INTERFERENSI DAN DIFRAKSI

Mata Kuliah: Gelombang & Optik

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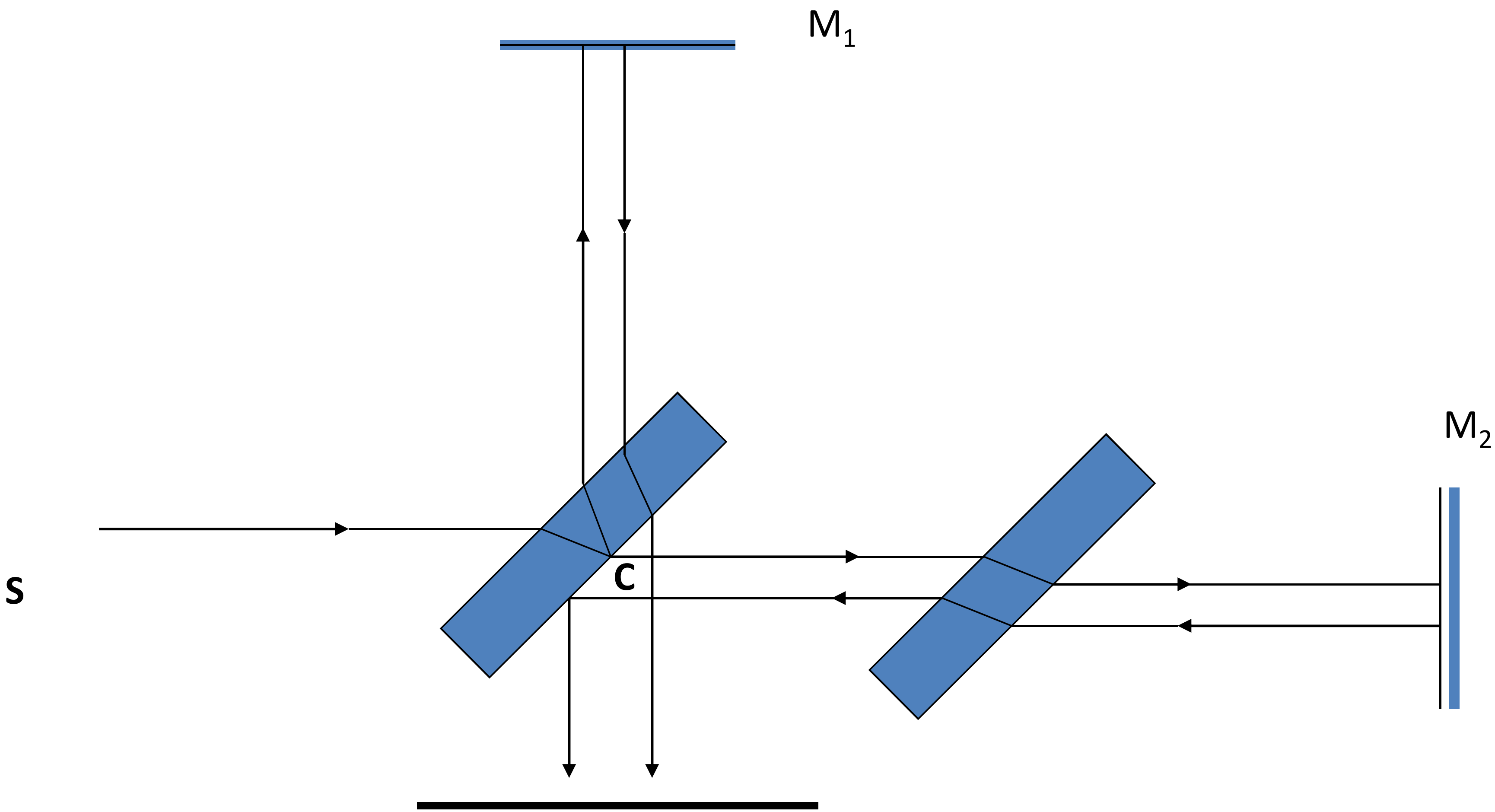
INTERFERENSI

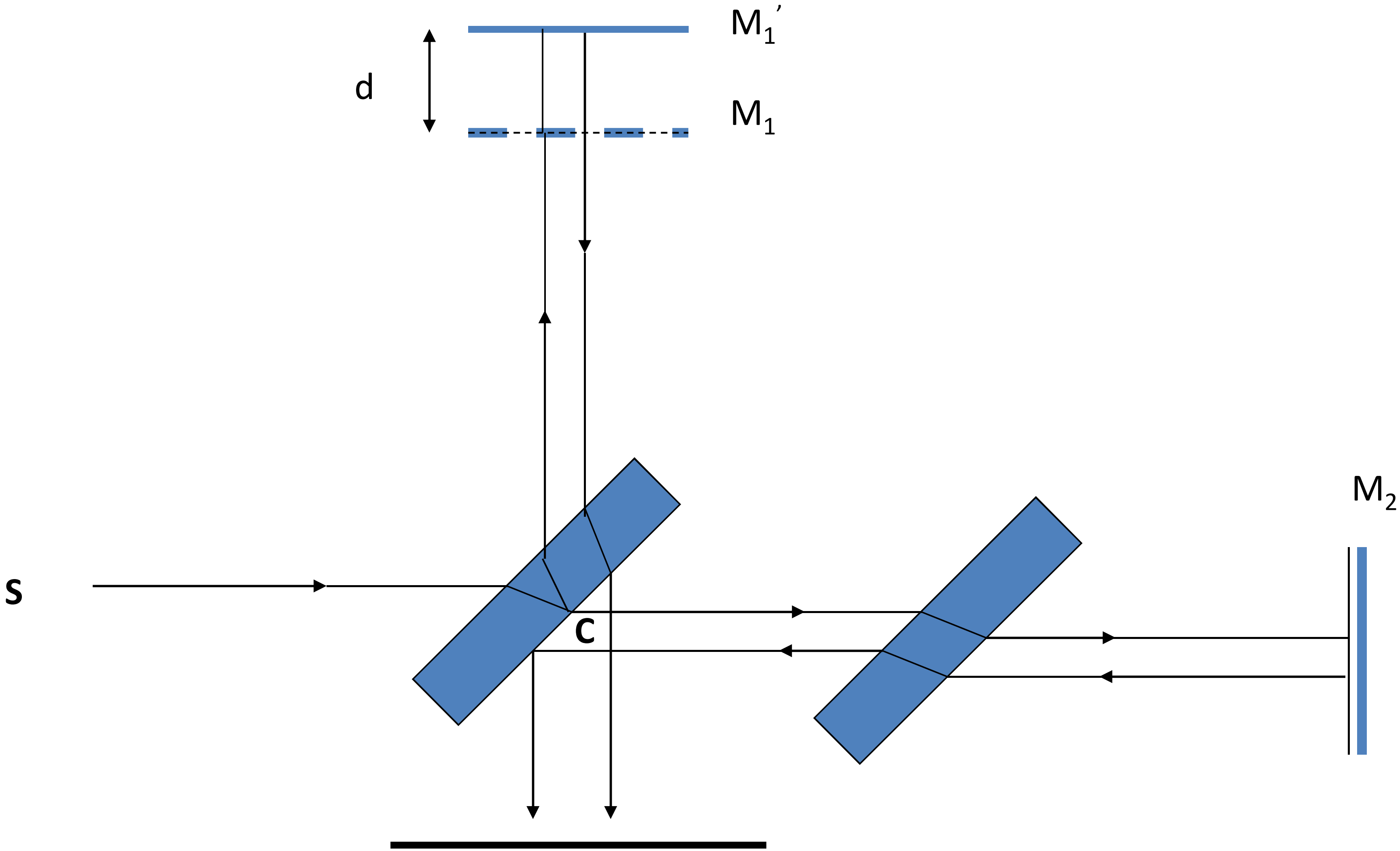
INTERFEROMETER PEMBELAH AMPLITUDO

A.2. inferometer Pembelah Ampliudo (Pemecah Berkas)

A.2.1. Interferometer Michelson



Gambar Interferometer Michelson


M$_1$'
d
M$_1$
M$_2$
S
C

"Kaca planpararel pada interferometer berfungsi untuk menyamakan lintasan optik"

Pada awalnya:

$CM_1 = CM_2$ dan $r_1 = r_2$

Selanjutanya ketika M1 digeser sebesar d, maka :

$$CM_1' = CM_1 + d$$

$r_1' = r_1 + 2d$ karena $r_1 = r_2$

$$r_1' = r_2 + 2d$$

Persamaan gelombangnya :

$E_1 = E_0 e^{i(k(r_1+2d)-\omega t)}$ dan $E_2 = E_0 e^{i(kr_2-\omega t)}$

$$\Delta r = r_1' - r_1 = r_1' - r_2$$

$$\Delta r = \left(r_1 + 2d\right) - r_1$$

$$\Delta r = 2d \rightarrow r_1' = r_1 + 2d$$

$$E_1 = E_0 e^{i(kr_1' - \omega t)} = E_0 e^{i(k\left(r_1 + 2d\right) - \omega t)}$$

$$E_2 = E_0 (e^{i(kr_2 - \omega t)}$$

Superposisi :

$$E = E_1 + E_2$$

$$E = E_0 (e^{i(k(r_1 + 2d) - \omega t)} + e^{i(kr_2 - \omega t)})$$

Intensitas :

$$I \approx |E|^2$$

$$I \approx E_0{}^2\left[e^{i(k(r_1+2d)-\omega t)} + e^{i(kr_2-\omega t)}\right]\left[e^{-i(k(r_1+2d)-\omega t)} + e^{-i(kr_2-\omega t)}\right]$$

$$I \approx E_0{}^2\left[1 + e^{-i(k(r_2-(r_1+2d)))} + e^{i(k(r_2-(r_1+2d)))} + 1\right]$$

karena $r_2 = r_1$ maka $I \approx E_0{}^2\left[2 + e^{-i(k2d)} + e^{i(k2d)}\right]$

$$I \approx E_0{}^2\left[2 + 2\cos 2kd\right]$$

karena $I_0 \approx |E_0|^2 \approx E_0^2$ maka

$$I = 2I_0\left[1 + \cos(2kd)\right]$$

$$I = 2I_0\left[1 + 2\cos^2(kd) - 1\right]$$

$$I = 4I_0\cos^2(kd)$$

$$\boxed{I = 4I_0 \cos^2(kd)}$$

I akan maksimum jika : $\cos^2(kd) = 1$

$$\Longrightarrow \quad kd = n\pi \rightarrow \frac{2\pi}{\lambda} d = n\pi$$

$$2d = n\lambda \qquad n = 0, \pm 1, \pm 2$$

terang ke-n diperoleh dengan mengeser M1 sebesar

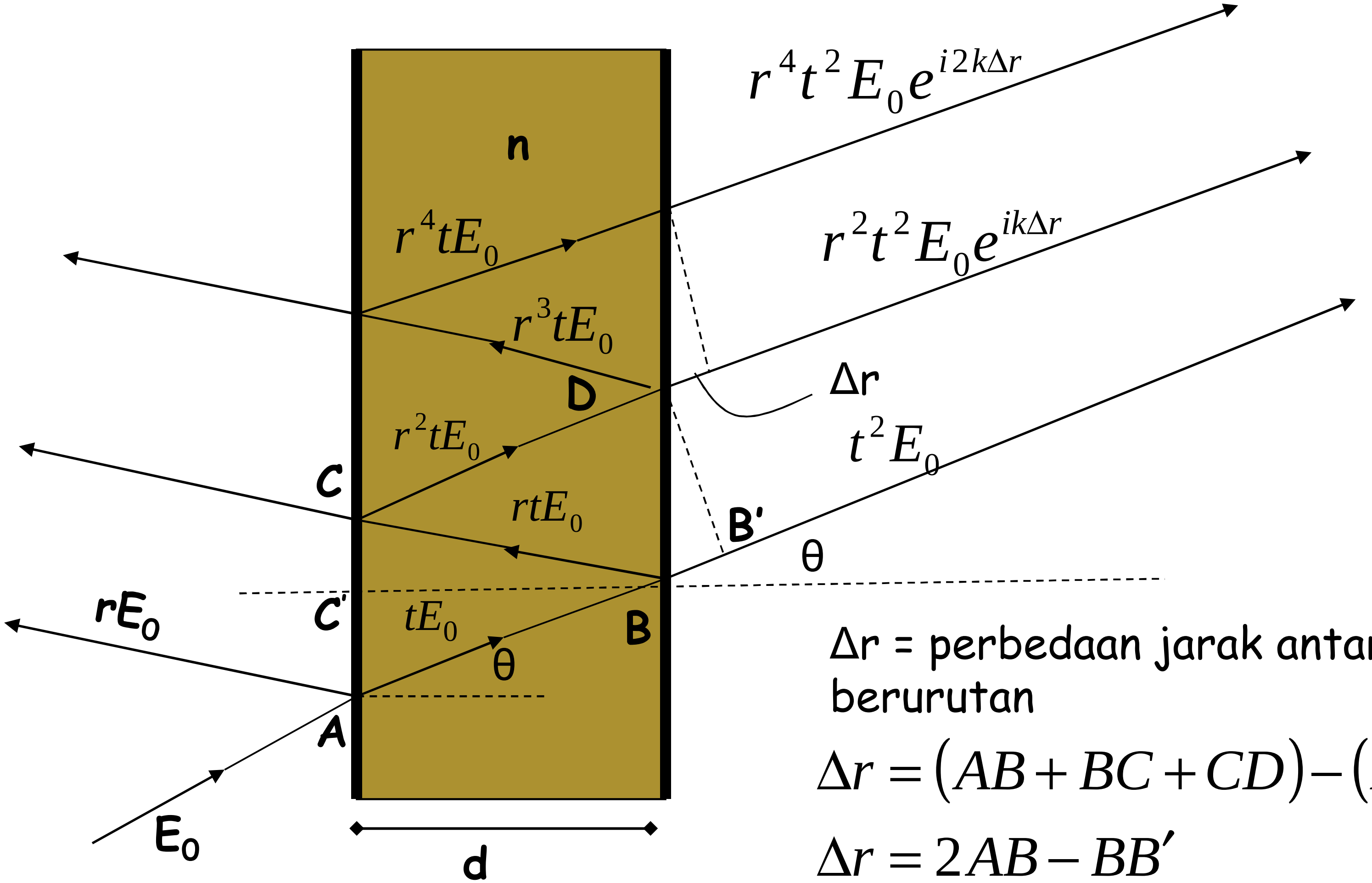
$$d = n\frac{\lambda}{2} \rightarrow \lambda = \frac{2d}{n}$$

I akan minimum jika : $\cos^2(kd) = 0 \quad \Longrightarrow \quad kd = \left[\frac{2n+1}{2}\right]\pi$

$$n = 0, \pm 1, \pm 2$$

$$d = \left[\frac{2n+1}{4}\right]\lambda \rightarrow \lambda = \frac{4d}{2n+1}$$

A.2.2. Interferometer Fabry Perot



Δr = perbedaan jarak antara dua lintasan berurutan

$$\Delta r = (AB + BC + CD) - (AB + BB')$$

$$\Delta r = 2AB - BB'$$

Gambar 11. Pemantulan ganda pada Interferometer Fabry Perot segitiga ABC'

$$\cos\theta = \frac{d}{AB} \longrightarrow AB = \frac{d}{\cos\theta}$$

$$\sin\theta = \frac{AC'}{AB} = \frac{AC'\cos\theta}{d} \longrightarrow AC' = d\tan\theta = CC'$$

segitiga $BB'D$

$$\sin\theta = \frac{BB'}{BD} \longrightarrow \sin\theta = \frac{BB'}{2CC'} \longrightarrow BB' = 2\sin\theta . d\tan\theta$$

$$\Delta r = 2AB - BB' \longrightarrow \Delta r = \frac{2d}{\cos\theta} - 2d\tan\theta\sin\theta$$

$$\Rightarrow \Delta r = 2\left[\frac{d}{\cos\theta} - \frac{d\sin^2\theta}{\cos\theta}\right] \Rightarrow \Delta r = 2d\left[\frac{1-\sin^2\theta}{\cos\theta}\right]$$

$$\Rightarrow \Delta r = 2d\left[\frac{\cos^2\theta}{\cos\theta}\right] \Rightarrow \Delta r = 2d\cos\theta$$

$$\varphi = k.\Delta r$$

$$\varphi = 2kd\cos\theta$$

Fungsi Gelombang:

$$E = E_0 t^2 + r^2 t^2 E_0 e^{ik\varphi} + r^4 t^2 E_0 e^{i2k\varphi} + \cdots$$

$$E = E_0 t^2 \left[1 + r^2 e^{ik\varphi} + r^4 e^{i2k\varphi}\right]$$

Deret ukur tak hingga dengan rasio $\rho = r^2 e^{ik\varphi}$

$$E = E_0 t^2 . \frac{1}{1 - r^2 e^{ik\varphi}}$$

$$S_\infty = \frac{1}{1-\rho} \longrightarrow S_\infty = \frac{1}{1 - r^2 e^{ik\varphi}}$$

Intensitas:

$$I \approx \frac{E_0{}^2 t^4}{\left|1 - r^2 e^{ik\varphi}\right|^2}$$

...

$$\left|1 - r^2 e^{ik\varphi}\right|^2 = \left(1 - r^2 e^{i\varphi}\right)\left(1 - r^2 e^{-i\varphi}\right)$$

$$= 1 - r^2\left(e^{-i\varphi} + e^{i\varphi}\right) + r^4$$

$$= 1 - 2r^2 \cos\varphi + r^4$$

$$= 1 - 2r^2 + r^4 + 2r^2 - 2r^2 \cos\varphi$$

$$= \left(1 - r^2\right)^2 + 2r^2\left(1 - \cos\varphi\right)$$

Karena reflektansi $R = r^2$

maka

$$\left|1 - r^2 e^{ik\varphi}\right|^2 = (1 - R)^2 + 2R(1 - \cos\varphi)$$

$$\left|1-r^2e^{ik\varphi}\right|^2=(1-R)^2+2R(1-\cos\varphi)$$

$$\cos\varphi=\left(1-2\sin^2\frac{\varphi}{2}\right)$$

$$\left|1-r^2e^{ik\varphi}\right|^2=(1-R)^2+\left(4R\sin^2\frac{\varphi}{2}\right)$$

$$\left|1-r^2e^{ik\varphi}\right|^2=(1-R)^2\left(1+\frac{4R}{(1-R)^2}\sin^2\frac{\varphi}{2}\right)$$

Sehingga intensitas:

$$I\approx\frac{E_0{}^2t^4}{\left|1-r^2e^{i\varphi}\right|^2}$$

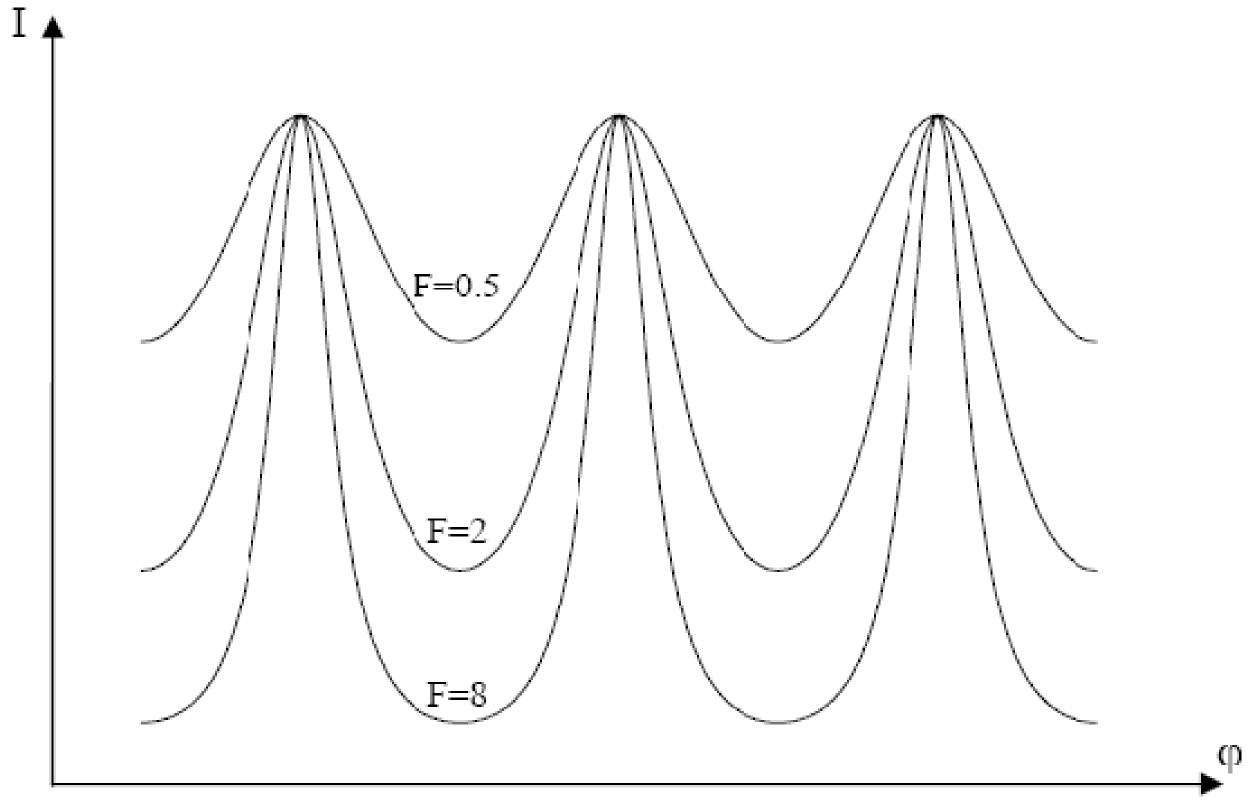
menjadi:

$$I=\frac{I_0t^4}{(1-R)^2\left(1+\frac{4R}{(1-R)^2}\sin^2\frac{\varphi}{2}\right)}$$

$$I=I_{maks}\left(1+F\sin^2\frac{\Delta\varphi}{2}\right)^{-1}$$

F dinamakan sebagai koefisisen *finess* (kehalusan)

Fungsi Airy : menentukan pola interferensi



Pola intensitas pada interferometer Fabry Perot