Wave optics → vs ray optics ?

1) Chapter 24 in Gio → geometrical (ray) optics explains image formation (high-school physics, but not simple!)
↳ ? optical engineering
→ optometry
ophtalmology } do these fields need wave optics ?

- ray optics is an approximation to wave optics
- we should understand wave optics first!

2) chapter 25 deals with interference phenomena

- Michelson interferometer: split a light wave into two, delay one against the other by adjusting one path length, + superimpose ⇄ dark vs bright fringes
- thin-film interference
- two-slit interference

} all three are quite conventional

- single-slit interference (25.6): EM wave property!

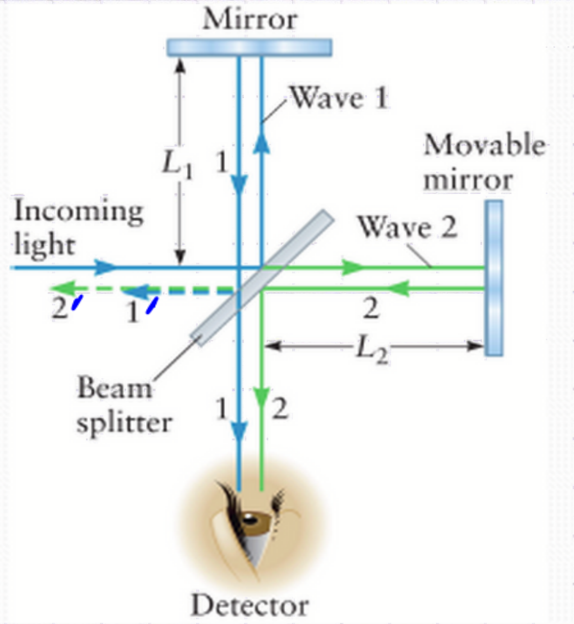
3) photons vs EM waves

Gio 23.3 : EM waves carry momentum (and energy)
28.2 : photons " " "

EM waves represent "ensembles" (groups of identical) particles
some phenomena are only described via the particle picture
→ photoelectric effect (Gio. 28.2)

Feynman 'sum-over-paths' method reconciles both pictures → quantum nature of light

• Michelson IF (Fig 25.3, 25.4)



beam splitter = glass plate with some metal vapor deposited, splits beam into $a\vec{E}_{reflected} + b\vec{E}_{transmitted}$ $(a^2+b^2 = 1)$

It works both ways. Each beam is once transmitted + once reflected when ① + ② combine in eye or ①′ + ②′ back in the source

geometric optics: ① + ② and ①′ + ②′ contain each 50% of the intensity of the incoming light (a = b is NOT required!)

wave optics: add waves: crests combining with crests = constructive IF (crests with troughs: destructive)

At the eye (or back at the source) the intensity varies like $\cos^2$ when $\Delta L = 2(L_2 - L_1)$ changes on the scale of λ_{wave}. Start with $\Delta L = 0$ and change L_2.

Q: is there a scale L_{coh} such that for $\Delta L \gtrsim L_{coh}$ the $\cos^2$ pattern disappears? → defines coherence length for the given light

$t_{coh} = \frac{L_{coh}}{c}$ = coherence time

Michelson with discharge lamp: $L_{coh} \sim 1\,m \quad \therefore t_{coh} \simeq 3 \cdot 10^{-9}\,s$

Light = bursts:

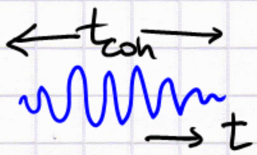
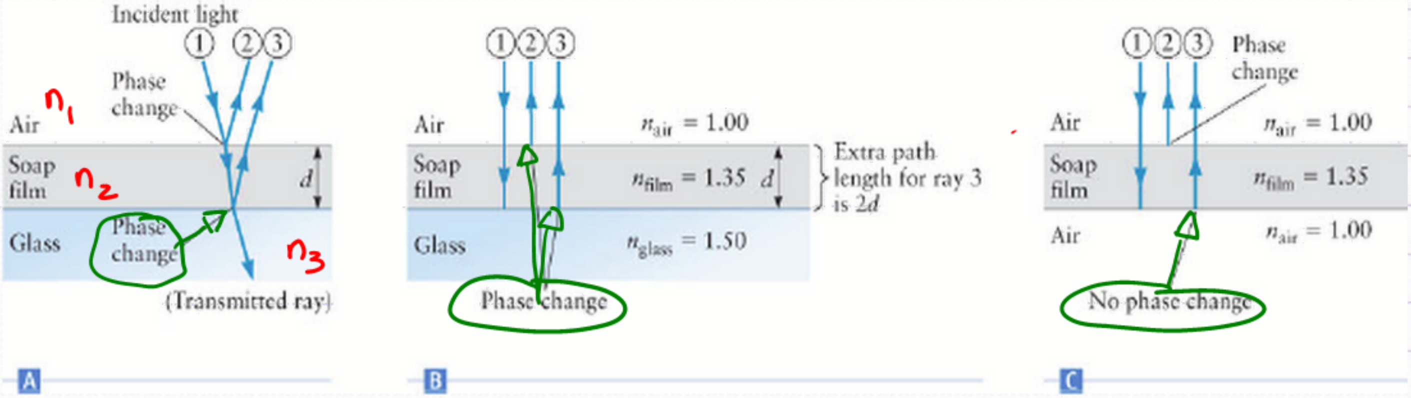


Fig 25.7

• Thin films (25.3)



1) Light travels in medium with speed $c_{med} = c/n$

where n = index of refraction (cf. Snell's law)

For air : $n_{air} \gtrsim 1.00$ almost vacuum.

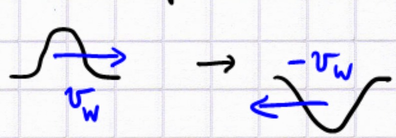
2) Wave propagation explains : how much gets reflected, how much refracted (transmitted into medium) as a function of : angle of incidence ; n_1 vs n_2

(PHYS 4020) → explains, e.g., total internal reflection
→ optical fiber

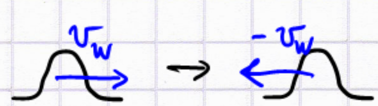
3) Reflection at an n_1/n_2 interface : if $n_2 > n_1$, then a phase change by π occurs!

- this is in analogy to pulses on ropes :

fixed-end reflection



open-end "



4) Note: interference occurs since our eye uses bundles of rays for image formation. Intensity $\sim (\vec{E}_1 + \vec{E}_2 + \dots)^2$