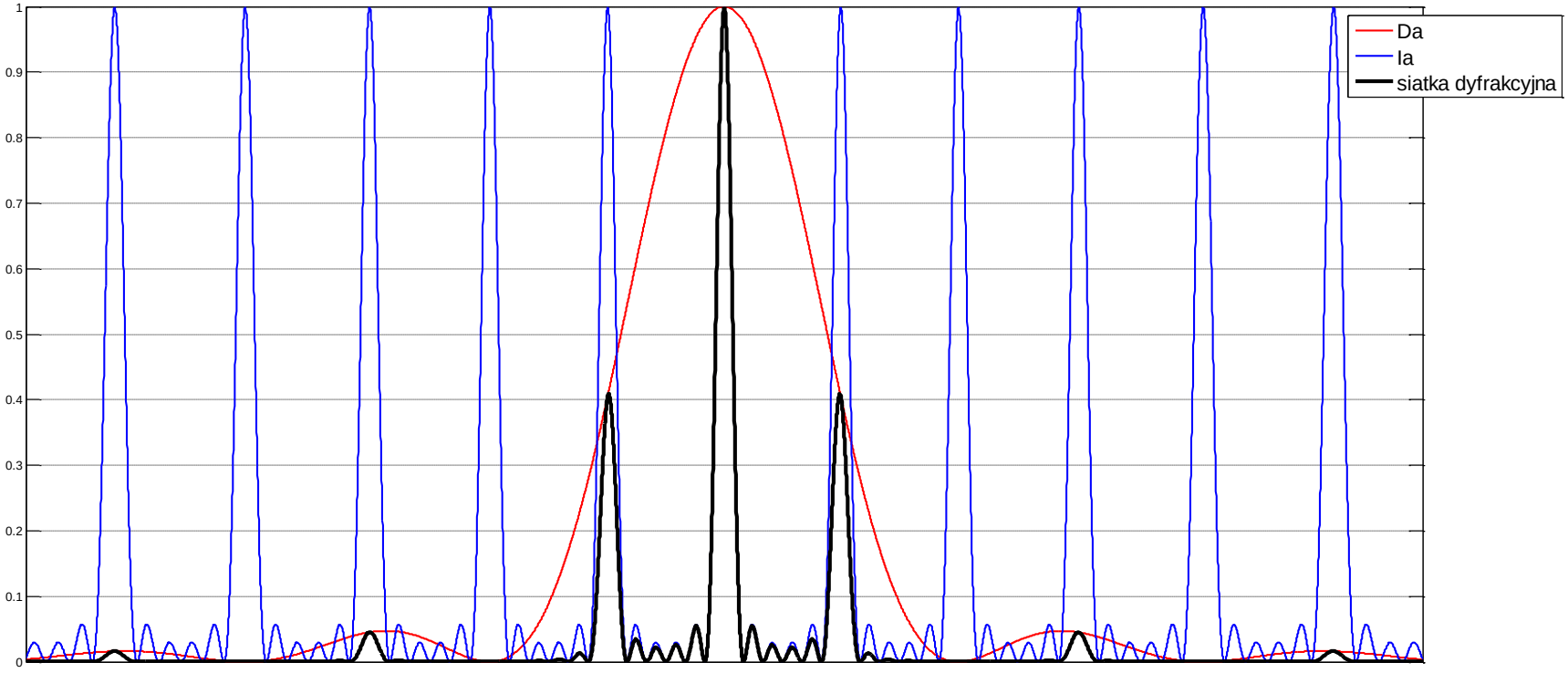
1100-4BW12, rok akademicki 2019/20

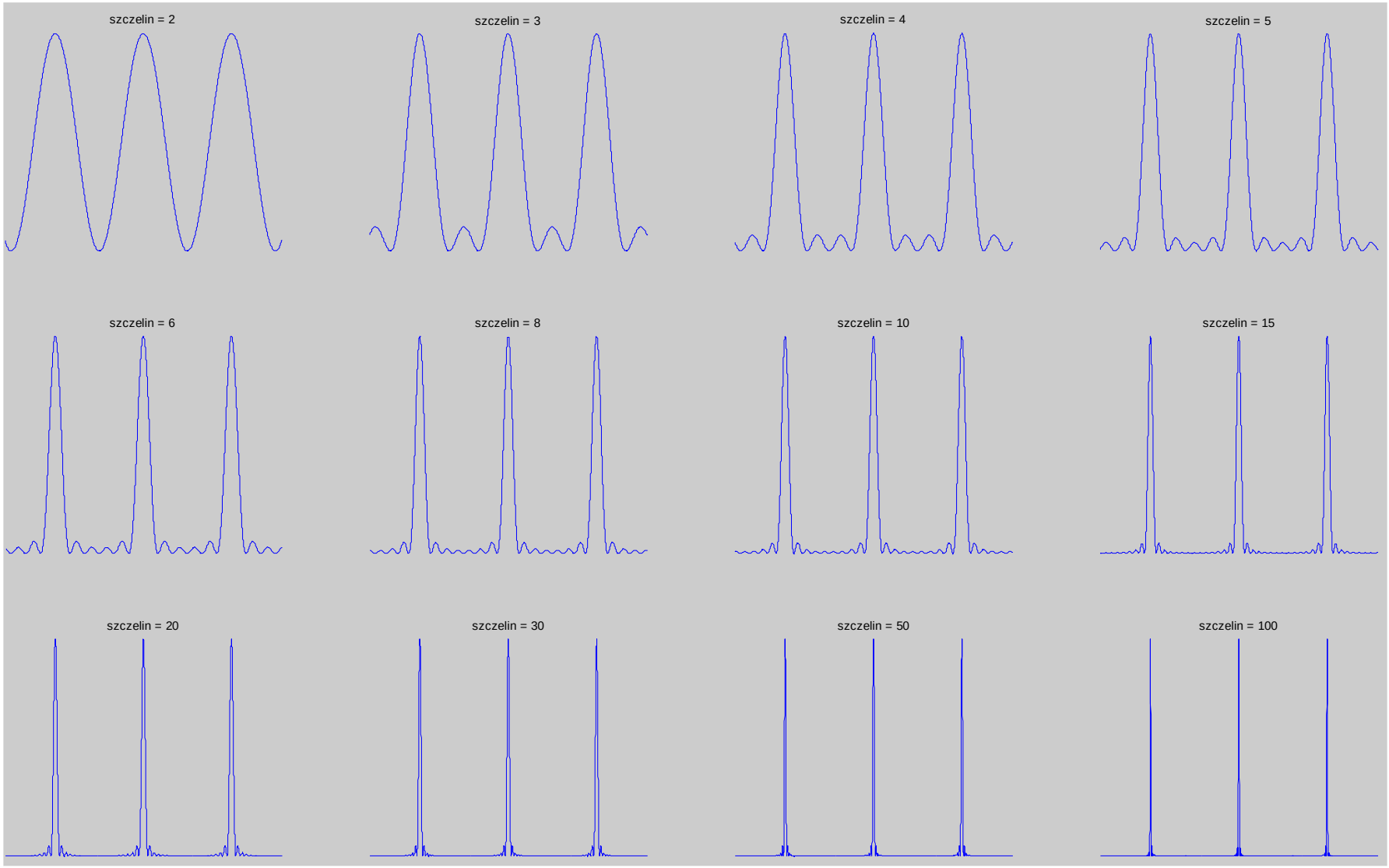
WSTĘP DO OPTYKI FOURIEROWSKIEJ

dr hab. Rafał Kasztelanic

Interferencja – siatka dyfrakcyjna

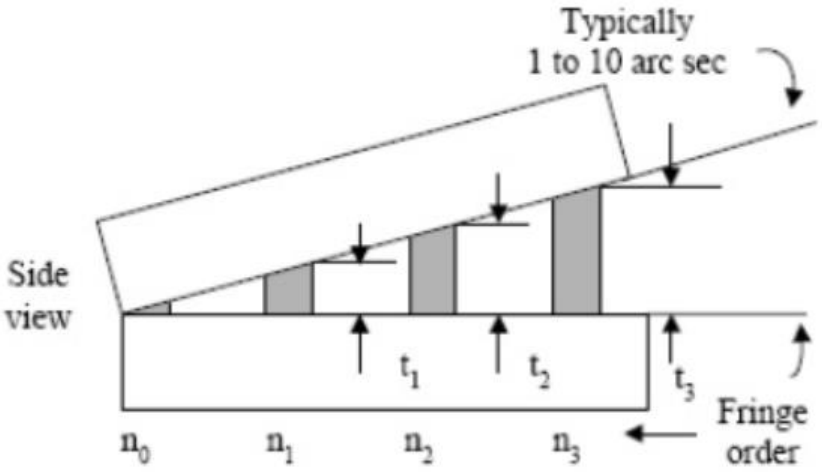


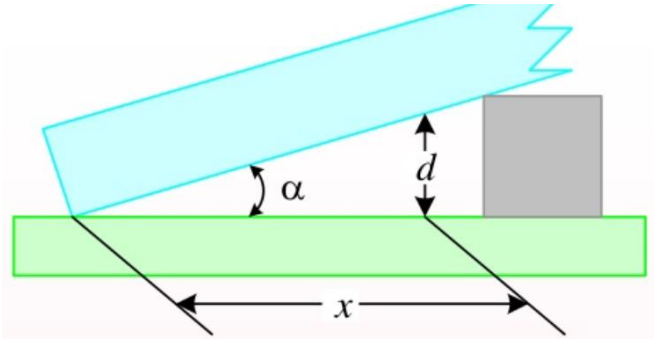
Interferencja – siatka dyfrakcyjna



Interferencja

Klin

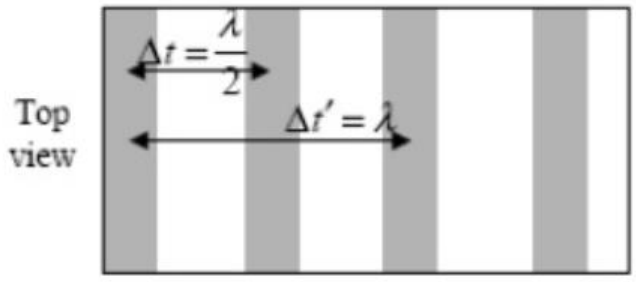




$$d = x\alpha$$

$$2n_f d_m = (m + \tfrac{1}{2})\lambda$$

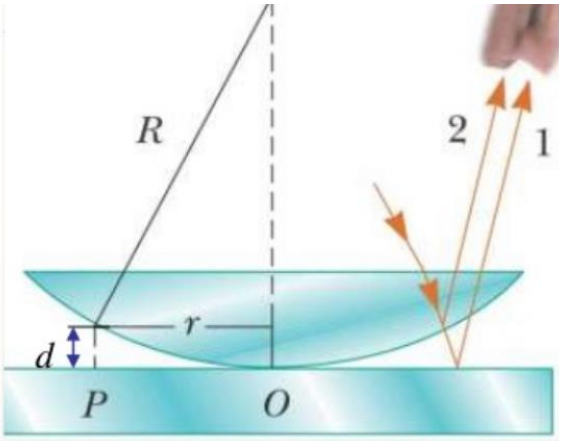
$$2n_f(\alpha x_m) = (m + \tfrac{1}{2})\lambda$$



www.slideshare.net/chinkitkit/chapter-4b-interference

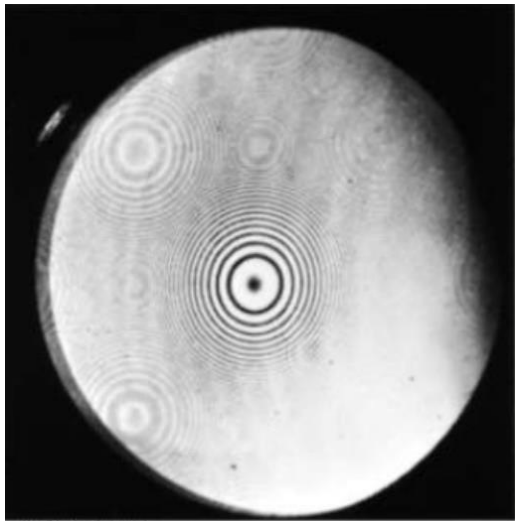
Interferencja

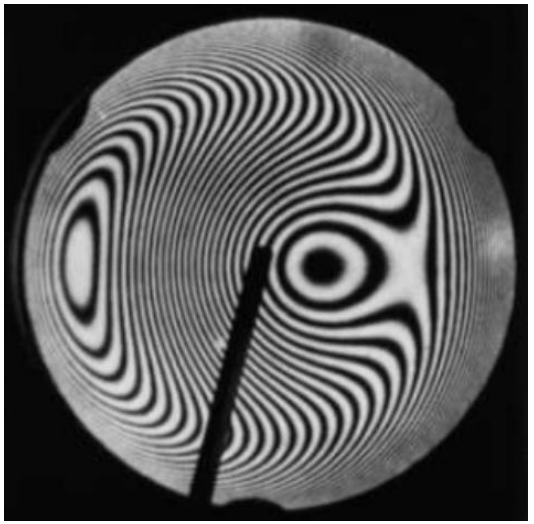
Soczewka - pierścienie Newtona



$$d = r^2/2R$$

$$r = \sqrt{\frac{m\lambda R}{n}}$$





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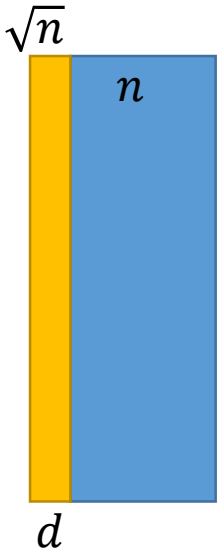
Interferencja

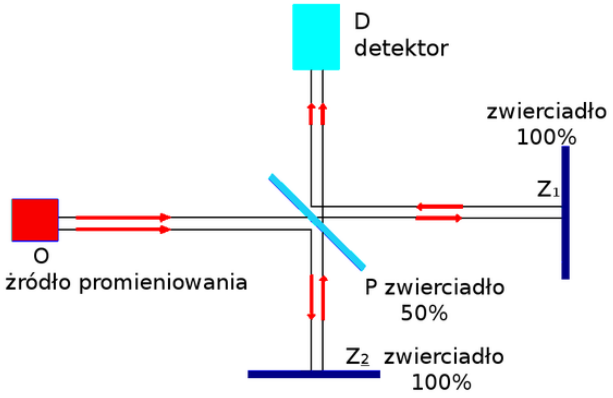
Warstwa antyrefleksyjna



$$d = \frac{\lambda}{4\sqrt{n}}$$

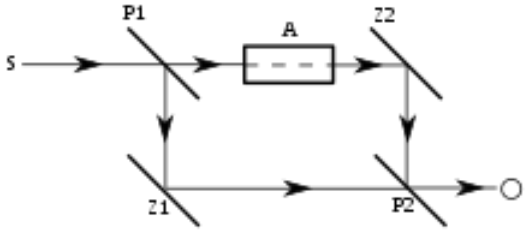
Interferometry

Michelsona

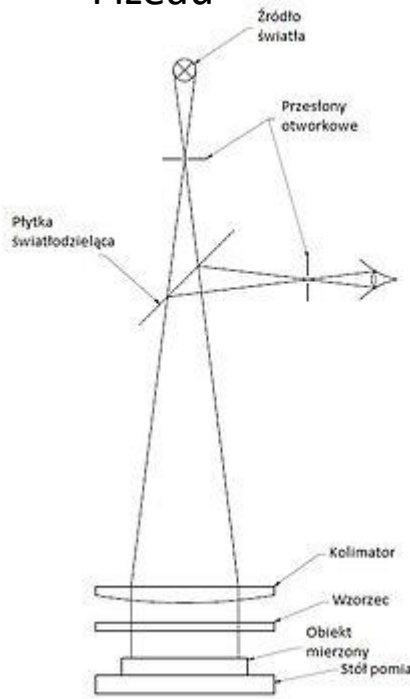


ilf.fizyka.pw.edu.pl/instrukcje/michelson/

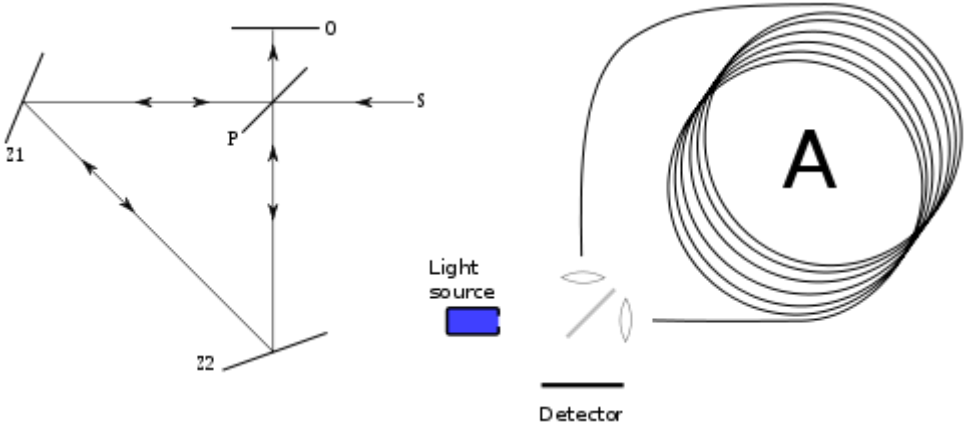
Macha-Zehndera



Fizeau



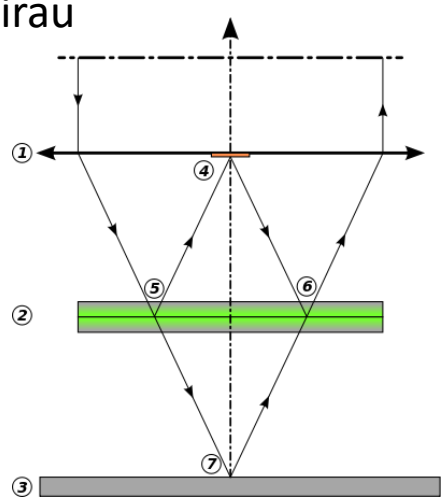
Sagnaca



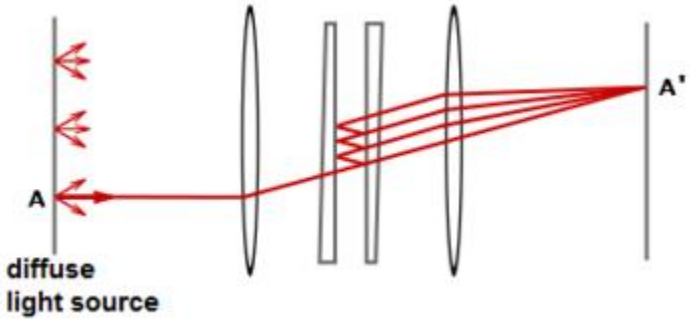
en.wikipedia.org

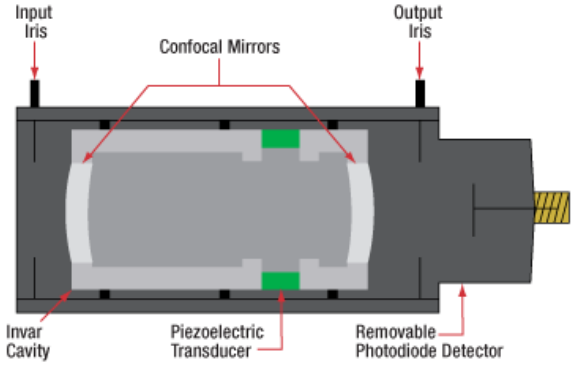
Interferometry

Mirau



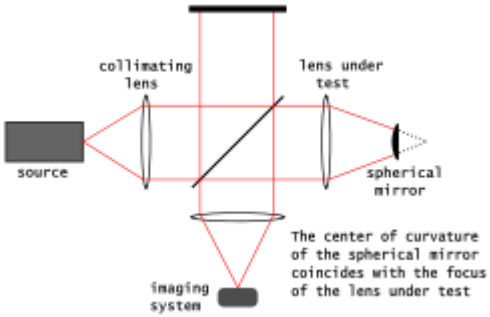
Fabry-Perot





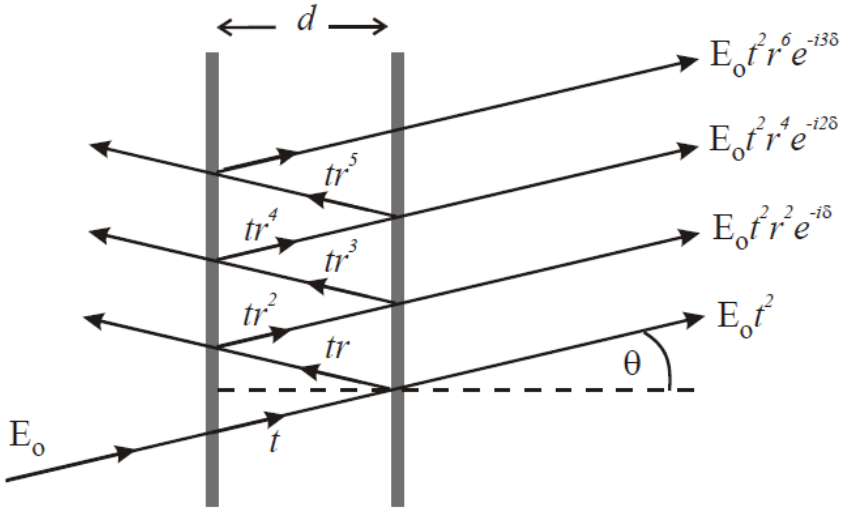
www.thorlabs.com

Twymana-Greena



en.wikipedia.org

Interferometr Fabry-Perot



Różnica faz: $\delta = \frac{2\pi}{\lambda} 2d\cos\theta$

$$E_t = E_0 t_1 t_2 e^{-i\omega t} + E_0 t_1 t_2 r_1 r_2 e^{-i(\omega t-\delta)} + E_0 t_1 t_2 r_1^2 r_2^2 e^{-i(\omega t-2\delta)} + \ldots etc.$$

$$E_t = E_0 t_1 t_2 e^{i\omega t}\left[\frac{1}{1 - r_1 r_2 e^{i\delta}}\right]$$

$$I_t = E_t E_t^* = E_0^2 t_1^2 t_2^2\left[\frac{1}{1 + r_1^2 r_2^2 - 2r_1 r_2\cos\delta}\right]$$

Interferometr Fabry-Perot

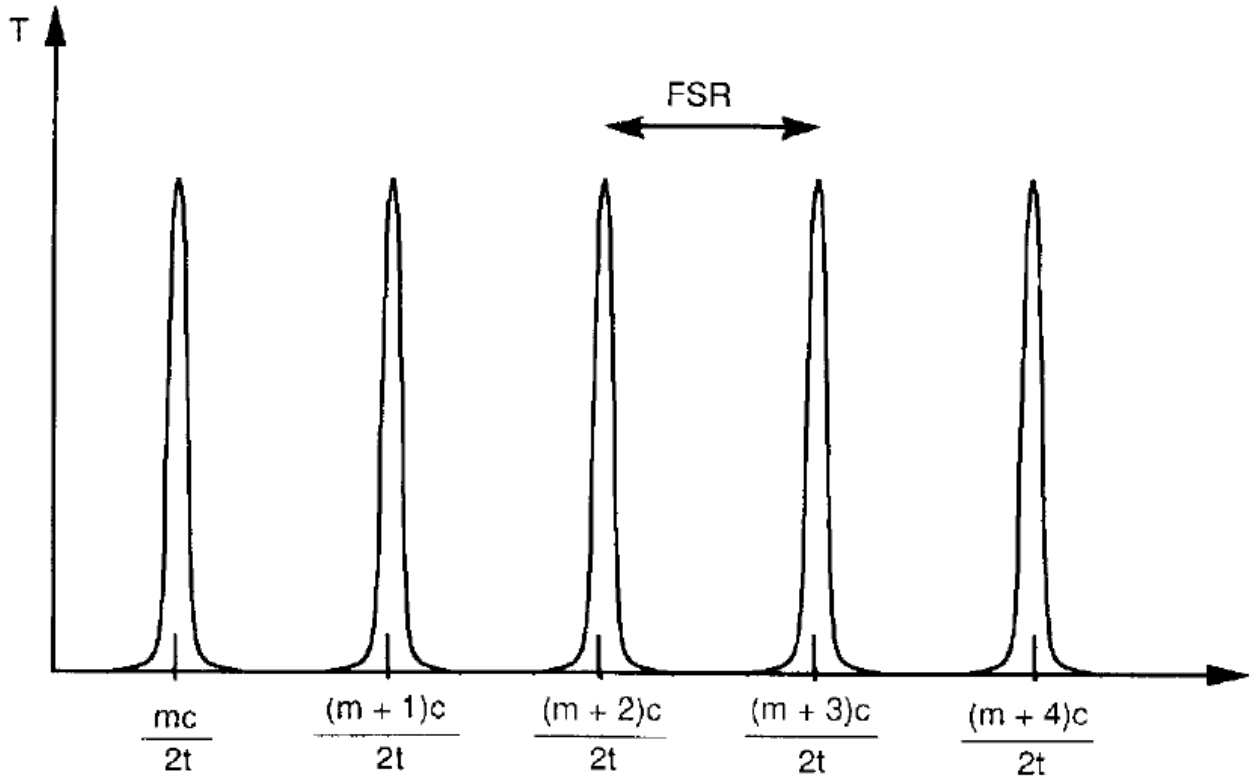
$$E_0^2 = I_0 \ , \ r_1 r_2 = R \ \text{and} \ t_1 t_2 = T, \ \text{and} \ \cos\delta = (1 - 2\sin^2\delta/2)$$

$$I_t = I_0 \frac{T^2}{(1-R)^2}\left[\frac{1}{1+\frac{4R}{(1-R)^2}\sin^2\delta/2}\right]$$

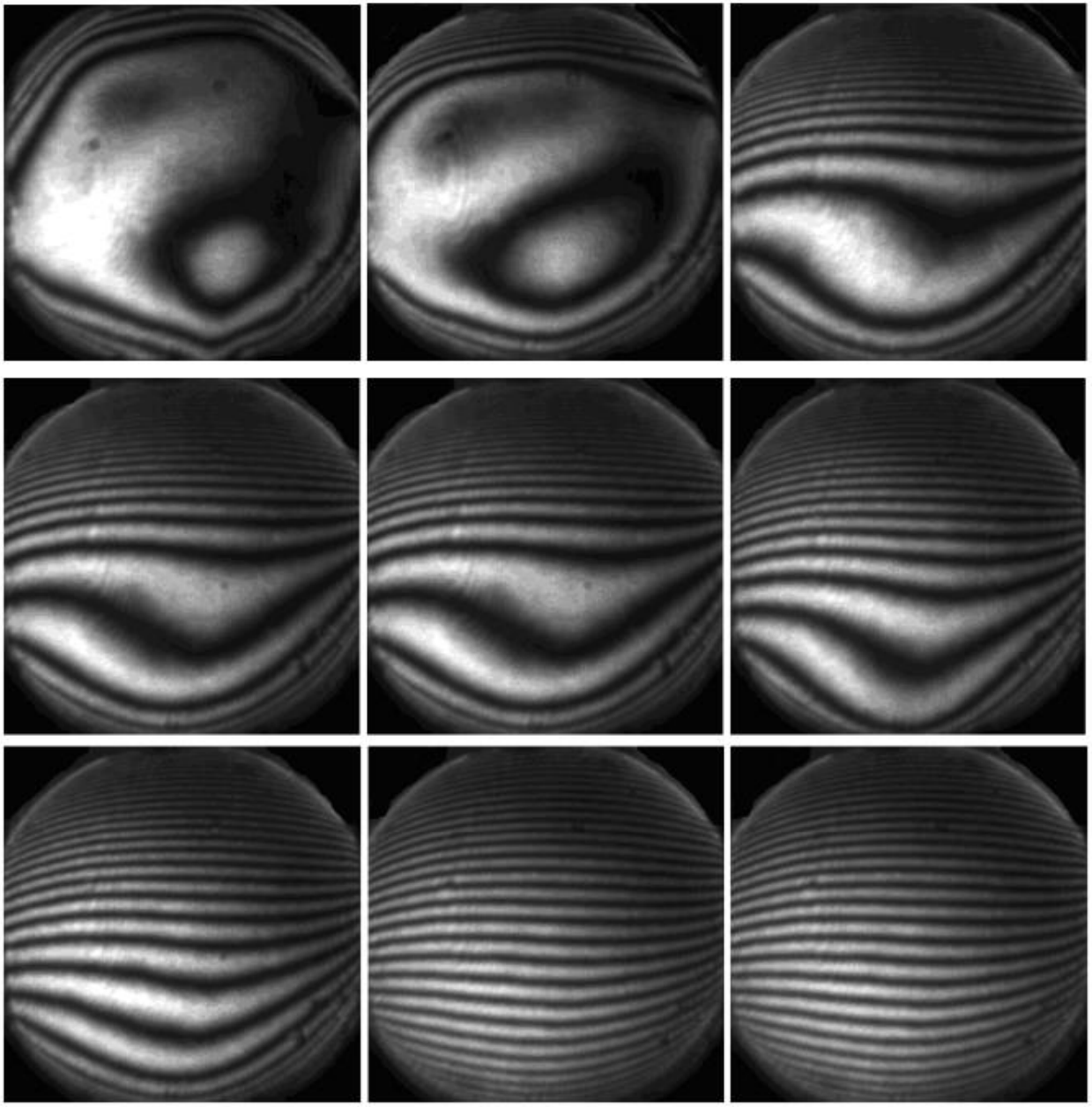
$$T = (1 - R)$$

$$\frac{4R}{(1-R)^2} = \Phi$$

$$I_t = I_0\left[\frac{1}{1+\Phi\sin^2\delta/2}\right]$$



Analiza interferogramu



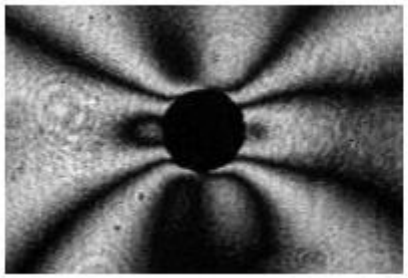
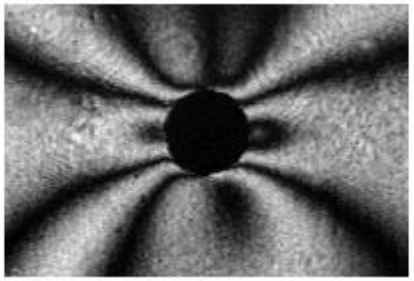
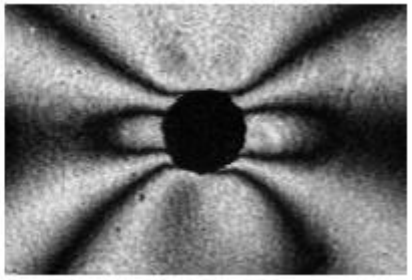
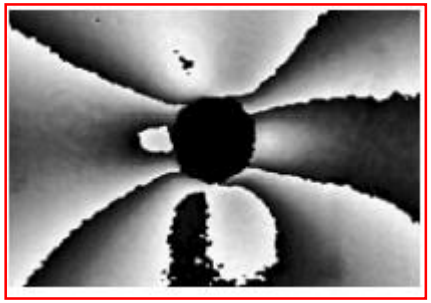
www.docsity.com/en/sample-interferograms-optical-measurement-techniques-in-thermal-sciences-lecture-notes/317111/

Analiza interferogramu

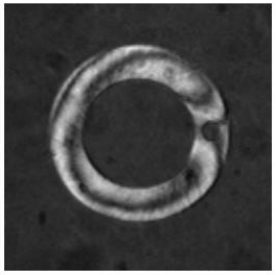
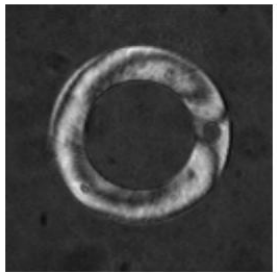
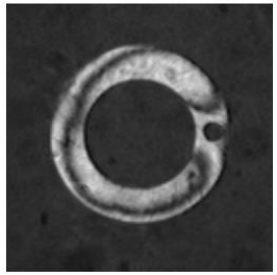
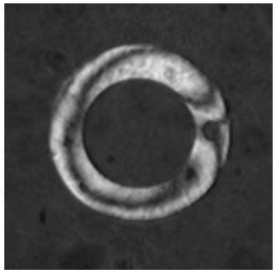
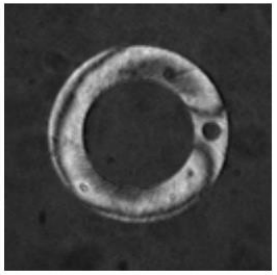
- Przesunięcie fazy

$$\alpha_i = \frac{i2\pi}{N} \quad \text{gdzie } i = 1,.....N$$

$$\Delta\alpha = \frac{2\pi}{3}\ [\text{rad}] \qquad \overline{\Phi} = \operatorname{arctg}\left[\sqrt{3}\,\frac{I_1 - I_3}{2I_2 - I_1 - I_3}\right] \quad \text{gdy} \quad \alpha_1 = \frac{2\pi}{3};\ \alpha_2 = 0;\ \alpha_3 = \frac{2\pi}{3}$$

$$\overline{\Phi} = \arctan\left[\frac{2(I_2 - I_4)}{2I_3 - I_1 - I_5}\right], \quad \text{gdy} \quad \alpha_1 = -\pi;\ \alpha_2 = -\frac{\pi}{2};\ \alpha_3 = 0;\ \alpha_4 = \frac{\pi}{2};\ \alpha_5 = \pi$$

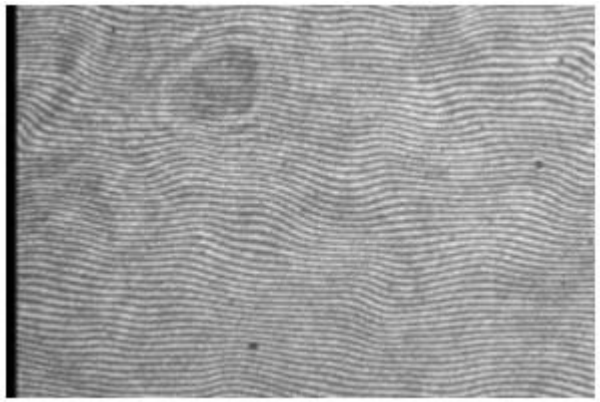






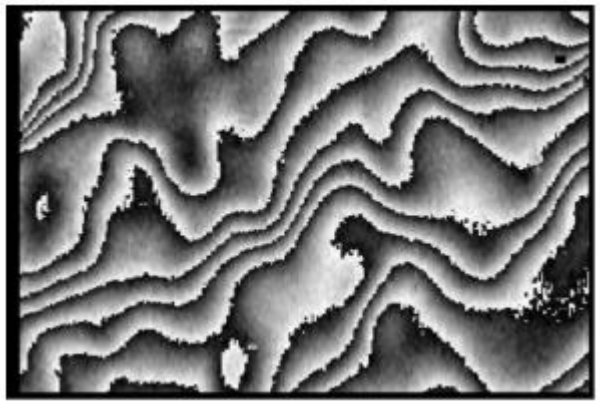

Analiza interferogramu

- Dodanie częstości nośnej $f_0 = \frac{M}{4}$ gdzie M jest rozdzielczością matrycy detektora

$$\phi(x,y) = \frac{\lambda}{2\pi}\arctan\left[\frac{\sqrt{4\left[I(x-1,y)-I(x+1,y)\right]^2-\left[I(x-2,y)-I(x+2,y)\right]^2}}{2I(x,y)-I(x-2,y)-I(x+2,y)}\right]$$

gdzie $I(x+i,y)$ jest natężeniem światła w pikselach i=-2, -1, 0, +1, +2





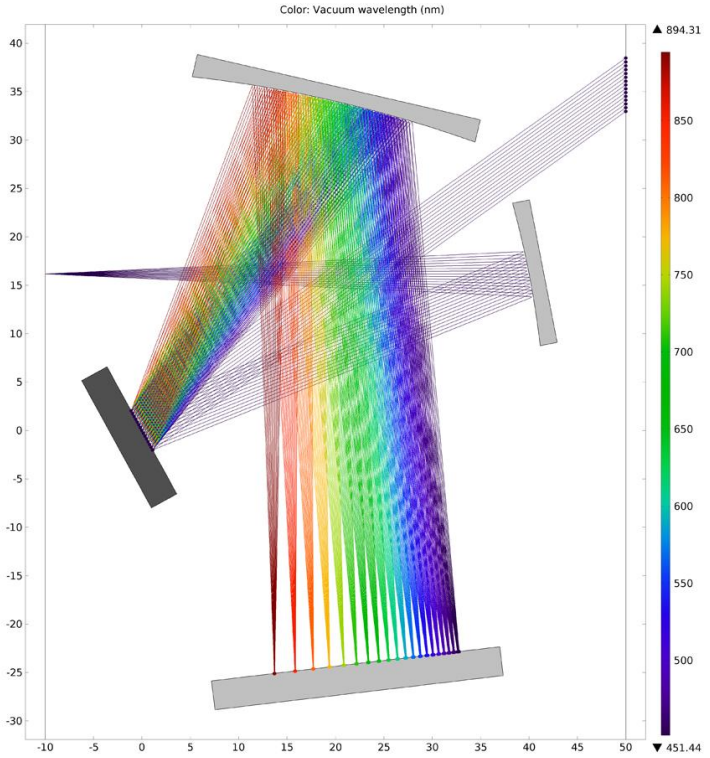
Poprawianie obrazu prążków

zto.mchtr.pw.edu.pl/download/18.pdf

Spektroskopia

W klasycznym spektroskopie – siatka dyfrakcyjna

- Detektor – linijka
- Pojedynczy detektor
  - skanowanie po λ
  - Interferencja + analiza Fourierowska



www.comsol.de/ray-optics-module

Spektroskopia Fourierowska

FTIR (Fourier Transform Infrared Spectroscopy)

Interferencja fal o różnych częstościach jest inna, bowiem dla tej samej drogi x, różnica faz jest inna, czyli w I(x) dla różnych długości fal zawarta jest informacja o WIDMIE.

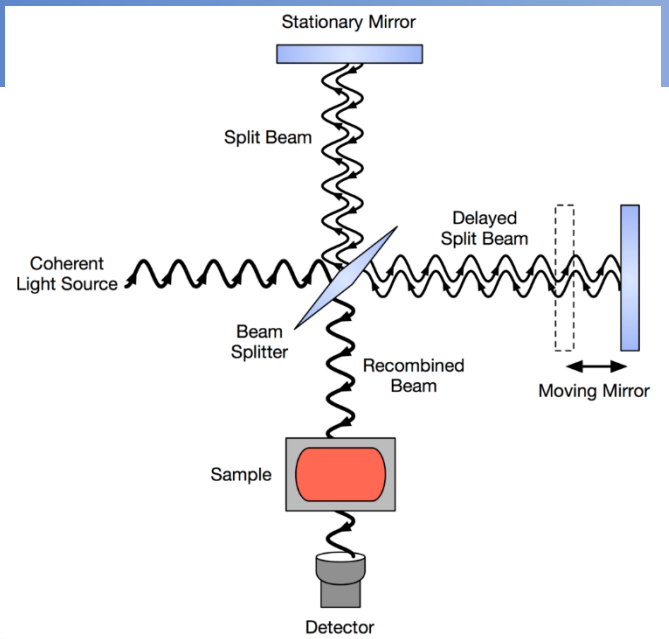
$$I(x) = \int_0^\infty 2I(\tilde{\nu})R(\tilde{\nu})T(\tilde{\nu})(1 + cos2\pi\tilde{\nu}x)d\tilde{\nu}$$

$I(\tilde{\nu})$ - intensywność promieniowania o częstości *v*
$R(\tilde{\nu})$ - współczynnik odbicia
$T(\tilde{\nu})$ - współczynnik transmisji

$$F(x) = \int_0^\infty 2I(\tilde{\nu})R(\tilde{\nu})T(\tilde{\nu})(1 + cos2\pi\tilde{\nu}x)d\tilde{\nu}$$

$$A(\tilde{\nu}) = 2I(\tilde{\nu})R(\tilde{\nu})T(\tilde{\nu})$$

$$A(\tilde{\nu}) = 2\int_{-\infty}^\infty F(x)cos2\pi\tilde{\nu}xdx$$ Transformata Fouriera



$$T(\tilde{\nu}) = \frac{A_{pr}(\tilde{\nu})}{A_0(\tilde{\nu})}$$ Widmo transmisyjne

A_{pr} – FT interferogramów z próbką
A_o – FT bez próbki