Phys 2310 Fri. Nov. 18, 2016
Today's Topics

- Continue Chapter 3: Interference
- Reading for Next Time

Reading this Week

By Mon.:

Finish Ch. 3 and Y&F Ch. 35

Amplitude-splitting Interferometers, Type of Fringes, Multiple Beam Interference, Single and Multi-layer Films, Applications

Homework this Week

By Mon. Nov. 13:

Y&F Chapter 33: 33.33, 33.34, 33.36

Y&F Chapter 35: 35.32, 35.38, 35.41, 35.43, 35.45, 35.59

Multiple Beam Interference

- **A partially reflective film can generate multiple reflections without too much loss**
  - **Fig. 9.36 shows one possible case**
    - **We can compute the amplitude of the reflected waves via a geometric series**
      - **Result is that first reflection is reduced so transmission is enhanced.**

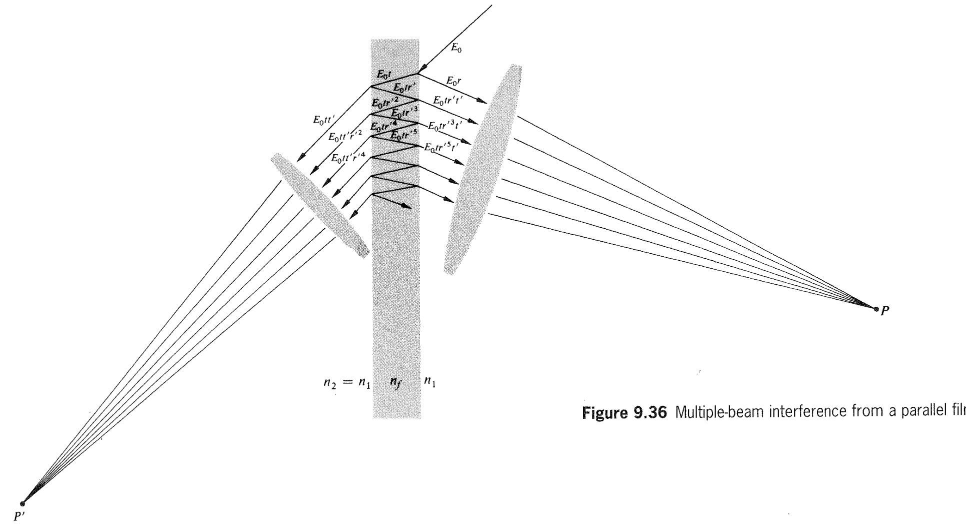


Figure 9.36 Multiple-beam interference from a parallel film.

Recall that the difference in the optical path length for adjacent rays is:

$OPL = 2n_f d\cos\theta_t$ (see derivation for fringes of equal inclination)

Note that each ray (except 1-st) undergoes an odd number of reflections within the film

This means that all but the first reflection will be in phase and we can add them:

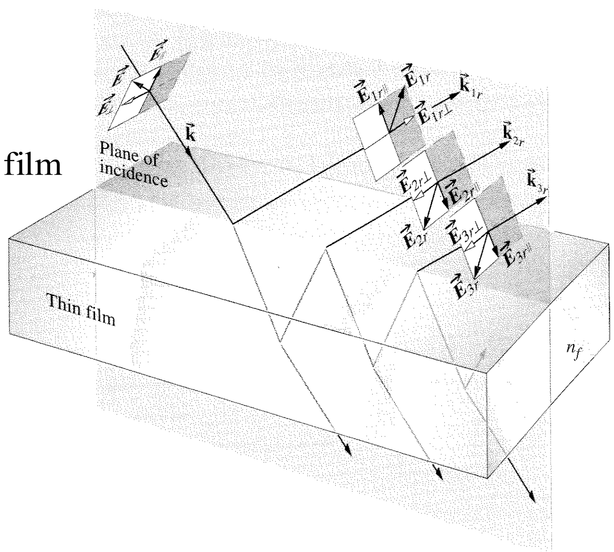
$E_{0r} = E_{0r} - (E_{0trt'} + E_{0tr^3t'} + E_{0tr^3t'} + \ldots)$ or:

$E_{0r} = E_{0r} - E_{0trt'}(1 + r^3 + r^5 + \ldots)$ but geometric series converges so we have:

$$E_{0r} = E_{0r} - \frac{E_{0trt'}}{(1-r^2)}$$

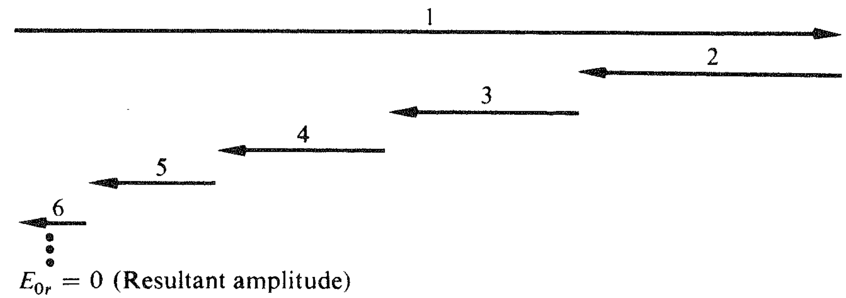
One special case occurs when $OPL = m\lambda$. In this case, $tt' = 1 - r^2$ and so

$E_{0r} = 0$ and the sum of the successive waves cancels the first.



Multiple Beam Interference-II

- **Phasors provide a nice geometric illustration of multiple beam interference**
  - **The previous example is illustrated at right.**
  - **A second special case occurs when the OPL = (m+1/2)λ**
    - **First and all even-numbered reflections are in phase.**
    - **Result is enhanced reflectivity**



The amplitude is then :

$$E_{0r} = E_{0r} + E_{0trt'} - E_{0tr^3t'} + E_{0tr^5t'} - \ldots \text{ or :}$$

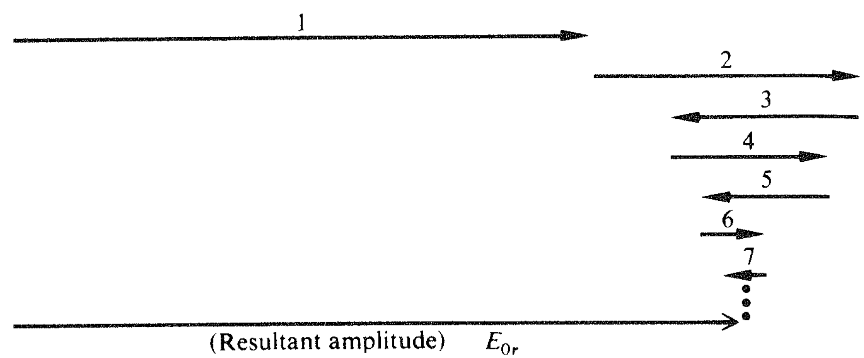
$$E_{0r} = E_{0r} + E_{0trt'}(1 - r^3 + r^5 - \ldots)$$

In this case the geometric series converges to $1/(1+r^2)$ and so :

$$E_{0r} = E_{0r}\left[1 + \frac{tt'}{(1+r^2)}\right] \text{ and since } tt' = 1 - r^2 \text{ we have :}$$

$$E_{0r} = \frac{2r}{(1+r^2)}E_0 \text{ and so the intensity is :}$$

$$I_r = \frac{4r}{(1+r^2)^2}\left(\frac{E_0^2}{2}\right)$$



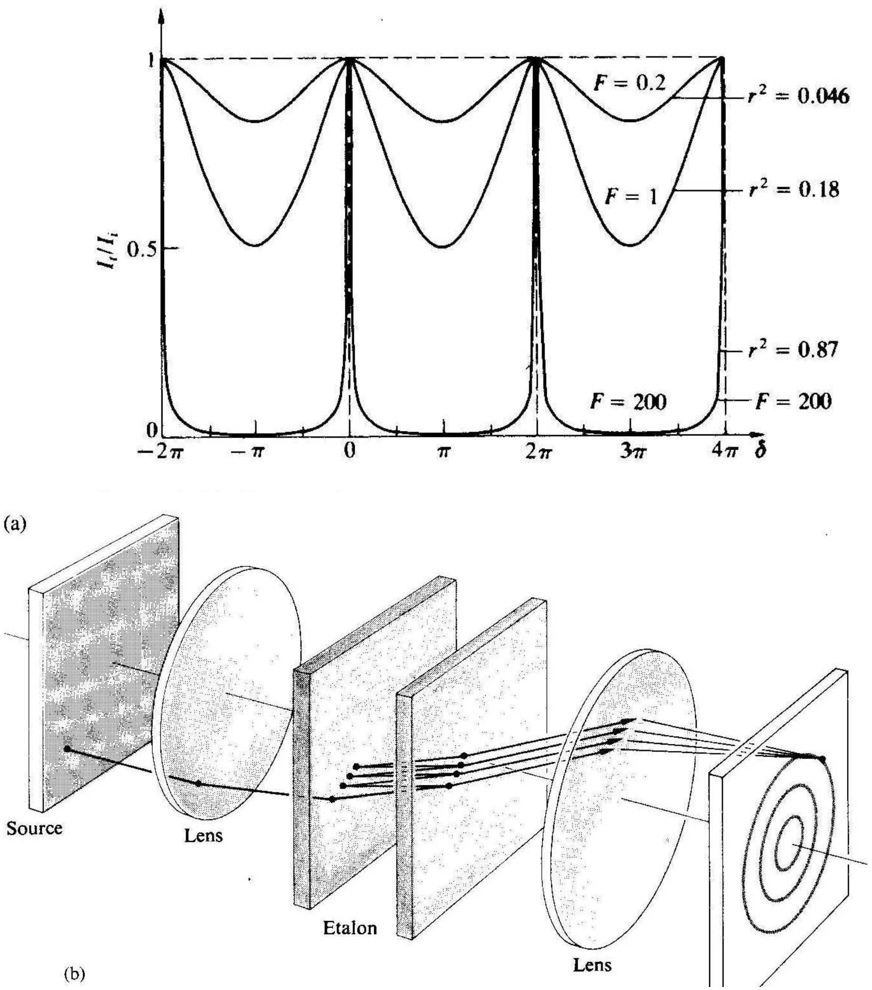
Chapter 3: Interference

- **Amplitude-splitting Interferometers**
  - **Fabry-Perot Interferometer**

A simple and yet powerful instrument for precision measurement of the wavelengths of spectral lines.

Each fringe represents a spectral order (m). Scanning the plate separation allows the interferometer to be scanned in λ.

See the text book for an extensive discussion of the Fabry-Perot interferometer.



(a)

(b)

Chapter 3: Interference

- **Multi-layer Interference Films**

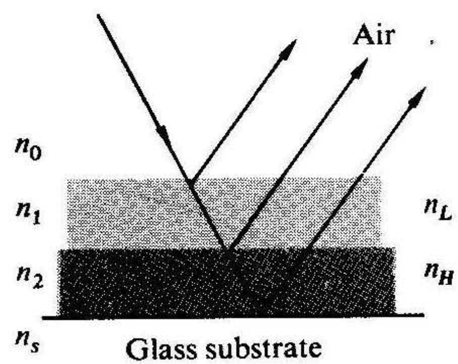
A quarter-wave thickness of lower index material on the surface of glass can reduce the amplitude of the reflected beam

Recall that the OPL is twice the thickness and that there is a phase change of π upon reflection off a higher index material. Specifically:

$\mathbf{n^2_1 = n_0 n_g}$

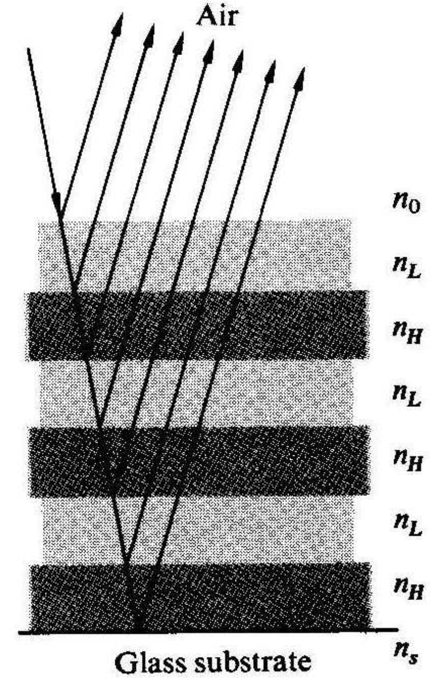
The addition of multiple layers can reduce reflection even further and broaden the wavelength of use.

Many periodic layers can be used to create a Fabry-Perot device known as an interference filter.



$g\,HL\,a$

Double-quarter



$g\,HL\,HL\,HL\,a$
$g(HL)^3a$

Quarter-wave stack

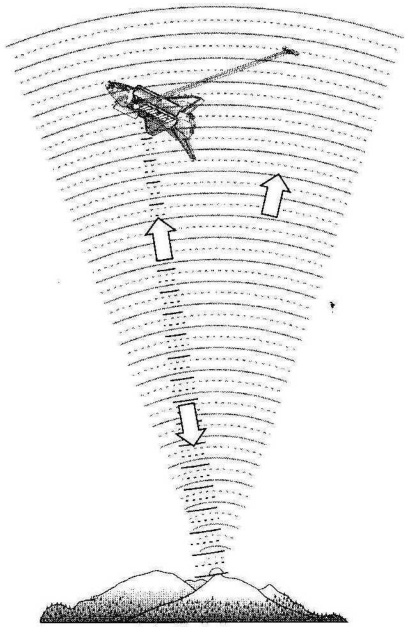
Chapter 3: Interference

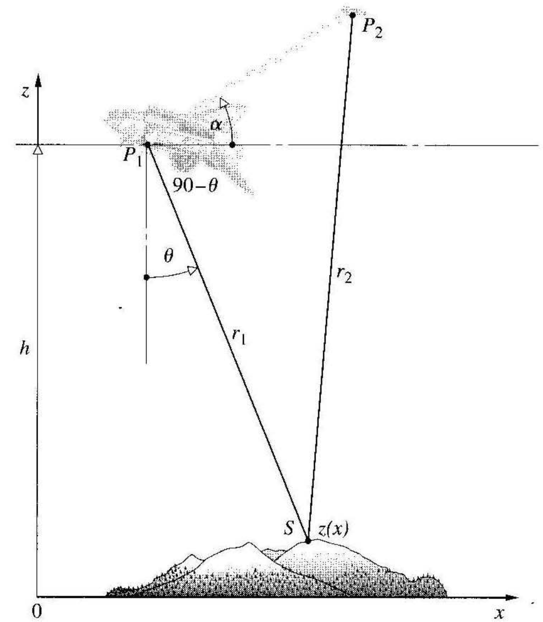
- **Applications of Interferometry**

Radar interferometry is an interesting application.

The emitted beam is reflected from the surface and detected at an offset receiver. This is analogous to the inverse of Young's two-slit experiment.

A Fourier transform of the received signal results in a map of surface elevation.





Chapter 3: Interference

- Other Interferometers
  - Tyman-Green Interferometer
    - Very Useful (a standard) for testing optical components
    - Makes use of a spherical or flat mirror acting as a reference against which optical components can be tested.
  - Rotating Sagnac Interferometer
    - Similar to a Michaelson Interferometer except that the interferometer rotates.
    - The path length change during rotation due to finite speed of light results in a shift of the fringes
    - One application is a "ring laser gyro" (used before GPS on commercial aircraft)

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