Física IV (IQ 2022)
Aula 15

- Objetivos de aprendizagem:
  - Descrever matematicamente ondas monocromáticas planas e esféricas
  - Descrever o fenômeno de interferência de ondas de duas fendas
  - Obter a intensidade da onda resultante de duas ondas esféricas coerentes em função da posição

Onda harmônica

$$u(\vec{r},t)=A(\vec{r})\cos(\omega t-\delta(\vec{r}))$$

Ex.: Onda harmônica progressiva plana

$$u(\vec{r},t)=A_0\cos(\vec{k}.\vec{r}-\omega t+\delta)$$

Formalismo complexo

$$u(\vec{r},t)=\Re[Z(\vec{r},t)]$$

$$Z(\vec{r},t)=Z_0(\vec{r})e^{-i\omega t} \qquad Z_0(\vec{r})=A(\vec{r})e^{i\delta(\vec{r})}$$

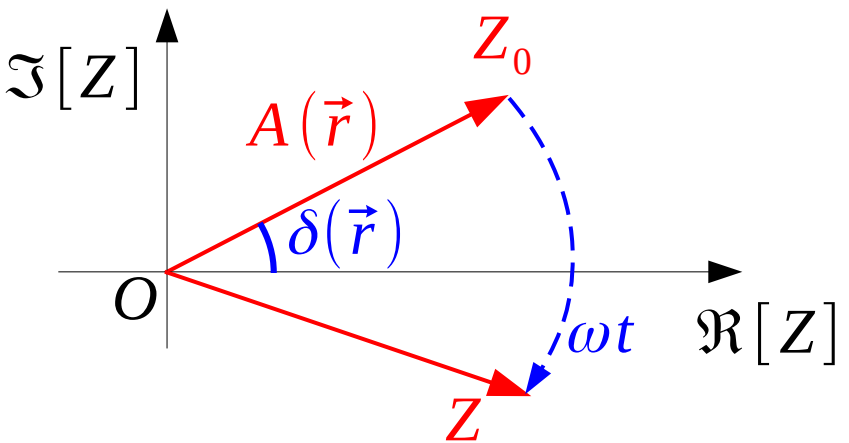
Formalismo complexo

$$u(\vec{r},t)=\Re[Z(\vec{r},t)]$$

$$Z(\vec{r},t)=Z_0(\vec{r})e^{-i\omega t}$$

$$Z_0(\vec{r})=A(\vec{r})e^{i\delta(\vec{r})}$$

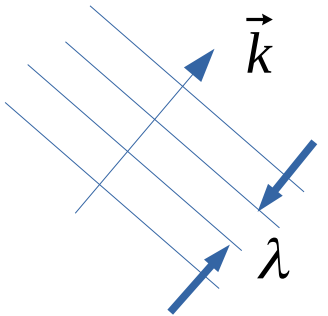
Diagrama de Argand (plano complexo)



Em uma certa posição do espaço o vetor Z gira em torno da origem com velocidade angular ômega

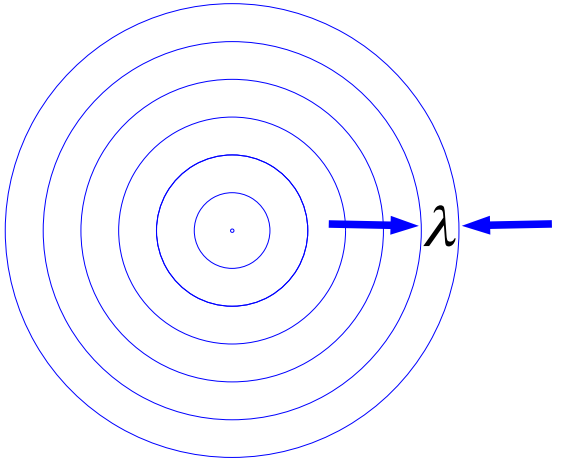
Onda harmônica (monocromática) progressiva em 1D

- Onda escalar, ou abordar só 1 componente
- Formalismo complexo.
- Onda Plana: $E(\vec{r},t)=\Re[\underbrace{E_0 e^{i(\vec{k}.\vec{r}+\delta)}}_{Z_0(\vec{r})} e^{-i\omega t}]$
- Onda esférica:



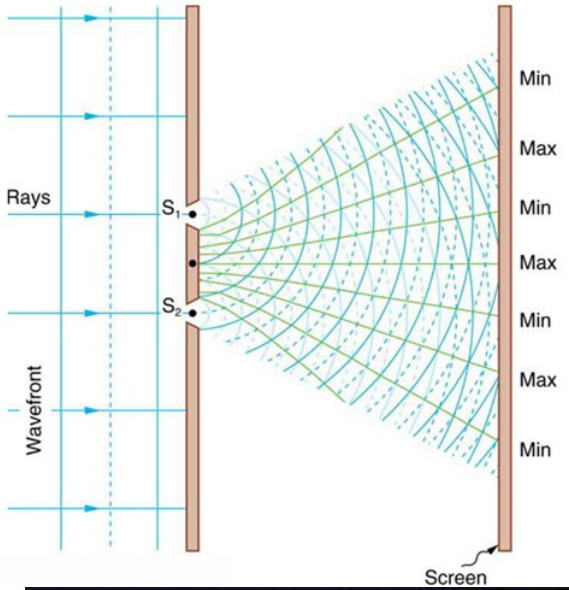
$$E(r,t)=\Re[\overbrace{\frac{A_0}{r}e^{i(k.r+\delta)}}^{Z_0(\vec{r})} e^{-i\omega t}]$$

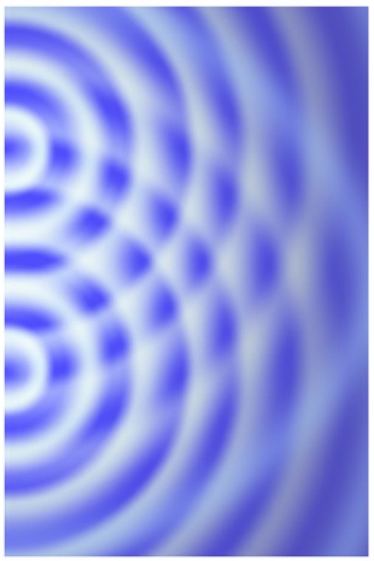
$$I_{med}\propto|Z|^2=Z^* Z=\frac{A_0^2}{r^2}$$

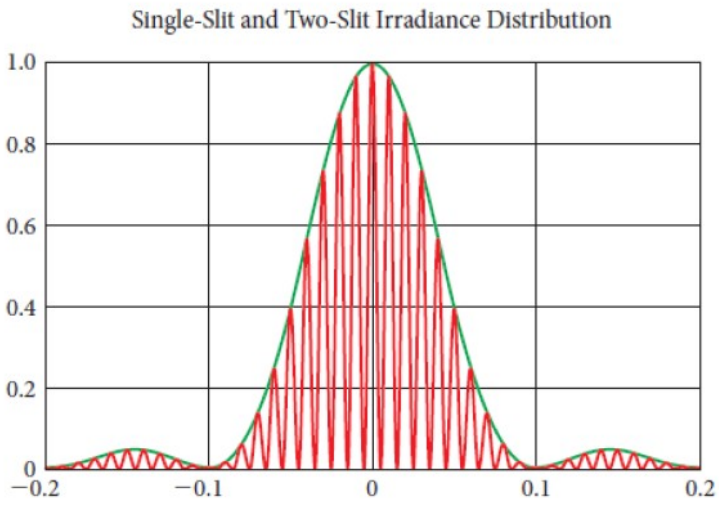


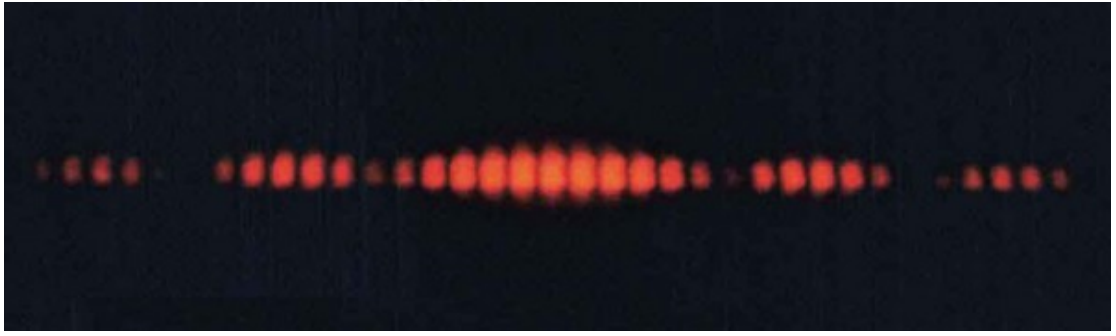
$$k=\frac{2\pi}{\lambda}$$

Interferência, fenda dupla (ou 2 furos)









Experimento de Young

Interferência de 2 ondas esféricas

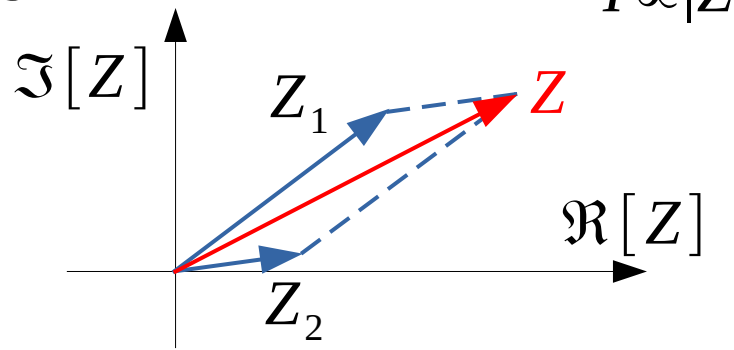
- ...Coerentes (fontes “sincronizadas”) de mesma frequência e mesma potência
- Superposição
- Intensidade

$$Z_1 = \frac{A_0}{r_1} e^{i(k r_1 + \delta)} e^{-i\omega t}$$

$$Z_2 = \frac{A_0}{r_2} e^{i(k r_2 + \delta)} e^{-i\omega t}$$

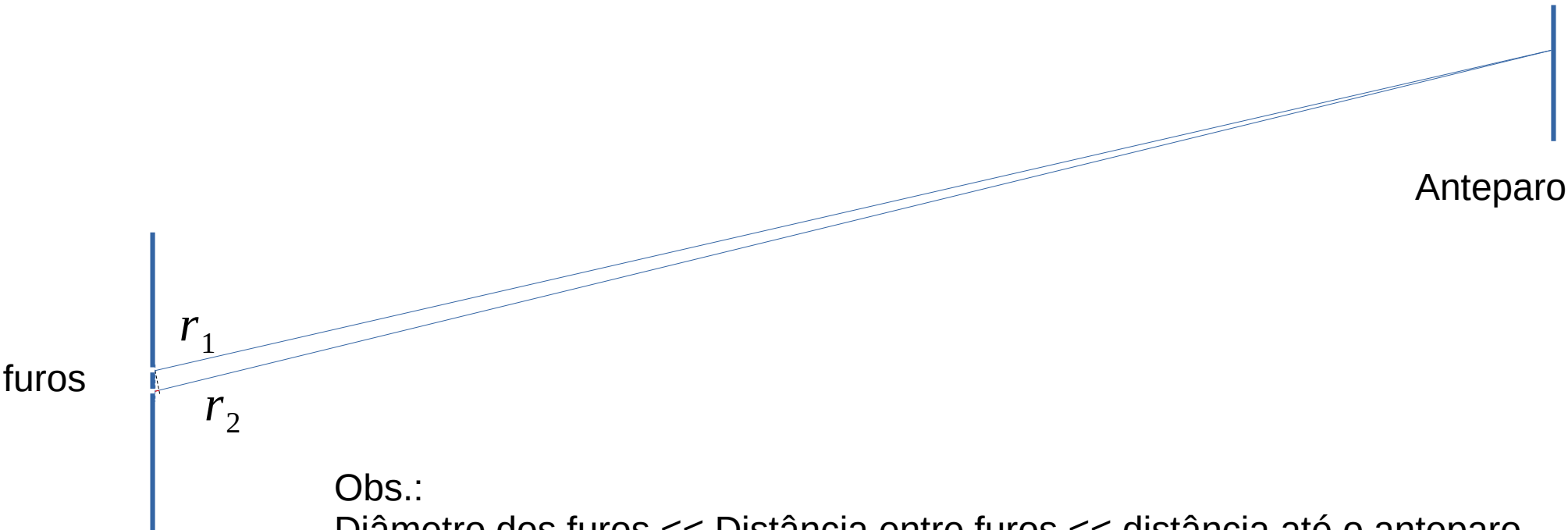
$$Z = Z_1(r_1, t) + Z_2(r_2, t)$$

$$I \propto |Z|^2 = |Z_1(r_1, t) + Z_2(r_2, t)|^2$$



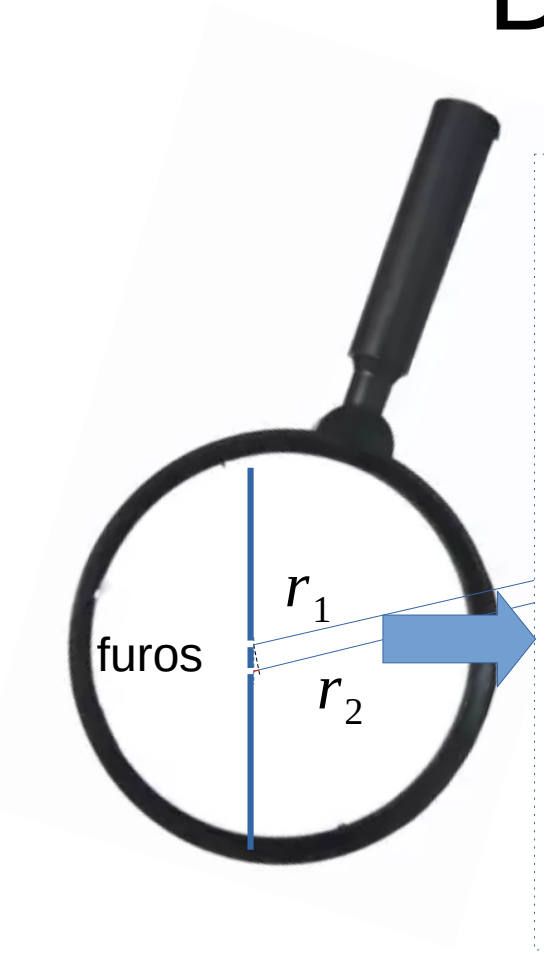
$$I_{tot} \propto A_0^2 \left| \frac{e^{ikr_1}}{r_1} + \frac{e^{ikr_2}}{r_2} \right|^2$$

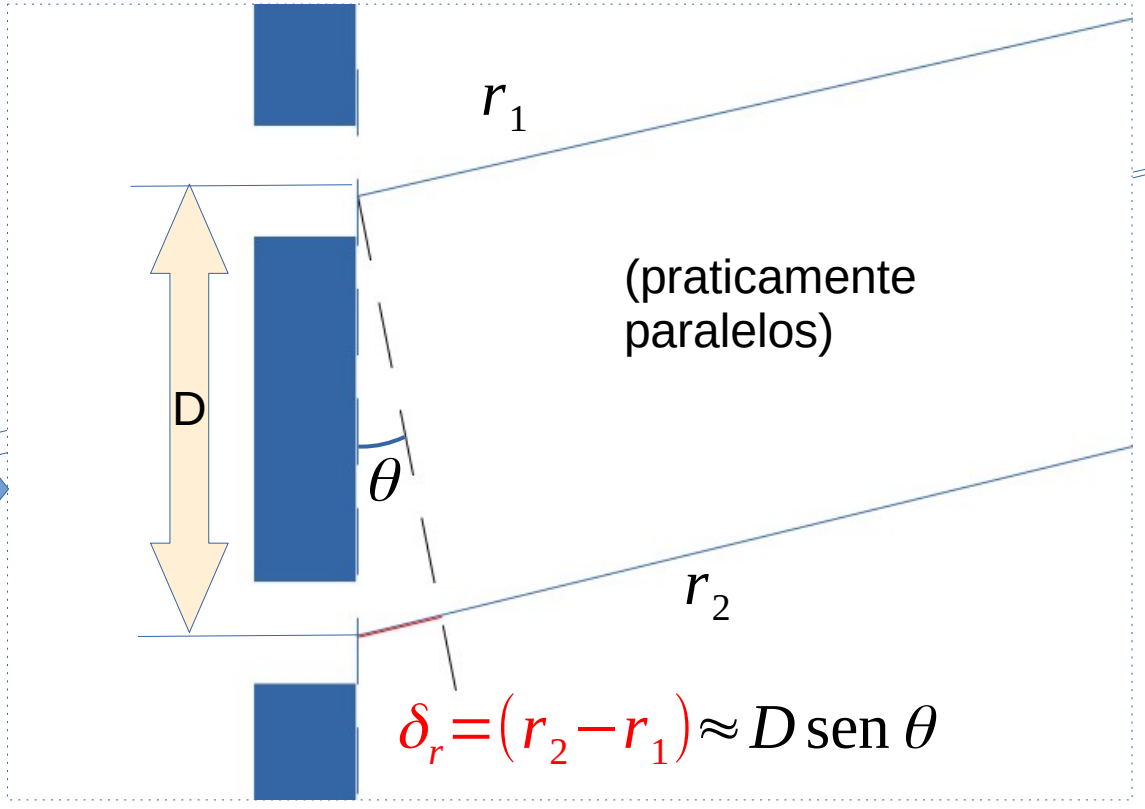
Interferência de 2 furos

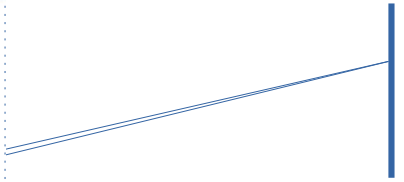


Obs.:
Diâmetro dos furos << Distância entre furos << distância até o anteparo

Diferença de caminho







OBS.:

$r_2 \approx r_1$

mas

$r_2 - r_1 \sim O(\lambda)$

Resultado

- Mostrar → $I \propto \frac{A_0^2}{r^2} \cos^2\left(k \frac{\delta_r}{2}\right)$
- Ângulos pequenos: $\operatorname{sen}\theta \approx \theta$

$$\delta_r = (r_2 - r_1) = D \operatorname{sen}\theta$$

$$I \propto \frac{A_0^2}{r^2} \cos^2\left(\frac{\pi D}{\lambda}\theta\right) \qquad \Delta\theta \approx \frac{\lambda}{D}$$