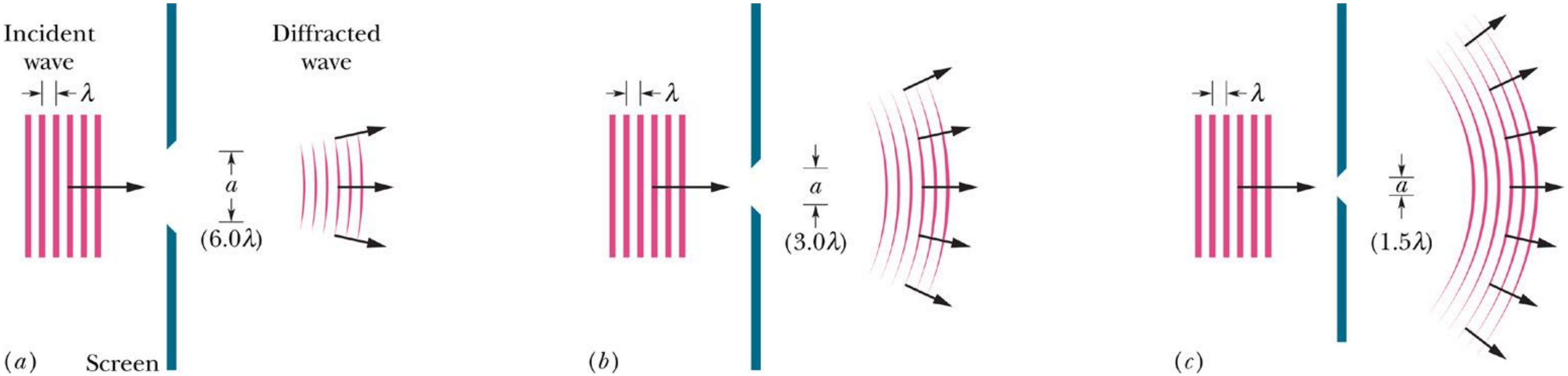
Copyright statement

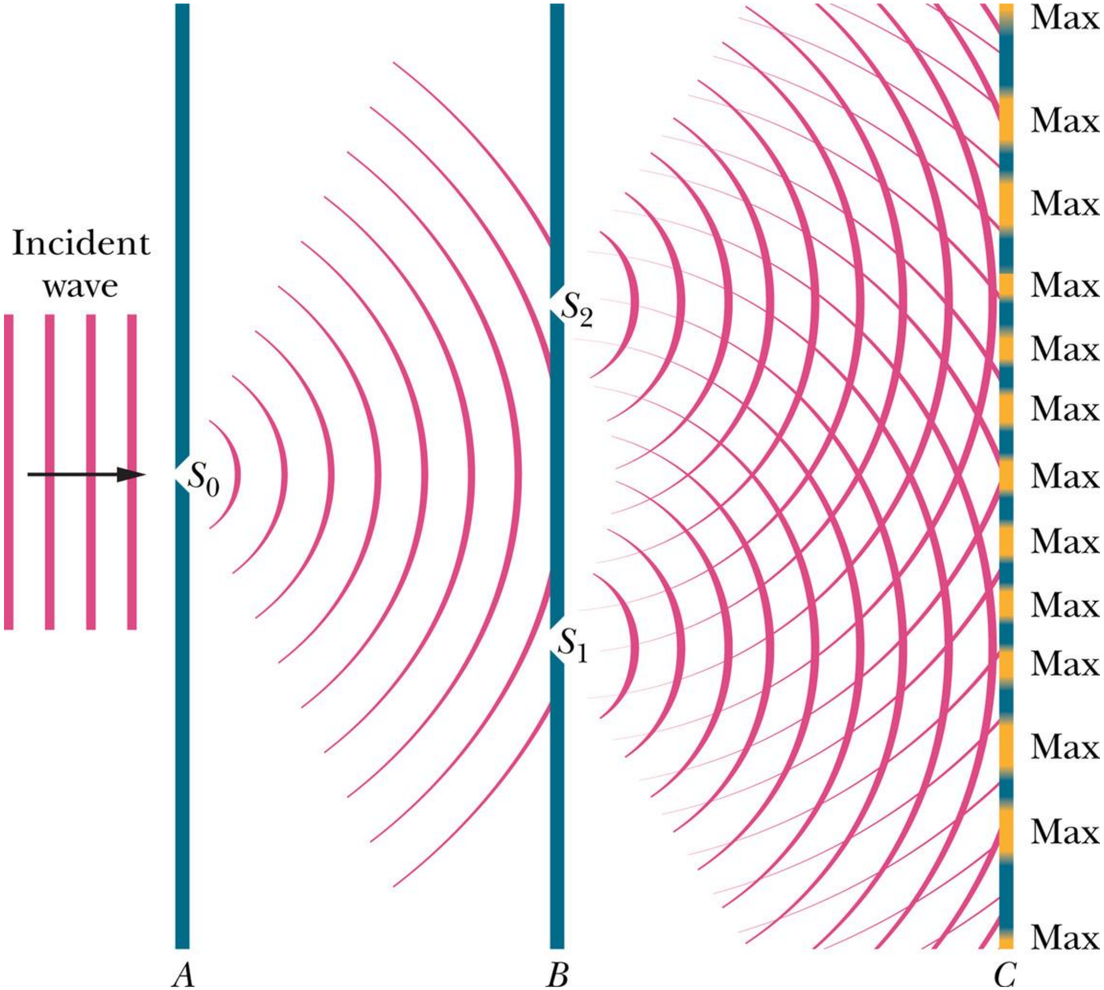
- The images and the pictures in this lecture are provided by the CDs accompanied by the books
  1. University Physics, Bauer and Westfall, McGraw-Hill, 2011.
  2. Principles of Physics, Halliday, Resnick, and Walker, Wiley, 8^{th} and 9^{th} Ed.
- The rest is made by me.

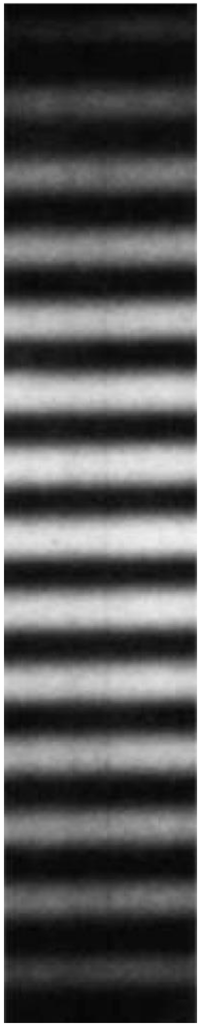
Geometric optics vs. wave optics

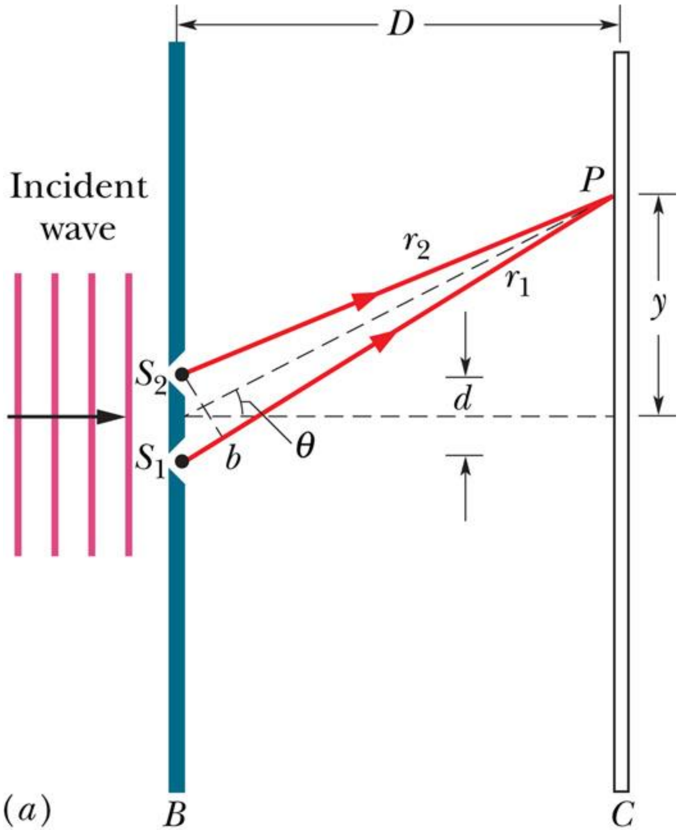
1. Geometric optics : 빛은 직진, 반사, 굴절한다.
2. Wave optics : 빛은 간섭과 회절을 한다.



Young’s double slit experiment







(a)

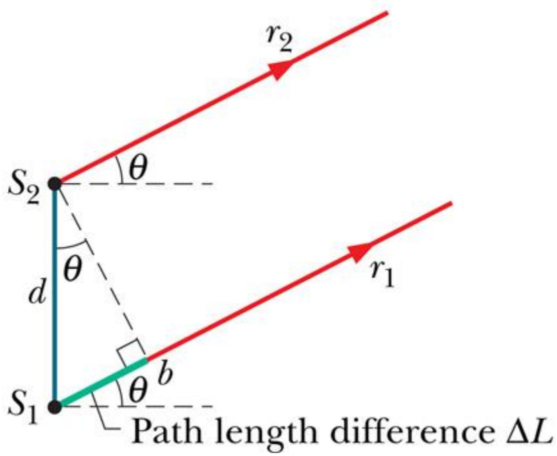
Path difference $\Delta L = d \sin\theta$

Maximum (bright fringes)

$$d \sin\theta = m\lambda, \quad m = 0, 1, 2, \cdots$$

Minimum (dark fringes)

$$d \sin\theta = \left(m + \frac{1}{2}\right)\lambda, \quad m = 0, 1, 2, \cdots$$



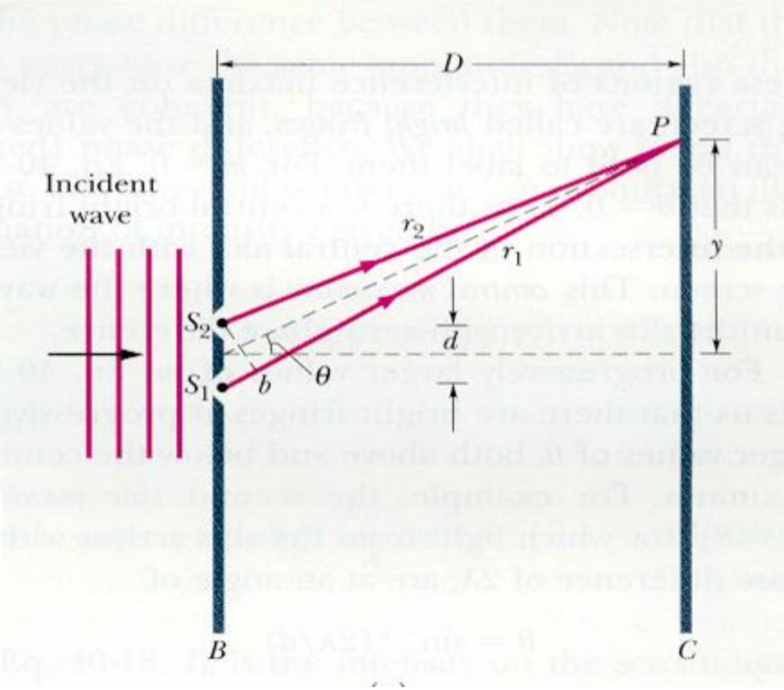
(b)

$$\tan\theta \approx \theta = \frac{y_m}{D} \qquad \sin\theta \approx \theta = \frac{m\lambda}{d}$$

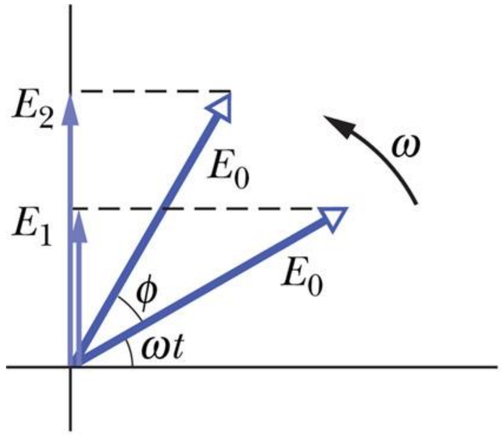
$$\Delta y = y_{m+1} - y_m = \frac{\lambda D}{d}$$

밝은 무늬, 혹은 어두운 무늬 사이의 간격은 일정

Interference: coherent source and superposition principle

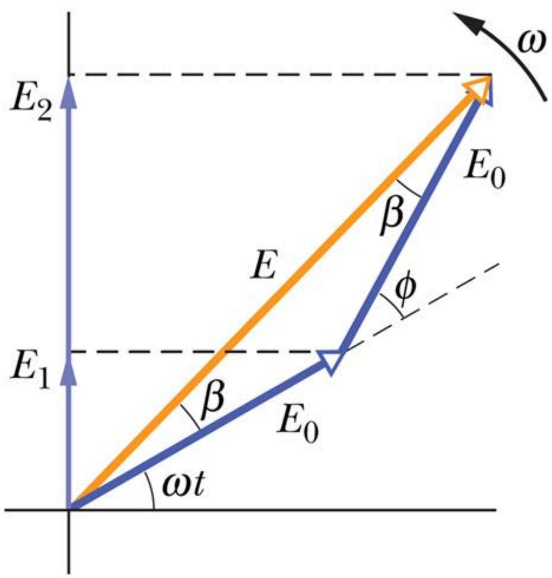


Intensity of double slit interference



(a)

$$E_1 = E_0 \sin \omega t, \quad E_2 = E_0 \sin(\omega t + \phi)$$



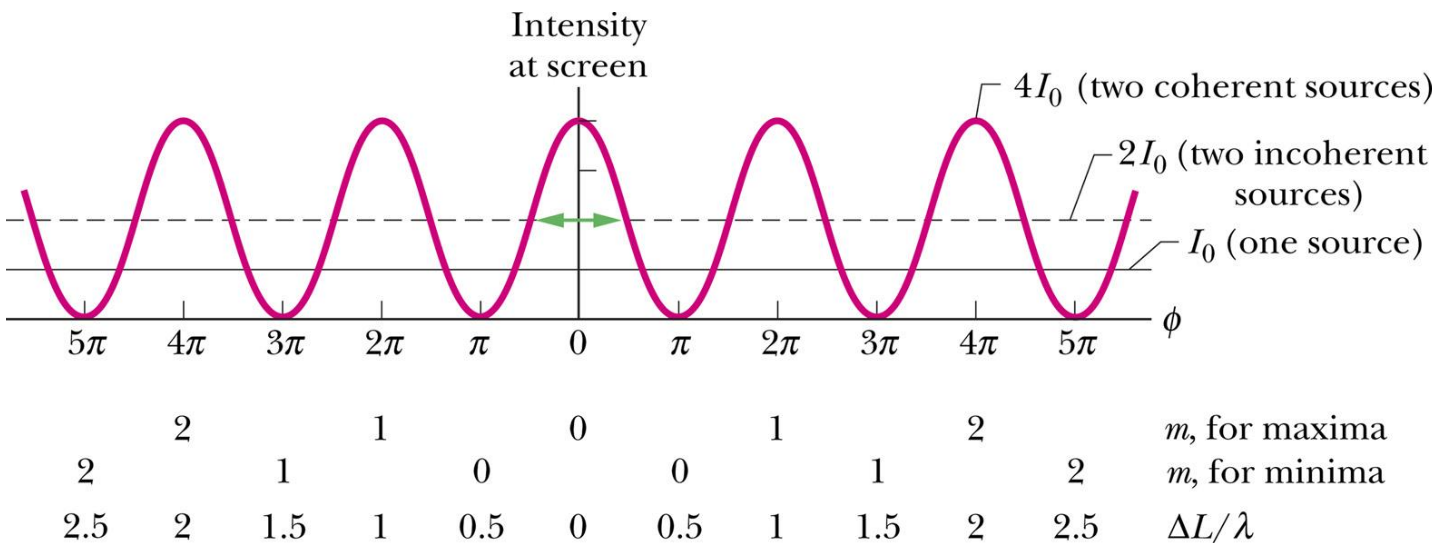
(b)

$$E = 2E \cos \beta = 2E_0 \cos \frac{\phi}{2} \longrightarrow E^2 = 4E_0^2 \cos^2 \frac{\phi}{2}$$

$$\frac{I}{I_0} = \frac{E^2}{E_0^2} \longrightarrow I = 4I_0 \cos^2 \frac{\phi}{2}$$

$$\text{위상차} = \frac{2\pi}{\lambda}(\text{경로차}) \longrightarrow \phi = \frac{2\pi d}{\lambda} \sin \theta$$

Intensity of interference pattern



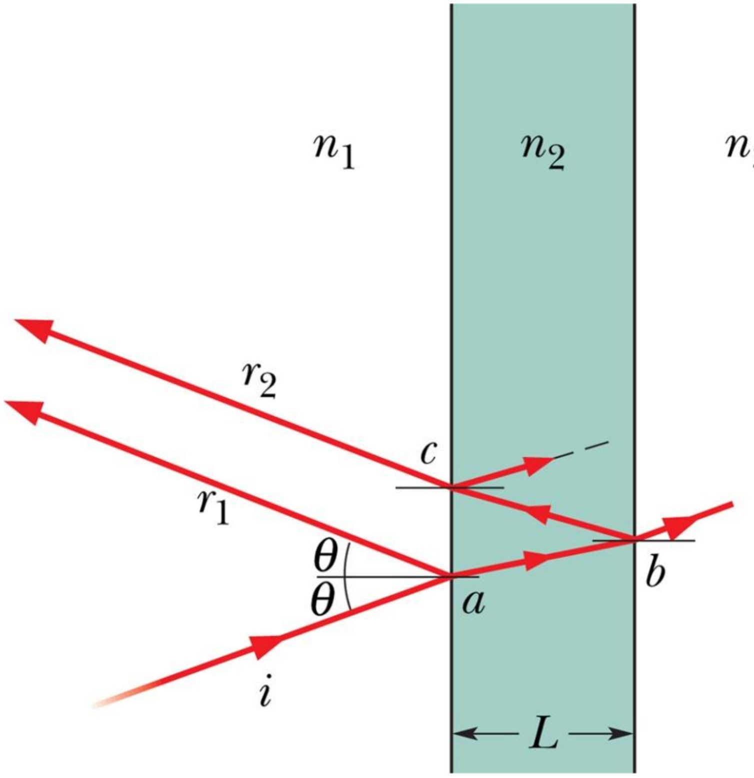
$$I = 4I_0 \cos^2 \frac{\phi}{2}$$

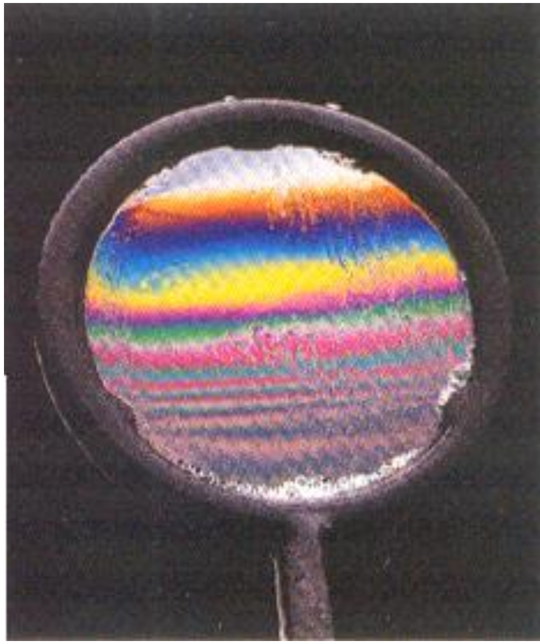
$$\phi = \frac{2\pi d}{\lambda} \sin\theta$$

$$\frac{\phi}{2} = m\pi \rightarrow 2m\pi = \frac{2\pi d}{\lambda} \sin\theta$$

$$d \sin\theta = m\lambda$$

Thin film interference

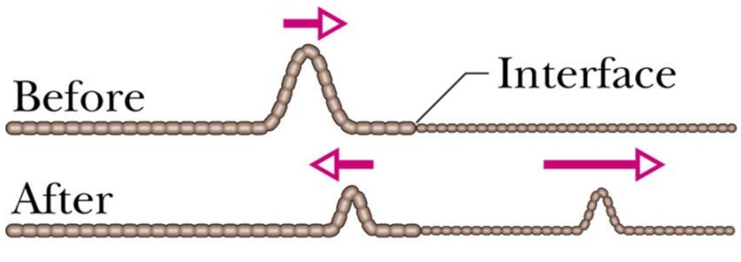




$2L \approx m\lambda$ 이면 보강간섭인가?

경계면에서 반사할 때 빛의
위상에 변화가 있는가? 그렇다!

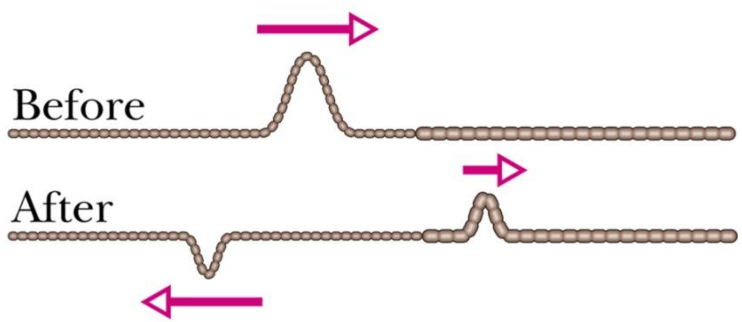
반사에 의한 위상변화



(*a*)

속도가 작은 곳에서 파동이 오며
반사될 때 위상차이는 없다.

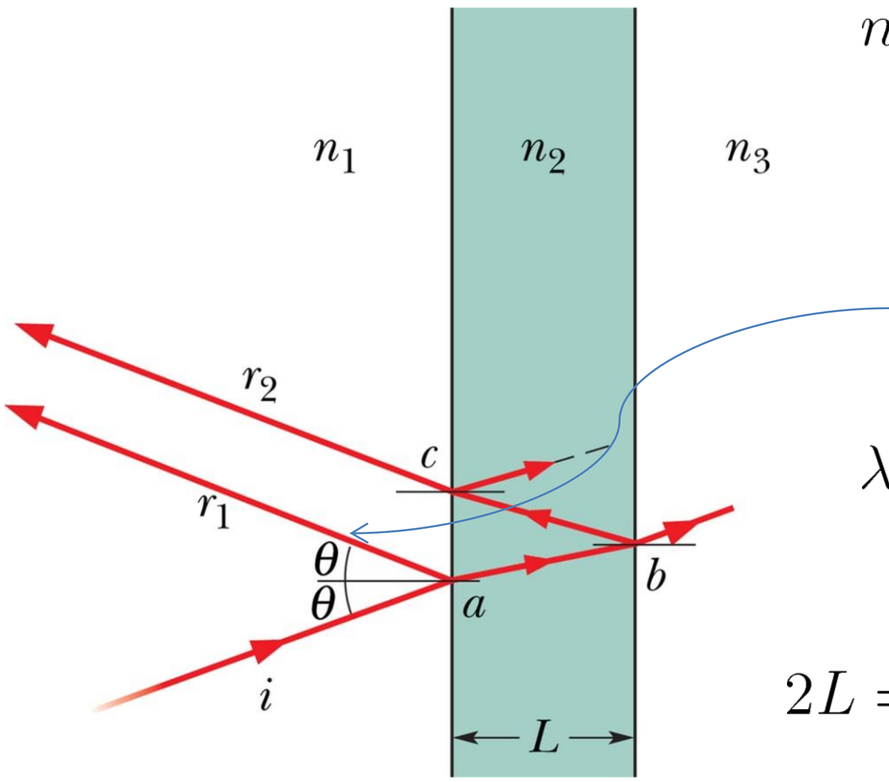
(굴절률이 큰 곳)



(*b*)

속도가 큰 곳에서 파동이 와서
반사될 때 180도의 위상차이가 있다.

굴절률이 작은 곳에서 파동이 와서 큰 곳의 경계면에서
반사될 때에만 180도의 위상차이가 생긴다.



$$n_1 = n_3 < n_2$$

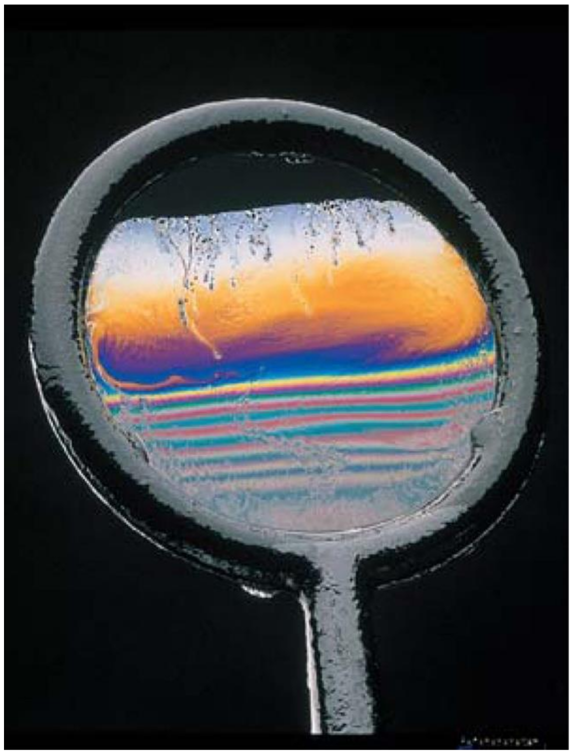
이 파동만 180도의 위상차이가 있다.

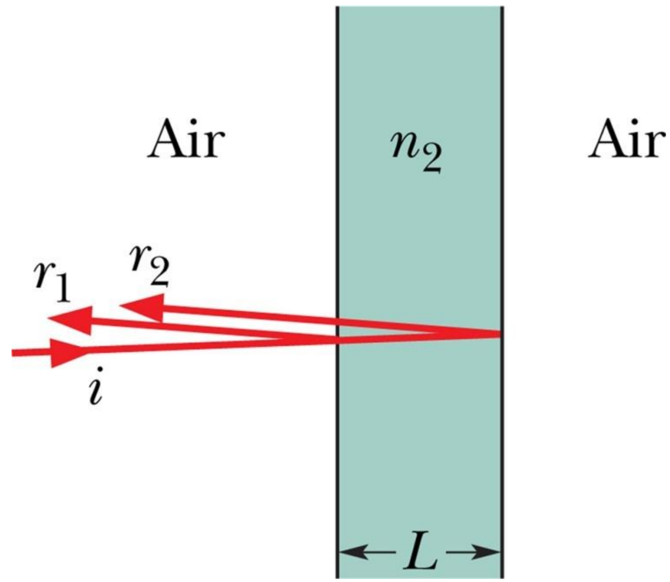
$$\lambda_n = \lambda \frac{v}{c} = \frac{\lambda}{n}$$

$$2L = \left(m + \frac{1}{2}\right)\frac{\lambda}{n_2}$$ 보강간섭

$$2L = m\frac{\lambda}{n_2}$$ 상쇄간섭

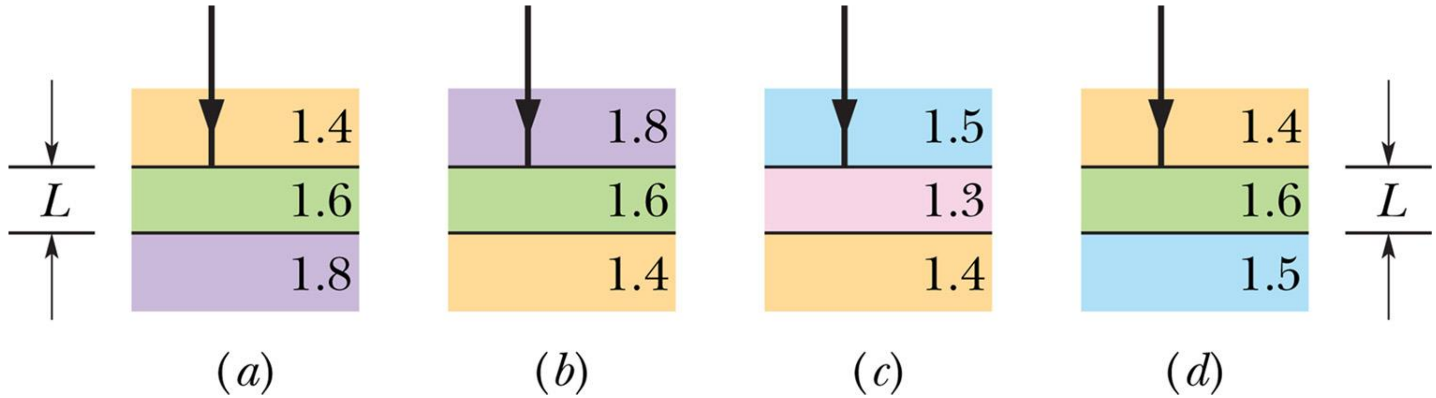
Very thin film



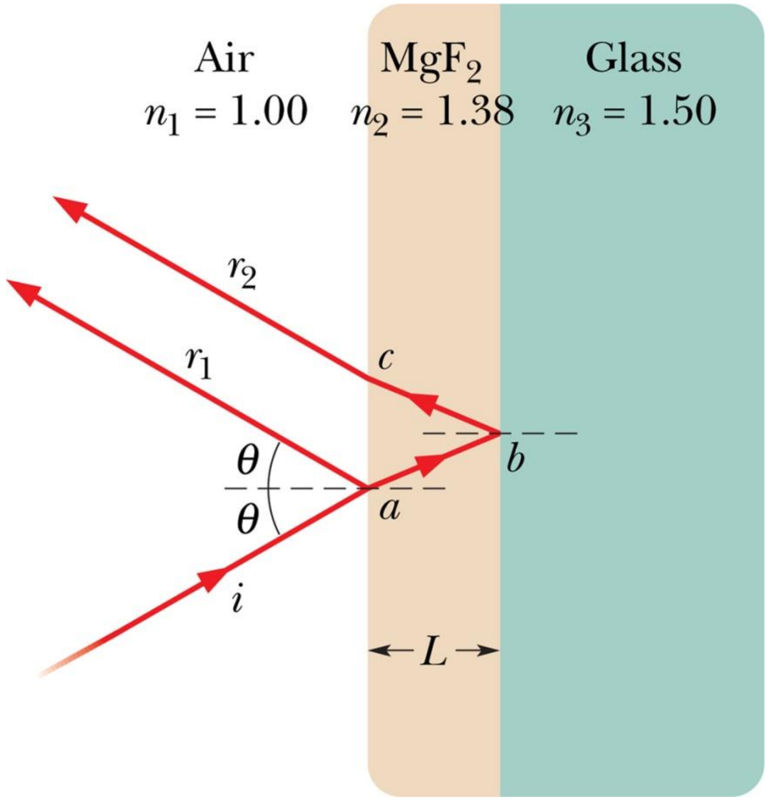


$2L \ll \lambda$ 상쇄간섭만 생김

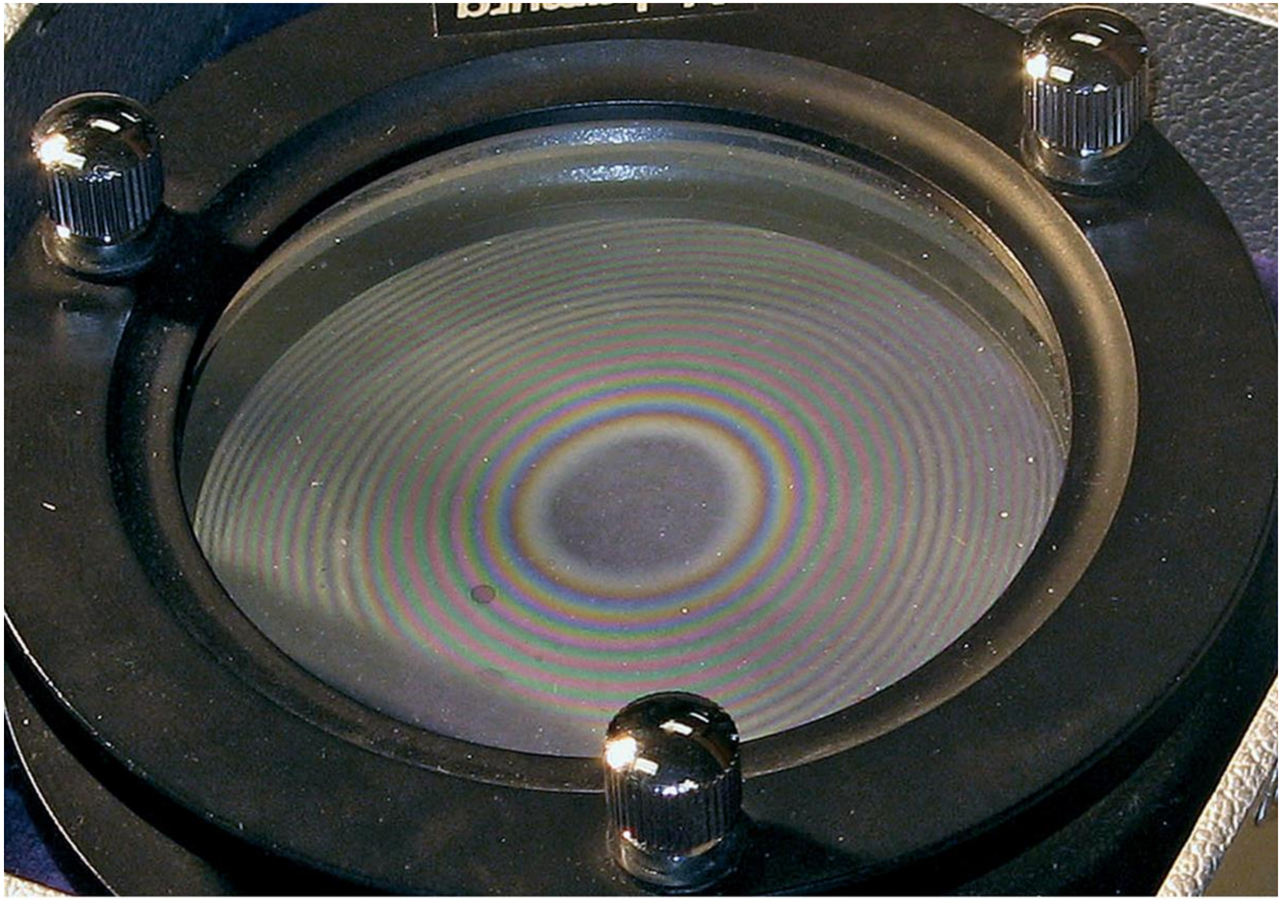
Phase differences

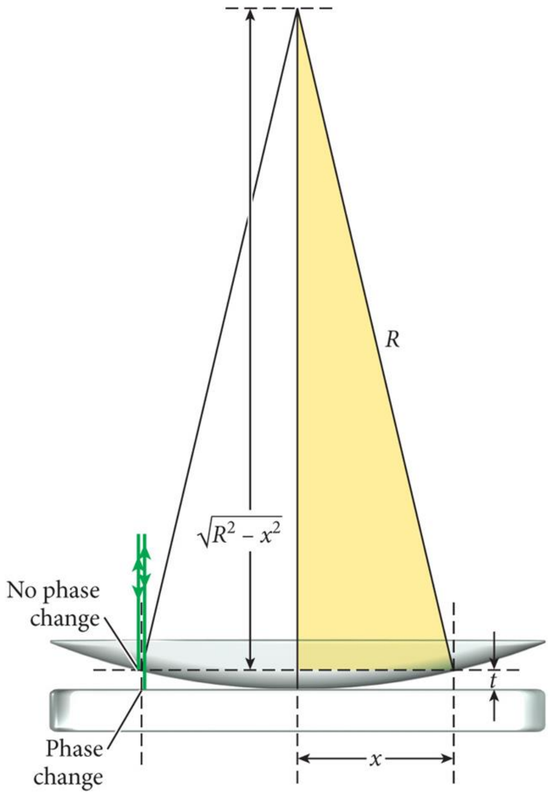


Lens coating



Newton's rings





$$t = R - \sqrt{R^2 - x^2} = R - R\sqrt{1 - (\frac{x}{R})^2}$$

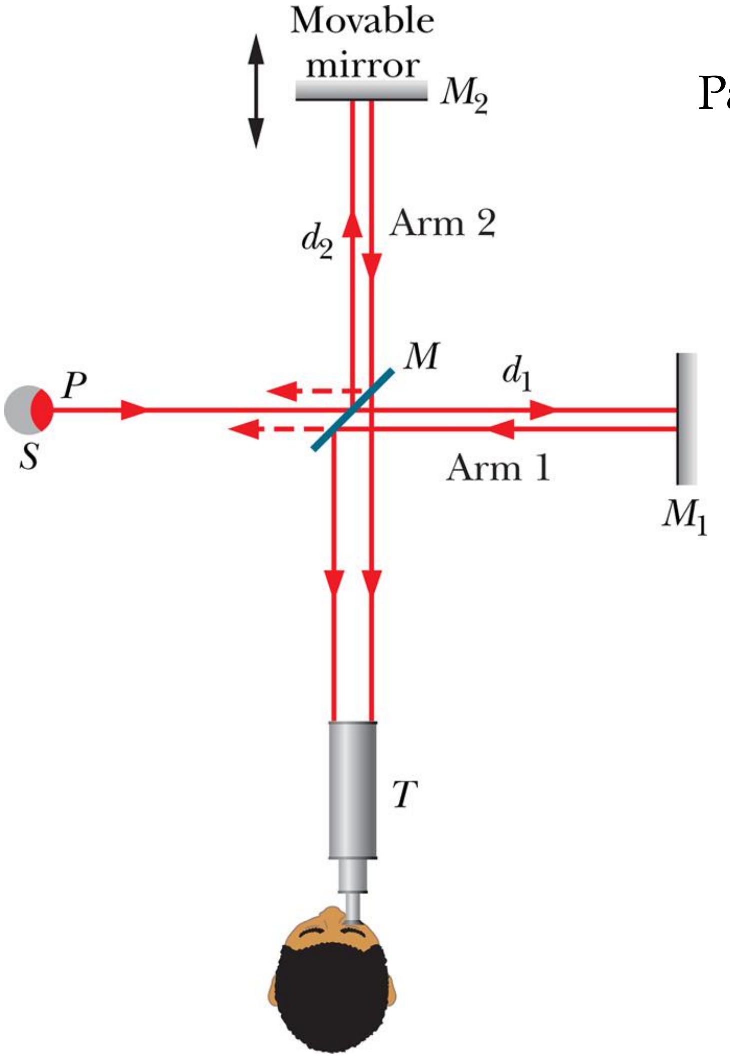
$$t \approx \frac{1}{2}\frac{x^2}{R}$$

For constructive interference,

$$2t = \frac{x_m^2}{R} = \left(m + \frac{1}{2}\right)\lambda \quad (m = 0, 1, 2, \cdots)$$

$$x_m = \sqrt{R\left(m + \frac{1}{2}\right)\lambda} \quad (m = 0, 1, 2, \cdots)$$

Michelson interferometer



Path difference $= 2(d_1 - d_2) \leftrightarrow \Delta M_2$

굴절률이 n인 물체 삽입

물체 안에서 왕복하는 경로
안의 파장수

$$N_m = \frac{2L}{\lambda_n} = \frac{2Ln}{\lambda}$$

물체가 없을 때 물질을
왕복하는 경로 안의 파장수

$$N_a = \frac{2L}{\lambda}$$

$$N_m - N_a = \frac{2L}{\lambda}(n-1)$$