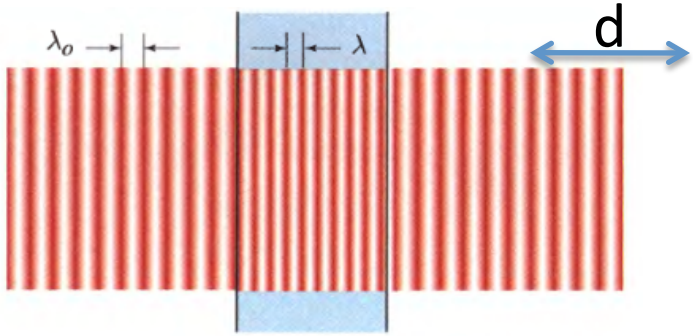
In previous E&M classes, you have probably learned that light going from one medium to another at normal incidence has a transmission coefficient $t_{12} = 2n_2/(n_1+n_2)$



For the piece of dielectric shown below, we found that the transmittance is $t_{z = 0 \text{ to } z = d} = e^{ikond}$

Image from B. Saleh and M Teich, Fundamentals of Photonics, 2nd Edition. (2007) Wiley and Sons



Your friend tells you that based on what you've previously learned, the transmittance should always be less than 1. Is this true for the transmittances we are currently studying?

Can we accurately predict the behaviour of light without including reflections and absorption into our transmittance calculations?

- Our transmittance describes what happens to the *phase* of a wave and equivalently what happens to the *wavefronts*. This allows us to model how the wave *propagates*.. Which is the interesting part!

- But we are limited. We will see later in the course that we will need to take into account reflections when studying cavity resonances.

PHYS 408 Group Activities for Jan 27 2011

$$t(x,y) = \underbrace{e^{ik_0[d_0 - d(x,y)]}}_{\text{phase delay in air}} \underbrace{e^{ik_0 n d(x,y)}}_{\text{phase delay in material}} = e^{ik_0 d_0} e^{ik_0(n-1)d(x,y)}$$

0.5-Using the expression for the transmittance above show mathematically that when a plane wave strikes the spherical lens below, it is transformed into a paraboloidial wave

Hint: In generating an expression for t(x,y) you will need to use the binomial expression just like the Fresnel approx.

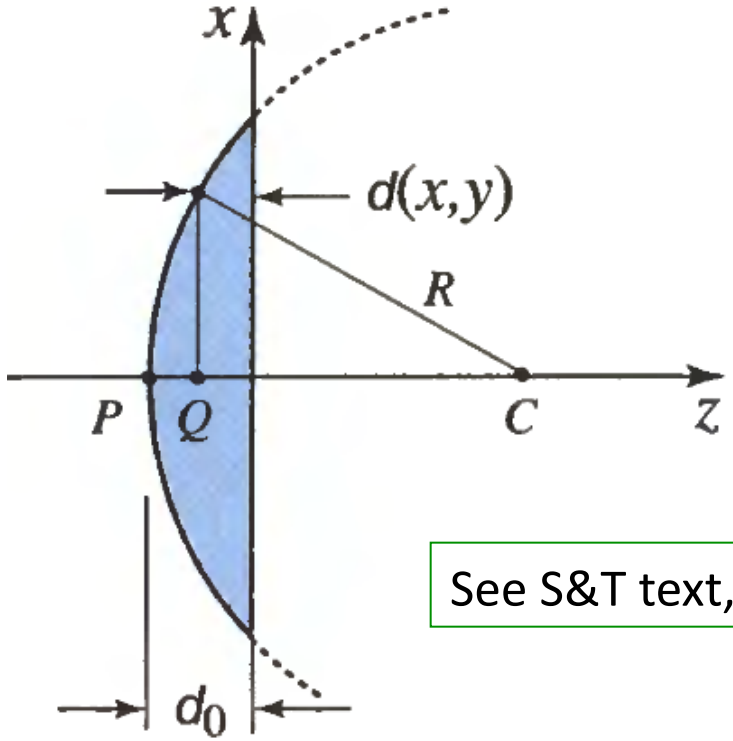
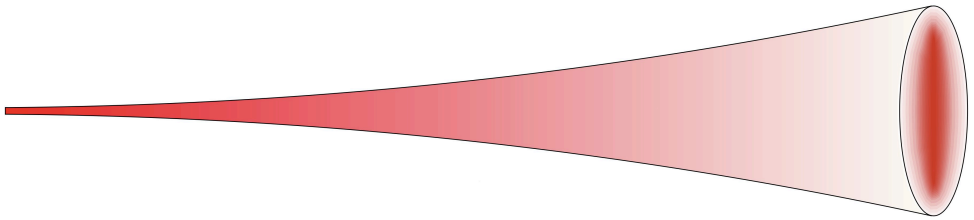


Image from B. Saleh and M Teich, Fundamentals of Photonics, 2nd Edition. (2007) Wiley and Sons

See S&T text, page 54 for answer

PHYS 408 Group Activities for Jan 27 2011



1-None of the solutions to the wave eqn. or paraxial wave eqn. listed previously can model the propagation of this laser beam. In your own words give a few reasons why each one fails.

2-However, one of the solutions has one key characteristic that matches the laser beam …what is this key characteristic and why does it match?

3- Prove your answer to 2 with math

Name

Label each wave as exact or approx E&M wave and then draw an arrow from the wave to appropriate wave equation it came from.

Exact or Approx solution write down the important aspects of this solution ie what assumptions/ approximations have you made, etc?	Wave Solution	Wave Equation
paraboloidal wave - approx. $k\frac{[x^2+y^2]^2}{8z^3} \ll \pi$ - doesn't have carrier wave - assume monochromatic ((((•))))	$\psi = \frac{A}{z} e^{ik(\frac{x^2+y^2}{2z})}$ (only slowly varying envelope portion)	$\nabla^2\psi - \epsilon\mu_o \frac{\partial^2}{\partial t^2}\psi = 0$
Spherical wave - finite power - exact soln - spherical wavefronts	$\psi = \frac{A}{r} e^{ikr}$ - assume monochromatic	$\nabla^2\psi + \frac{\omega^2}{c^2}\psi = 0$
- plane wave - infinite power - time dependent - exact soln	$\psi = A\cos(kz - \omega t)$ - prop. in +z direction	$\nabla_T^2\psi + i2k\frac{\partial}{\partial z}\psi = 0$
same as 3 but assumed monochromatic wave	$\psi = Ae^{ikz}$	

Answers from previous page

spherical wave:

a) - singularity @ z=0

b) - wave not propagating in a beam ($\vec{k}$ are $\hat{r}$ directed)

c) - at a fixed z, radial/transverse (x,y dependence) constant

plane wave

- same as c)
- only a single $\vec{k}$ vector (beam has many)
- infinite power

paraboloidal wave

- same as 4

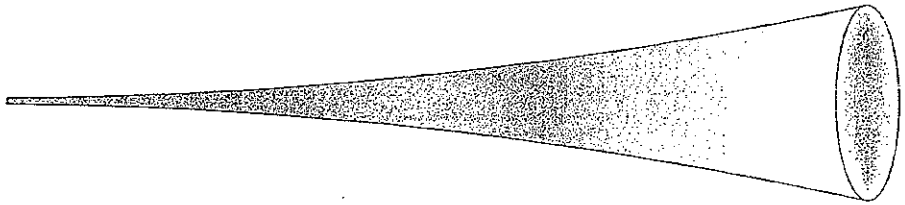
- same as c

Sketch the interference pattern in the x-y plane for the 1st and 2nd solutions

↳ $U_T = U_1 + U_2$ = ↳ steps ① sum total field, ② take $|\ |^2$, ③ then what?

PHYS 408 Group Activities for Jan 29 2010

Please complete these exercises without opening the textbook. If you have questions talk with your group mates or raise your hand and Louis or David will come to help



1-None of the solutions to the wave eqn. or paraxial wave eqn. listed previously can model the propagation of this laser beam. In your own words give a <u>few</u> reasons why each one fails. see previous

2-However, one of the solutions has one key characteristic that matches the laser beam ...what is this key characteristic and why does it match? It correctly models that beam divergence (i.e. the wavefronts that are slowly changing ~~w/~~ their curvature

3- Prove your answer to 2 with math

collection of paraxial E-waves