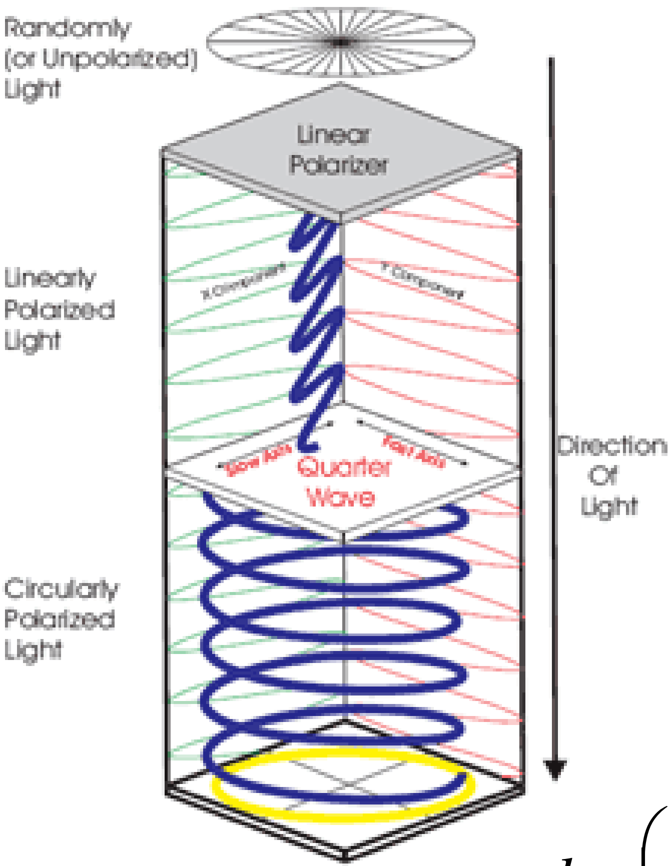
$$E_{out} = E_0\left(\hat{e}_x + \hat{e}_z e^{j\pi}\right)e^{j\varphi_o} e^{j(ky-\omega t)} =$$

$$= E_0\left(\hat{e}_x - \hat{e}_z\right)e^{j\varphi_o} e^{j(ky-\omega t)}$$

$$d = \left(\frac{\lambda}{2} + m\lambda\right)\frac{1}{n_e - n_o}$$

Lamine λ/4

$$\varphi_e - \varphi_o = \pi(2m + \frac{1}{2})$$



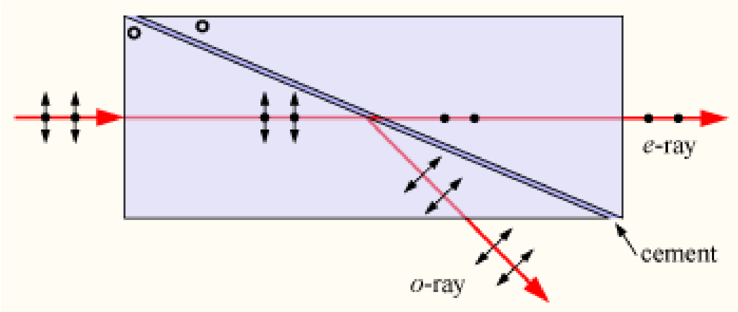
$$E_{in} = E_0(\hat{e}_x + \hat{e}_z)e^{j(ky-\omega t)}$$

$$E_{out} = E_0\left(\hat{e}_x + \hat{e}_z e^{j\frac{\pi}{2}}\right)e^{j\varphi_o}e^{j(ky-\omega t)} =$$

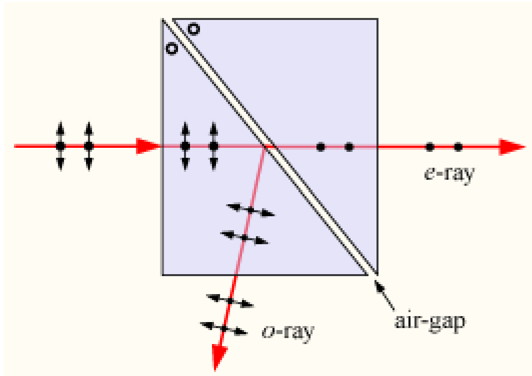
$$= E_0(\hat{e}_x + j\hat{e}_z)e^{j\varphi_o}e^{j(ky-\omega t)}$$

$$d = \left(\frac{\lambda}{4} + m\lambda\right)\frac{1}{n_e - n_o}$$

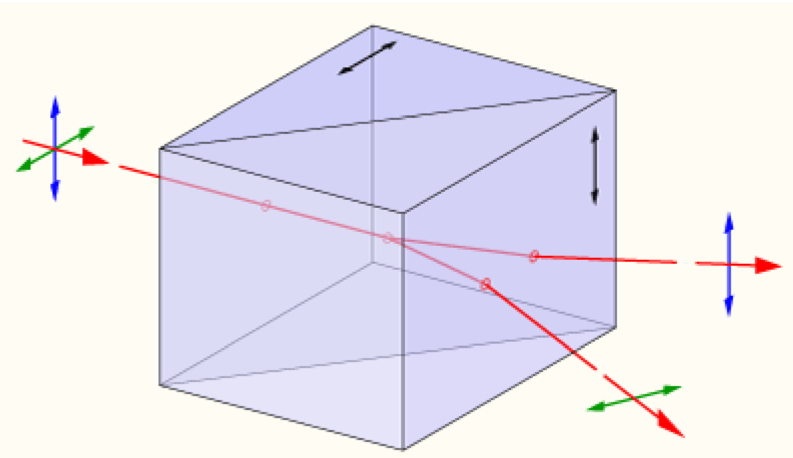
Polarizer prisms



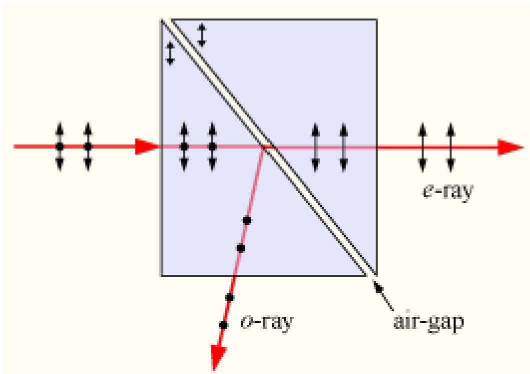
Glan Thompson



Glan Foucault



Wollaston

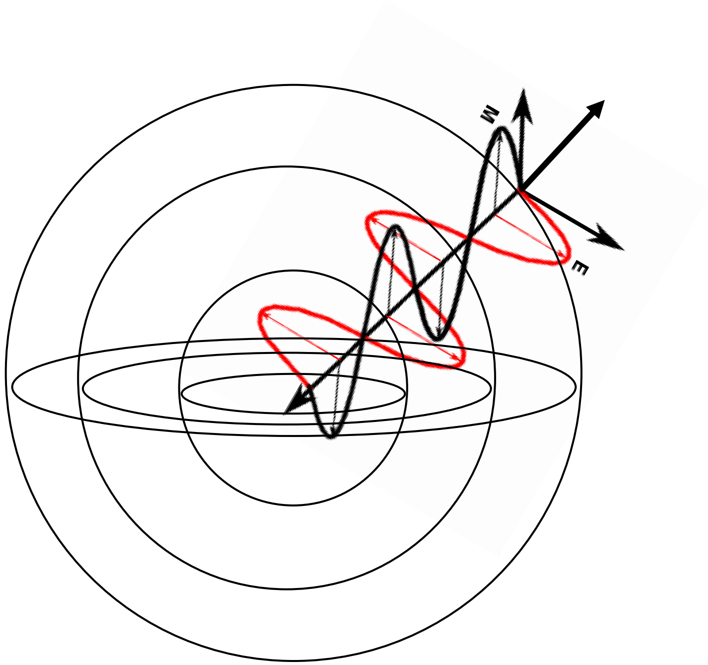


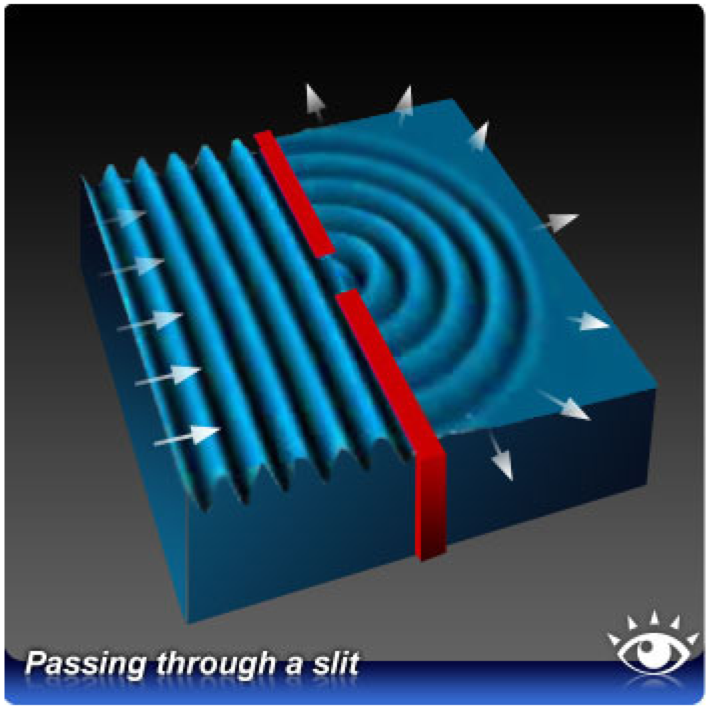
Glan Taylor

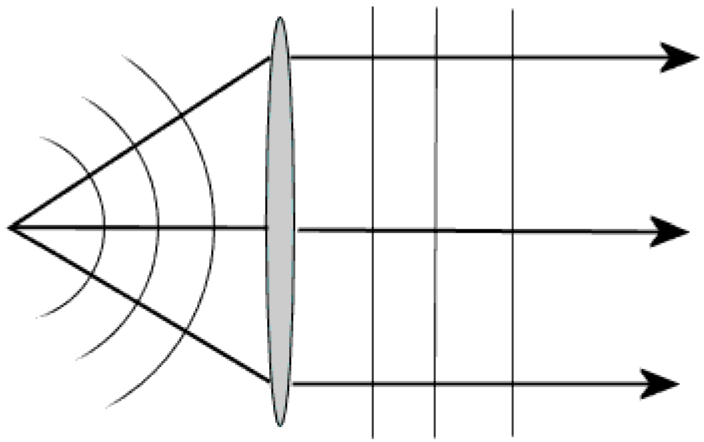
Onde sferiche

$$\vec{E} = \vec{E}_o \frac{e^{i(kr-\omega t)}}{kr}$$

$$\vec{k} \cdot \vec{E} = 0 \qquad \vec{k} \times \vec{B} = \omega \vec{E}$$




Passing through a slit



Equazioni Maxwel nella materia

$$\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\varepsilon_o} \qquad \vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\vec{\nabla} \cdot \vec{B} = 0 \qquad \vec{\nabla} \times \vec{B} = \mu_o \vec{J} + \mu_o \varepsilon_o \frac{\partial \vec{E}}{\partial t}$$

Equazioni Maxwell nella materia

$$\vec{D} = \varepsilon_o \vec{E} + \vec{P} \qquad \vec{H} = \frac{\vec{B}}{\mu_o} - \vec{M}$$

$$\vec{\nabla} \cdot \vec{D} = \rho \qquad \vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\vec{\nabla} \cdot \vec{B} = 0 \qquad \vec{\nabla} \times \vec{H} = \vec{J} + \frac{\partial \vec{D}}{\partial t}$$

Equazioni Maxwell semplificate nella materia

$$\vec{\nabla} \cdot \vec{D} = 0 \qquad \vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

Non metalli

$$\vec{\nabla} \cdot \vec{B} = 0 \qquad \vec{\nabla} \times \vec{H} = \frac{\partial \vec{D}}{\partial t}$$

$$\vec{D} = \varepsilon_o \vec{E} + \vec{P} = \varepsilon \vec{E}$$

Mezzi lineari

$$\vec{H} = \frac{\vec{B}}{\mu_o} - \vec{M} = \frac{\vec{B}}{\mu}$$

Equazioni Maxwell risemplificate nella materia

$$\vec{D} = \varepsilon_o \vec{E} + \vec{P} = \varepsilon \vec{E}$$

$$\vec{H} = \frac{\vec{B}}{\mu_o} - \vec{M} = \frac{\vec{B}}{\mu}$$

Mezzi omogenei e isotropi

$$\vec{\nabla} \cdot \vec{E} = 0 \qquad \vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\vec{\nabla} \cdot \vec{B} = 0 \qquad \vec{\nabla} \times \vec{B} = \varepsilon\mu \frac{\partial \vec{E}}{\partial t}$$

Equazioni Maxwell risemplificate nella materia

$$\vec{\nabla} \cdot \vec{E} = 0 \qquad \vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

$$\vec{\nabla} \cdot \vec{B} = 0 \qquad \vec{\nabla} \times \vec{B} = \mu\varepsilon \frac{\partial \vec{E}}{\partial t}$$

$$\nabla^2 \vec{E} = -\mu\varepsilon \frac{\partial^2 \vec{E}}{\partial t^2}$$

Equazione delle onde

$$\nabla^2 \vec{B} = -\mu\varepsilon \frac{\partial^2 \vec{B}}{\partial t^2}$$

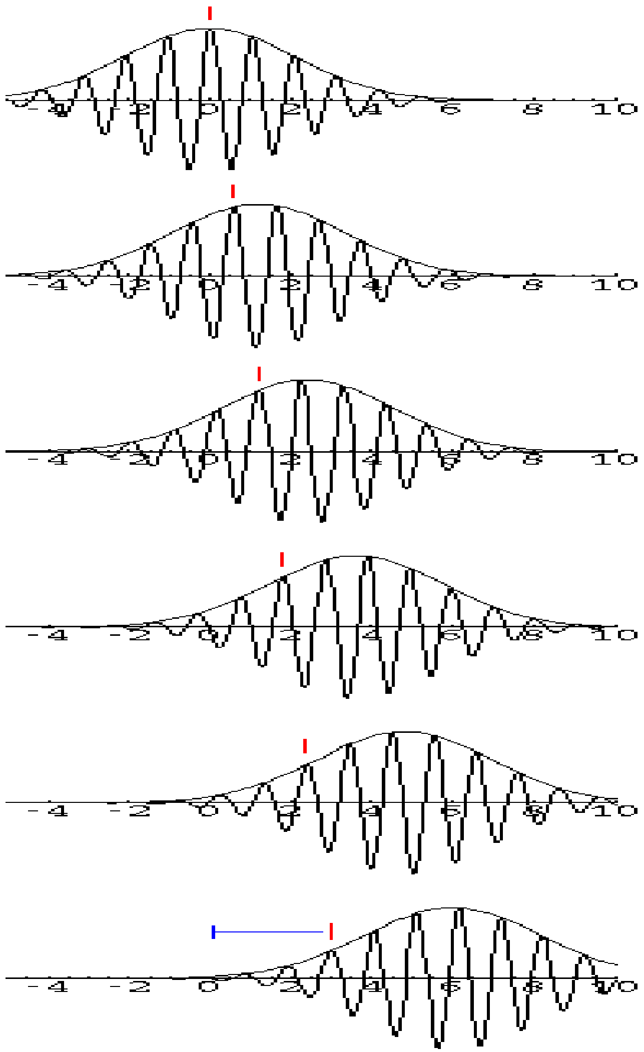
Equazioni di Helmholtz

$$\nabla^2 \vec{E} = \mu_o \varepsilon_o \frac{\partial^2 \vec{E}}{\partial t^2} = -k^2 \vec{E}$$

$$\nabla^2 \vec{B} = \mu\varepsilon \frac{\partial^2 \vec{B}}{\partial t^2} = -k^2 \vec{B}$$

$$k^2 = \frac{\omega^2 n^2}{c^2}$$ Relazione dispersione

Velocità di gruppo

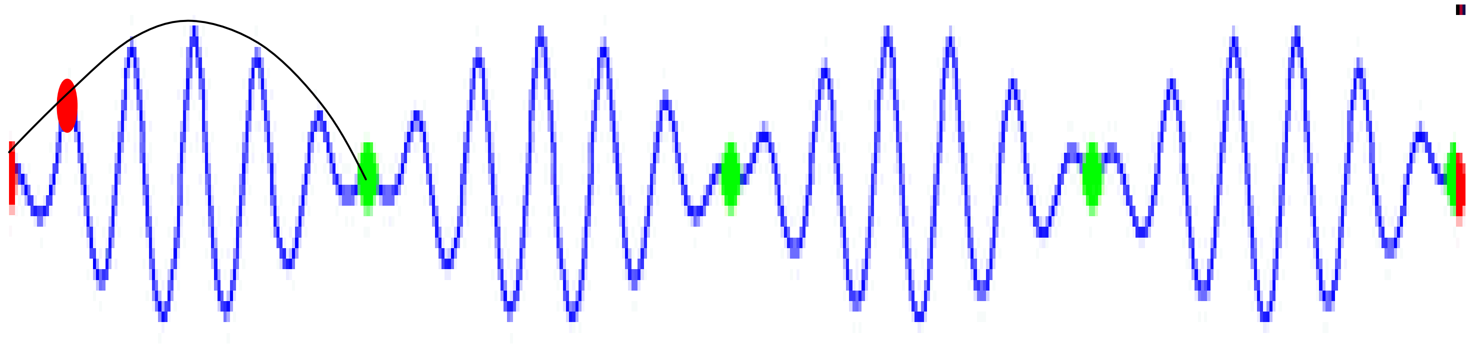


$$k = \frac{\omega n(\omega)}{c}$$

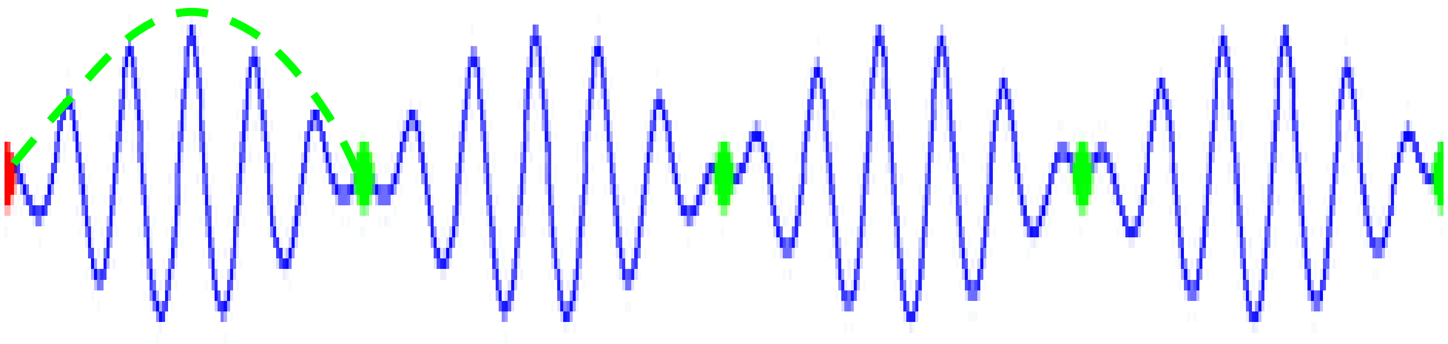
$$v_p = \frac{c}{n} \qquad v_g = \frac{d\omega}{dk}$$

$$v_g = \frac{c}{n + \omega \frac{dn}{d\omega}}$$

Velocità di gruppo

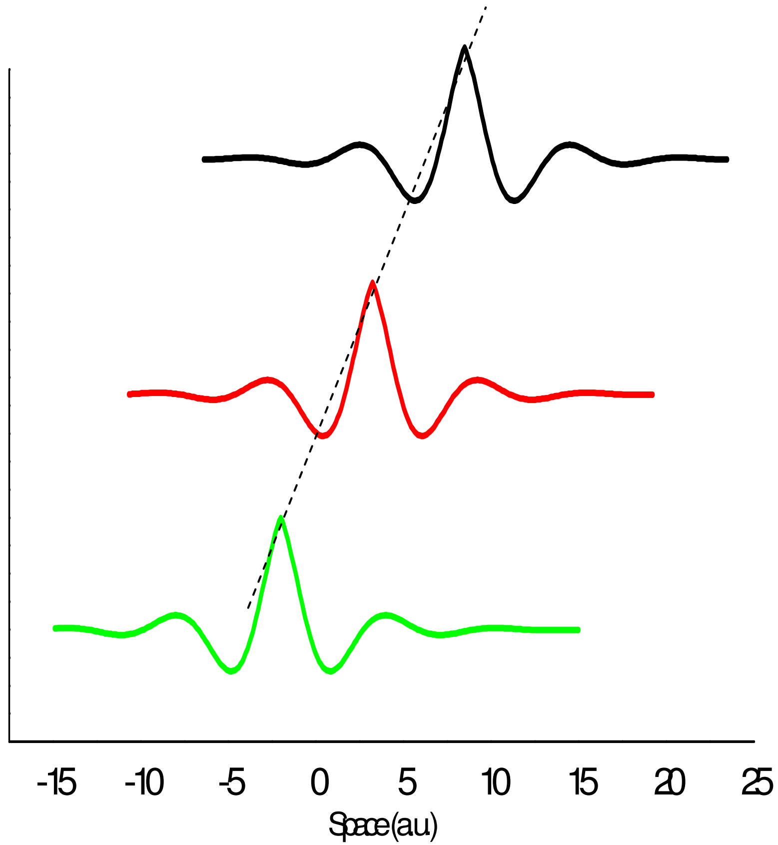


Velocità di gruppo

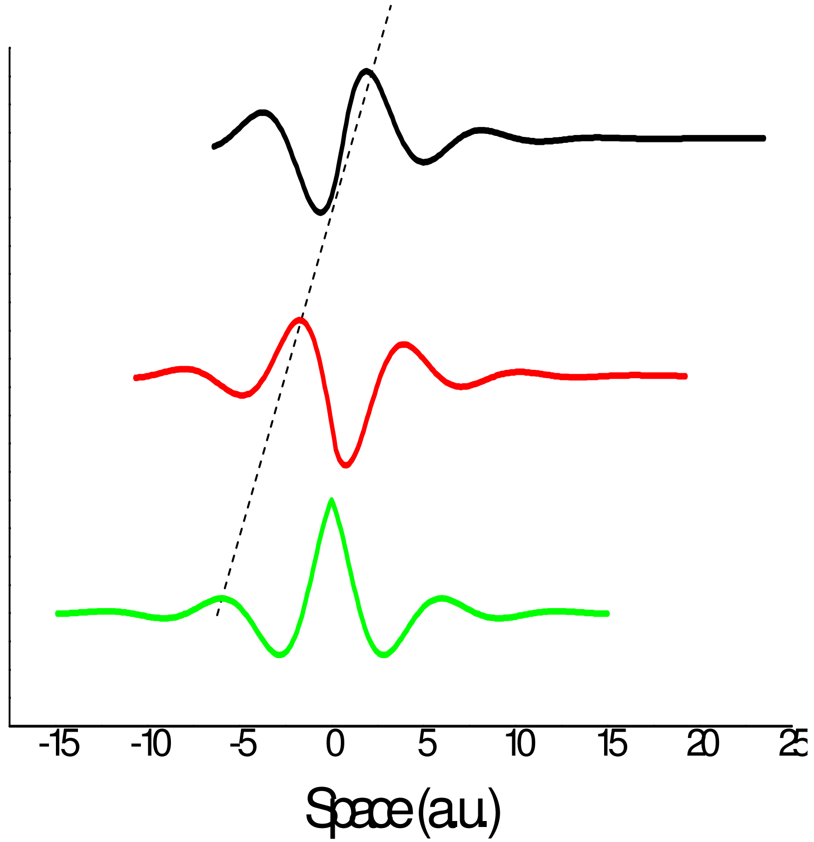


Velocità di gruppo

$$v_p = v_g$$



$$v_p \neq v_g$$



Pacchetto di 3-4 wavelets