PhysicsTutor

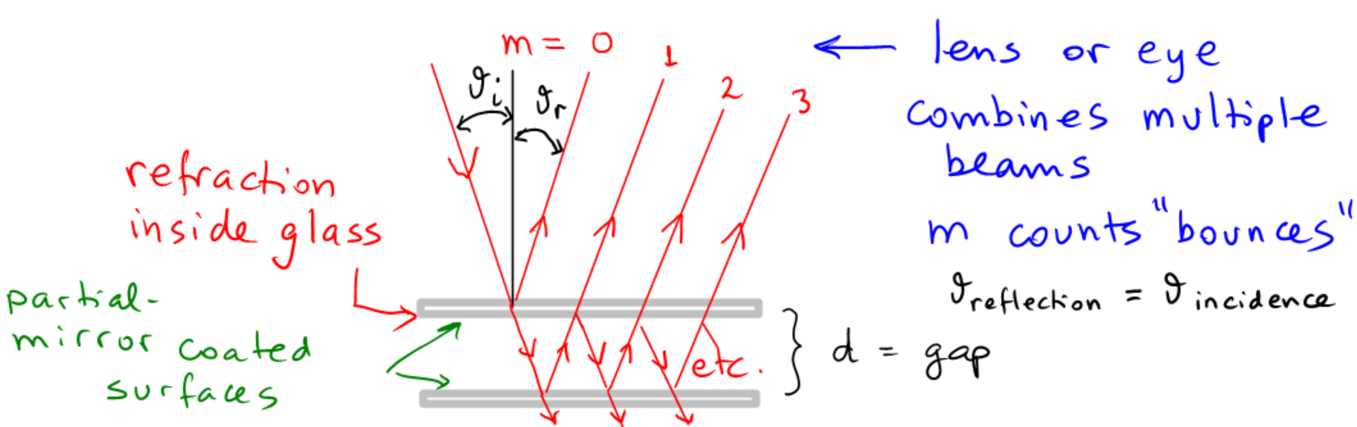
mh

Fabry-Perot Interferometer

Giordano 25.23

Problem:

- Two parallel glass plates with metallic vapour deposited on the inside surfaces form a multiple-beam interferometer (gap = 3.3 μm).
- For nearly-normal incidence, and constructive interference for the waves emitted at the top find all possible λ between 600 and 700 nm.



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- A phase change occurs at the first surface (air-glass) reflection, and also for a bounce inside.
- The added optical path for each bounce is about 2d (d=gap) for near-normal incidence.

$\vartheta_i \approx 0$

Otherwise correct the path length using $\cos\vartheta_i$ factor

Equations associated with ideas:

$$E_{\perp}(x,t) = E_0 \sin(\omega t - kx + \phi) = E_0 \sin\left(\frac{2\pi t}{T} - \frac{2\pi x}{\lambda} + \phi\right)$$

Coherent monochromatic Light = transverse EM wave; intensity $\sim E_0^2$

extra optical path lengths : $\approx 2d \cdot m$ (air inside the gap)
(for m bounces) $\cos\theta_i$ is ≈ 1

$\phi_0 = \pi$ (air-glass reflection)

$\phi_1 = \pi + 2d\frac{2\pi}{\lambda}$ first air-glass reflection at bottom

$\phi_m = \pi + 2d\frac{2\pi}{\lambda}m$ $(+2\pi(m-1))$ doesn't matter

e.g., path $m=2$ has 2 additional phase changes from air→glass reflections

Constructive interference : $\phi_m - \phi_0 = j \cdot 2\pi$ $j = 1, 2, 3, \ldots$

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- The accumulated additional phase for the nth beam equals $(4\pi d/\lambda)\, m$
- Constructive interference with beams for m=1,2,..., but how intense are they?
- Complementary set of beams out of the bottom surface: e.g., top=bright, bottom=dark

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- $d = 3.3\,\mu m = 3300\,nm \;\therefore\; \lambda_j = \frac{6600}{j} \;\therefore\; j = 10 \mathrel{\hat{=}} 660\,nm$
- $\lambda_{11} = 600\,nm$ and $\lambda_{10} = 660\,nm$ inside $[600, 700]$

In 2nd yr optics (course + lab) one proves an important property of multi-beam IF: instead of simple, equally wide bright + dark fringes one obtains narrow super-bright fringes → sharpness yields precision.