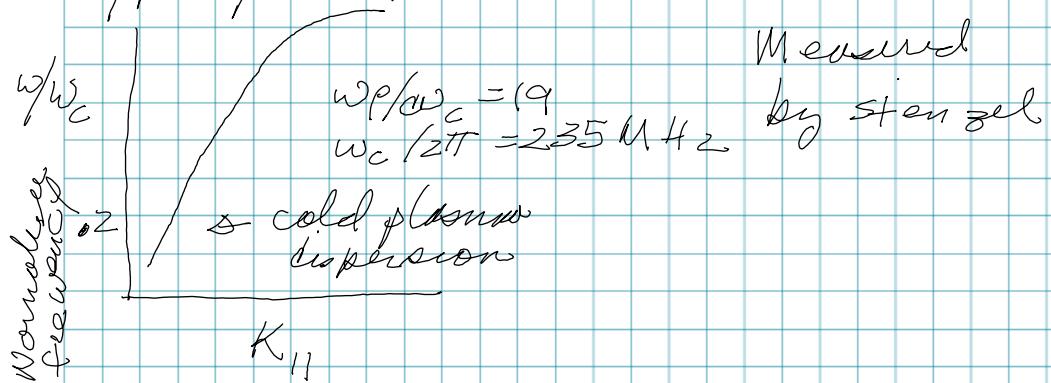
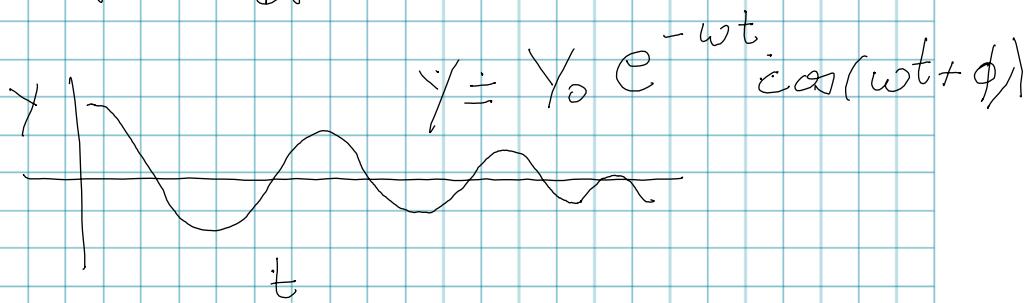


6/20/15 Lecture



$$m \frac{d^2 Y}{dt^2} + b \frac{dy}{dt} + k_y Y = A \cos(\omega_0 t)$$



Dispersion

$$\omega = 2\pi f, \text{ angular } \omega$$

$$\cos(\omega t)$$

$$\omega = 2\pi f = \frac{2\pi}{T} \text{ & Period } T$$

$$\cos\left(\frac{2\pi t}{T}\right)$$

$$k = \frac{2\pi}{\lambda} \quad \text{wave length / meter}$$

$$\cos(\omega t - \vec{k}_0 \cdot \vec{r}) \quad \frac{2\pi L}{\lambda} \approx \text{Angle}$$

In days of Refraction,

$$\frac{\omega_p^2 k_{||} v_{beam}}{\omega^2 [(\omega - k_{||} v_b)^2 - n\omega_{ce}^2]}$$

↑ ↑ ↑
Pepper Hege "resonance" term
shift

\parallel ≡ parallel to magnetic field

v_b = Velocity of electron beam.

$$\omega_R = \frac{2\pi f}{\lambda} = \frac{L}{T} = \text{Velocity}$$

beam makes ~~wave~~ wave.

Doppler Effect

frame of references.

Source moves toward observer $f = \frac{c}{\lambda}$

$$\lambda' = \lambda - \Delta\lambda = \lambda - \frac{v_{\text{source}}}{f}$$

$$f' = \frac{c}{\lambda'} = \frac{c}{\lambda - \frac{v_{\text{source}}}{f}} = \frac{c}{\left(\frac{c}{f} - \frac{v_{\text{source}}}{f}\right)}$$

$f\lambda = c$
Observe toward

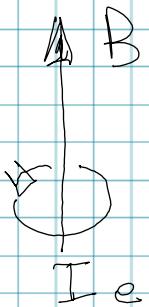
$$V' = c + v_{\text{obs}} ; f' = \frac{V'}{\lambda} = \frac{c + v_{\text{obs}}}{\lambda}$$

observer away

$$V' = c - v_{\text{obs}} ; f' = \frac{V'}{\lambda} = \frac{c - v_{\text{obs}}}{\lambda}$$

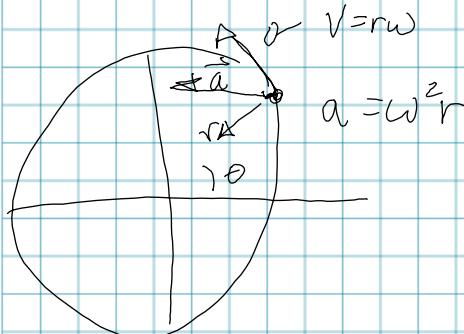
$$f' = f \left(1 \pm \frac{v_{\text{obs}}}{c} \right), + \text{ towards away}$$

electrons ~~sphere~~
around magnetic field.



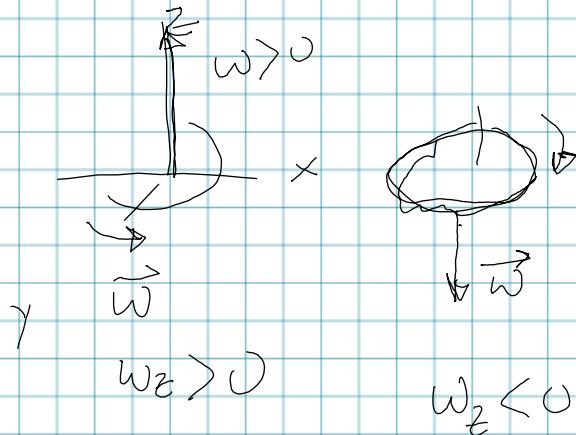
to counteract magnetic field

Dia magnetoo effect



$$v = r\omega$$

$$a = \omega^2 r$$



$$\omega_2 < 0$$

$$\omega_{ce} = \frac{qB}{m_e}$$

$$(w - k_{||}^2 V_B)^2 - \omega_{ce}^2$$

beam doppler
shift

$$A$$

$$(w'^2 - \omega_{ce}^2)$$

$$f_{ce} = 2.8 \times 10^6 B$$

V_{beam} - must move as fast as
whistler wave -

what are whistler waves

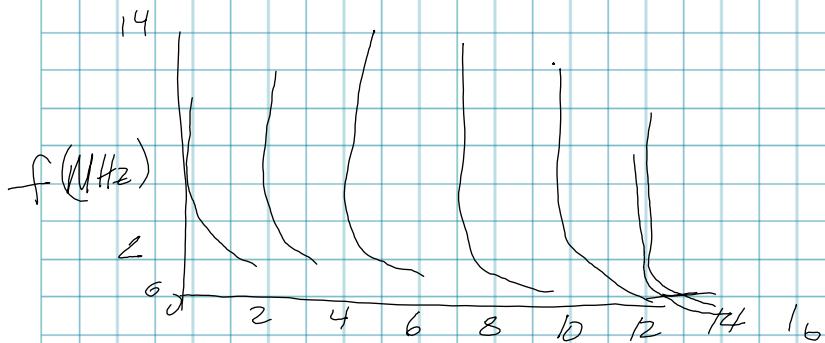
close to the earth 3 bands

A B C
travel between ^{the} pole

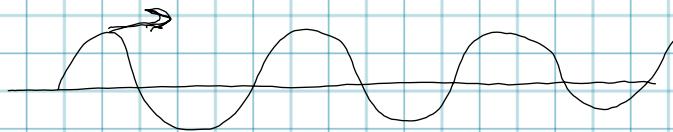
Appleton -

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$$\frac{\omega}{K} = \sqrt{V}$$



$$V_{\text{group}} \propto \frac{d\omega}{dk} \omega^{\frac{1}{2}} t$$



$$\frac{\omega}{K} = V_{\text{phase}}$$

$$V_{\text{group}} = \frac{d\omega}{dk} \approx \cancel{t \frac{d\omega}{dt}} \omega^{\frac{1}{2}} \xrightarrow{\text{Assumption}} 1926$$

$$d\omega = dk c \Rightarrow \frac{d\omega}{dk} = c$$

$$\frac{\omega}{K} = \frac{C}{h} \quad n = \frac{KC}{\omega} \text{ & } V_p = \sqrt{\frac{h}{K}}$$

Index of refraction $n = \frac{KC}{\omega}$ $\frac{\omega}{K} = V$

$$V = \frac{1}{\sqrt{\mu_0 \epsilon_r}}$$

↑
magnetism ↓
electricity

1) $\epsilon = \epsilon_0$ vacuum

2) $\epsilon = \epsilon_0 K$ glass, K is number (1-3)

3) $\epsilon = \epsilon_0 \vec{K}$, K is tensor 3×3

$$\vec{K} = \begin{bmatrix} K_{\perp} & -K_{xy} & 0 \\ K_{yx} & K_{\perp} & 0 \\ 0 & 0 & K_{||} \end{bmatrix}$$

$f_{ce} = \frac{qB}{me} = 2.8 \times 10^6 \text{ Hz}$

$f_{pe} = \sqrt{\frac{n e^2}{m_e}} = 8.9 \times 10^3 \text{ Hz}$

$$\omega = 2\pi f$$

$$K_{\perp} = 1 - \frac{\omega_{pe}^2}{(\omega^2 - \omega_{ce}^2)}$$

$$K_{||} = 1 - \frac{\omega_{pe}^2}{\omega^2}$$

$$K_{xy} = K_{yx} = \frac{i \omega_{ce} \omega_{pe}^2}{\omega (\omega^2 - \omega_{ce}^2)}$$

$$\eta^2 = 1 - \frac{X}{Q}$$

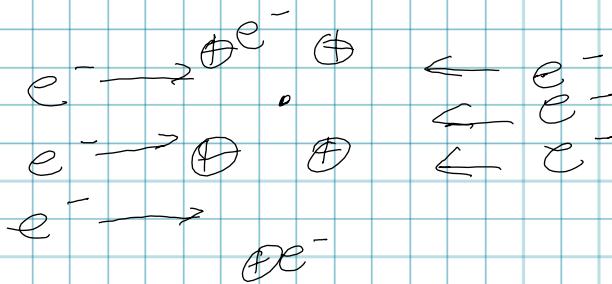
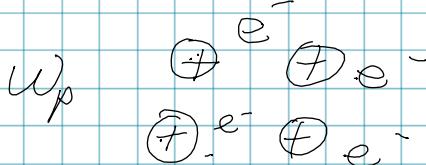
$$\eta^2 = 1 - \frac{\frac{\omega_{pe}^2}{\omega^2}}{\left(1 + \frac{iV}{\omega}\right) - \frac{\omega_{ce}^2 \sin^2 \theta}{2\left(1 - \frac{\omega_{pe}^2}{\omega^2}\right)} + \frac{\left(\frac{\omega_{ce}^2}{\omega^2} \sin^2 \theta\right)^2}{4\left(1 - \frac{\omega_{pe}^2}{\omega^2}\right)} + \frac{\omega_{ce}^2 \cos^2 \theta}{1 - \frac{\omega_{pe}^2}{\omega^2}}}$$

Resonance

Doppler Shift

Index of Refraction

ω_{ce} = natural spinning



$$\omega_{pe} =$$

ions } cold
electrons }

ions - don't move
waves - so small
don't interfere waves