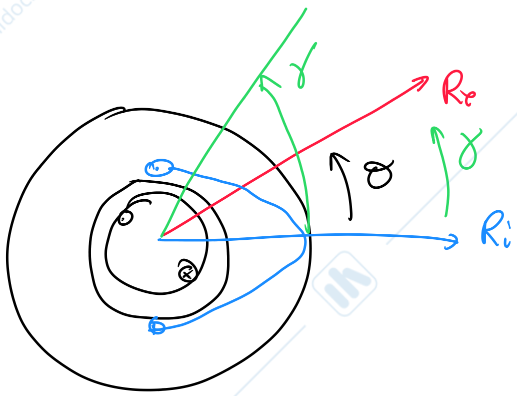
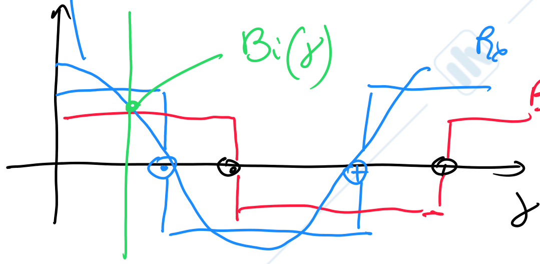


$$B_i(\gamma) = \frac{4}{\pi}\frac{N_i i_i}{2\delta}\mu_0 \cos(\gamma)$$

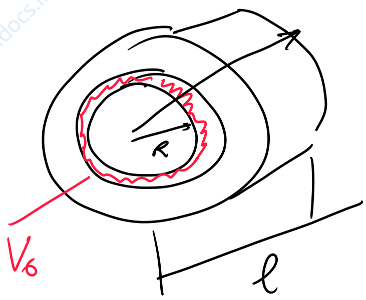
$$B_e(\gamma) = \frac{4}{\pi}\frac{N_e i_e}{2\delta}\mu_0 \cos(\gamma-\theta)$$

Ri



coenergia $\quad W^* = W$

$$T = \frac{\partial W^*}{\partial \theta} = \frac{\partial}{\partial \theta}\int_{V_0} \frac{B^2}{2\mu_0}\, dV_0$$



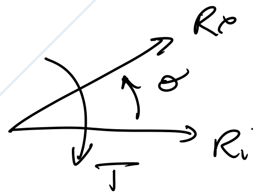
$R_{int} = R_{est} = R$

x chè traferro piccolo

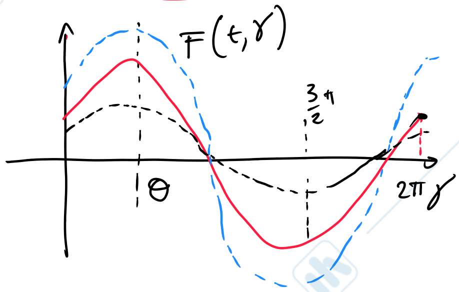
$B \simeq cost \Rightarrow \varphi_{int} = \varphi_{est} = B A_{int} = B A_{est} \qquad A_{int} \simeq A_{est}$

V0 $\qquad$ mutua ind ecc.ind

$$T = -K^* B_e B_i \sin\theta = -\underbrace{L_{ie}}_{K} i_e i_i \sin\theta$$



FASORE SPAZIALE



$$F(\gamma,t) = f(t)\cos(\theta-\gamma) \quad \cos(\gamma-\theta)$$

$$B_e(\gamma,t) = \frac{4}{\pi}\frac{N_e\, i_r(t)}{2\delta}\mu_0 \cos(\theta-\gamma)$$

$\gamma = 2\pi \quad B_e(2\pi, t)$

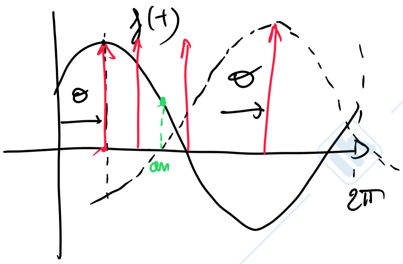
$\gamma = \frac{3}{2}\pi \quad B_e\left(\frac{3}{2}\pi, t\right) \quad \ldots$

$$\cos(x) = Re\left(e^{jx}\right) \qquad e^{jx} = \cos x + j\sin x$$

$$F(\gamma,t) = f(t)\cos(\theta-\gamma) = Re\left(f(t)\,e^{j(\theta-\gamma)}\right) = Re\left(\underbrace{f(t)\,e^{j\theta}}\,e^{-j\gamma}\right)$$

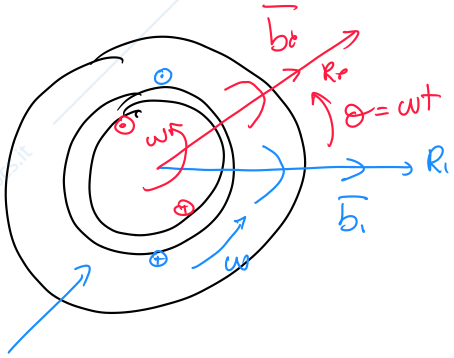
FASORE SPAZIALE $\rightarrow \bar{f}$

$$F(\gamma,t) = f(t)\cos(\theta-\gamma) \rightarrow F(\gamma,t) = Re\Big(\underbrace{f(t)\,e^{j\theta}}_{\bar{f}\,=\,\text{FASORE SP.}}\,e^{-j\gamma}\Big)$$ angolo



$$v(t) = V_M\cos(\omega t+\varphi) = Re\Big(\overbrace{V_M\,e^{j\varphi}}^{\bar{V}}\,e^{j\omega t}\Big)$$

$$V_M = \sqrt{2}\,V$$

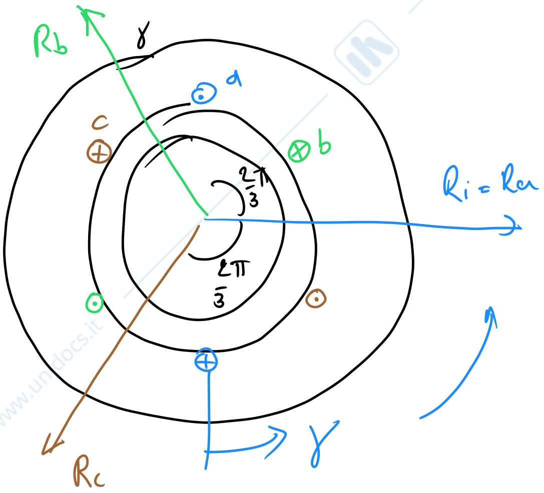


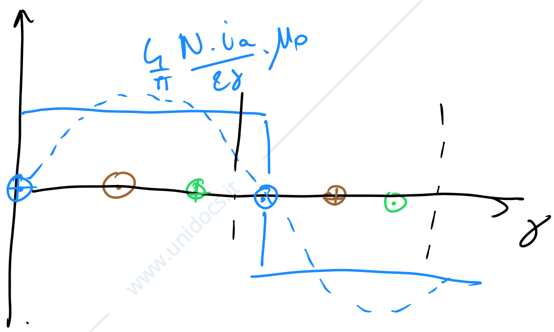
$$B_i(t,\gamma) = \frac{4}{\pi}\frac{N_i\, i_i(t)}{2\delta}\mu_0\cos(\gamma)$$

$$B_r(t,\gamma) = \frac{4}{\pi}\frac{N_r\, i_r(t)}{2\delta}\mu_0\cos(\theta-\gamma)$$

$$\bar{b}_r = \frac{4}{\pi}\frac{N_r\, i_r(t)}{2\delta}\mu_0\, e^{j\theta} = \frac{4}{\pi}\frac{N_r\, i_r(t)}{2\delta}\mu_0\, e^{j\omega t}$$

$$\bar{b}_i = \frac{4}{\pi}\frac{N_i\, i_i(t)}{2\delta}\mu_0\, e^{j0}$$





$$i_a(t) = I_M\cos\omega t$$

$$i_b(t) = I_M\cos\left(\omega t-\frac{2\pi}{3}\right)$$

$$i_c(t) = I_M\cos\left(\omega t+\frac{2\pi}{3}\right)$$

$$B_a(t,\gamma) = \frac{4}{\pi}\frac{N \cdot i_a(t)}{2\delta}\mu_0 \cos(\gamma+0) = \dots \cos(-\gamma) \quad \mathbb{R} \equiv \mathbb{R}_a \Leftarrow \gamma=0$$

$$B_b(t,\gamma) = \frac{4}{\pi}\frac{N i_b(t)}{2\delta}\mu_0 \cos\left(\gamma-\frac{2}{3}\pi\right) = \frac{4}{\pi}\frac{N i_b(t)}{2\delta}\mu_0 \cos\left(\frac{2}{3}\pi-\gamma\right)$$

$$B_c(t,\gamma) = \frac{4}{\pi}\frac{N i_c(t)}{2\delta}\mu_0 \cos\left(\gamma+\frac{2}{3}\pi\right) = \frac{4}{\pi}\frac{N i_c(t)}{2\delta}\mu_0 \cos\left(-\frac{2}{3}\pi-\gamma\right)$$

$$B_a(t,\gamma) = Re\left(\frac{4}{\pi}\frac{N i_a(t)}{2\delta}\mu_0 e^{j0} e^{-j\gamma}\right) \Rightarrow \bar{b}_a = \frac{4}{\pi}\frac{N i_a(t)}{2\delta}\mu_0 e^{j0}$$

$$B_b(t,\gamma) = Re\left(\frac{4}{\pi}\frac{N i_b(t)}{2\delta}\mu_0 e^{j\frac{2}{3}\pi} e^{-j\gamma}\right)$$

$$B_c(t,\gamma) = Re\left(\frac{4}{\pi}\frac{N i_c}{2\delta}\mu_0 e^{-j\frac{2}{3}\pi} e^{-j\gamma}\right) \Rightarrow \bar{b}_c = \frac{4}{\pi}\frac{N i_c(t)}{2\delta}\mu_0 e^{-j\frac{2}{3}\pi}$$

$$B_{TOT}(t,\gamma) = B_a(t,\gamma) + B_b(t,\gamma) + B_c(t,\gamma)$$

$$= R_e\left(\frac{4}{\pi}\frac{N\, i_a(t)}{2\delta}\mu_0 e^{j0} e^{-j\gamma}\right) + R_e\left(\frac{4}{\pi}\frac{N\, i_b(t)}{2\delta}\mu_0 e^{j\frac{2}{3}\pi} e^{-j\gamma}\right) + \dots$$

$$= R_e\left(\frac{4}{\pi}\frac{N}{2\delta}\mu_0\left(i_a e^{j0} + i_b e^{j\frac{2}{3}\pi} + i_c e^{-j\frac{2}{3}\pi}\right) e^{-j\gamma}\right)$$

$\alpha = e^{j\frac{2}{3}\pi}$

$\alpha^2 = e^{j\frac{4}{3}\pi} = e^{-j\frac{2}{3}\pi}$

$$B(t,\gamma) = R_e\left(\frac{4}{\pi}\frac{N}{2\delta}\mu_0 \Big(\underbrace{i_a(t)\cdot 1 + i_b(t)\,\alpha + i_c(t)\cdot\alpha^2}_{\bar{i}}\Big) e^{-j\gamma}\right)$$

$\bar{i}$ = FASORE SPAZIALE CORR. (NATURALE)

$$\bar{i} = \underbrace{i_a \cdot 1 + i_b\,\alpha + i_c\,\alpha^2}_{\text{valori istantanei!!}} \qquad \alpha = e^{j\frac{2}{3}\pi},\ \alpha^2 = e^{-j\frac{2}{3}\pi}$$

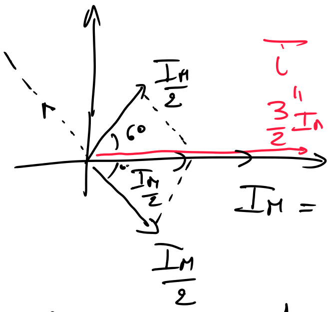
$i_a + i_b + i_c = 0$ se equilibrato

$i_a = I_M \cos\omega t = I_M$

$i_b = I_M \cos\left(\omega t - \frac{2}{3}\pi\right) = -\frac{I_M}{2} \Longrightarrow \bar{i}$

$i_c = I_M \cos\left(\omega t + \frac{2}{3}\pi\right) = -\frac{I_M}{2} \quad t=0$

$i_b = -\frac{I_M}{2}$ a $t=0$



$I_M = i_a$

$\bar{i} = \frac{3}{2} I_M \quad t=0$

La posizione di $\bar{i}$ individua il massimo di $B(\gamma,t)$

$i_a, i_b, i_c \Longrightarrow \bar{i}$ = cost modulo e rotante alla velocità ω

$$\bar{i}(t=0) = I_M \cdot 1 - \frac{I_M}{2} e^{j\frac{2}{3}\pi} - \frac{I_M}{2} e^{-j\frac{2}{3}\pi} = \frac{3}{2} I_M$$

$$\bar{i}(t) = i_a(t) + i_b(t)\,\alpha + i_c(t)\,\alpha^2 = \qquad \alpha = e^{j\frac{2}{3}\pi} \qquad \alpha^2 = e^{-j\frac{2}{3}\pi}$$

$$= I_M \cos\omega t + I_M \cos\left(\omega t - \tfrac{2}{3}\pi\right)\alpha + I_M \cos\left(\omega t + \tfrac{2}{3}\pi\right)\alpha^2$$

$$\bar{i}(t) = \bar{I}\, e^{j\omega t} \Leftarrow \text{dimostrazione!!} \Rightarrow \text{c'è un campo rotante}$$

$$\bar{B} = \frac{4}{\pi}\frac{N}{2\delta}\mu_0 \,\bar{I}\, e^{j\omega t} \rightarrow B(t,\gamma) = \mathrm{Re}\left(\bar{B}\, e^{-j\gamma}\right)$$

= il massimo si sposta a velocità ω sulla perif.

$$\cos\left(\omega t - \tfrac{2}{3}\pi\right) = \cos\omega t \cos\tfrac{2}{3}\pi + \sin\omega t \sin\tfrac{2}{3}\pi$$

$$\cos\left(\omega t + \tfrac{2}{3}\pi\right) = \cos\omega t \cos\tfrac{2}{3}\pi - \sin\omega t \sin\tfrac{2}{3}\pi$$

$$\Rightarrow \bar{I} = \frac{3}{2} I\left(\cos\omega t + j\sin\omega t\right) = \frac{3}{2} I\, e^{j\omega t}$$

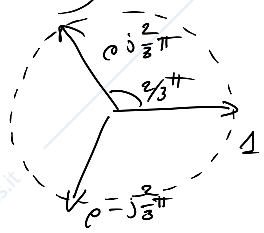
$$\cos x = \cosh(jx) = \frac{e^{jx} + e^{-jx}}{2} = \frac{\cos x + \cancel{j\sin x} + \cos(-x) + \cancel{j\sin(-x)}}{2} = \cos x$$

$$\bar{i} = I_M \cdot \overbrace{\frac{e^{j\omega t} + e^{-j\omega t}}{2}}^{\cos\omega t} + I_M \underbrace{\frac{e^{j\omega t}e^{-j\frac{2}{3}\pi} + e^{-j\omega t}e^{j\frac{2}{3}\pi}}{2}}_{\cos(\omega t - \frac{2}{3}\pi)} \cdot e^{j\frac{2}{3}\pi} + I_M \underbrace{\frac{e^{j\omega t}e^{j\frac{2}{3}\pi} + e^{-j\omega t}e^{-j\frac{2}{3}\pi}}{2}}_{\cos(\omega t + \frac{2}{3}\pi)} \cdot e^{-j\frac{2}{3}\pi}$$

$$= \frac{I_M}{2}\left(e^{j\omega t} + e^{-j\omega t} + e^{j\omega t} + e^{-j\omega t}e^{j\frac{4}{3}\pi} + e^{j\omega t} + e^{-j\omega t}e^{-j\frac{4}{3}\pi}\right) =$$

$$= \underbrace{\frac{3 I_M}{2} e^{j\omega t}}_{\text{vettore rotante}} + \cancel{e^{-j\omega t}\underbrace{\left(1 + e^{-j\frac{2}{3}\pi} + e^{j\frac{2}{3}\pi}\right)}_{=0}}$$

$$e^{-j\frac{2}{3}\pi} = e^{j\frac{4}{3}\pi} \qquad e^{j\frac{2}{3}\pi} = e^{-j\frac{4}{3}\pi}$$

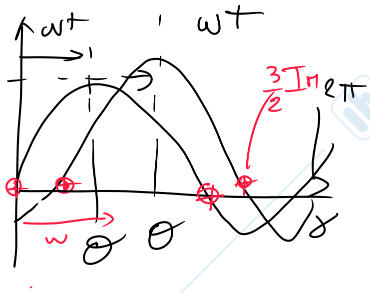


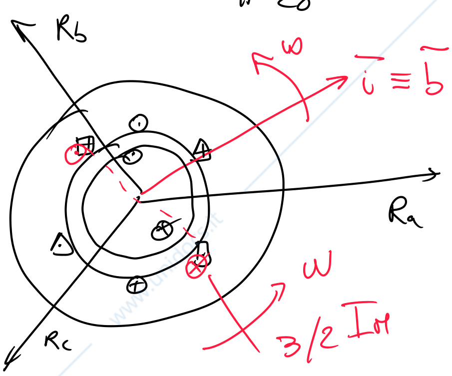
$$\boxed{B(t,\gamma)} = \mathrm{Re}\left(\frac{4}{\pi}\frac{N}{2\delta}\mu_0\, \bar{i} \cdot e^{-j\gamma}\right) = \mathrm{Re}\left(\frac{4}{\pi}\frac{N}{2\delta}\mu_0 \frac{3}{2} I_M e^{j\omega t} e^{-j\gamma}\right)$$

$$\bar{i} = (i_a + i_b\alpha + i_c\alpha^2)$$

$$= \frac{4}{\pi}\frac{N}{2\delta}\mu_0 \frac{3 I_M}{2} \cos(\omega t - \gamma)$$

$$(\theta - \gamma)$$





alimentaz. i_a, i_b, i_c equilibrate $\Rightarrow$ generano un campo rotante