Çankaya University – ECE Department – ECE 474 (Final)

Student Name : Date : 31.05.2011
Student Number : Open book exam

Questions

1. (70 Points) A convergent Gaussian beam with $\alpha_s = 2$ cm, $\lambda = 1.55\ \mu$m, $F_s = 750$ m is given on the source plane. Find the followings ;

A) α_r (beam size) and F_r (radius of curvature) on a receiver plane at $z = L = 1200$ m away from the transmitter plane.

B) Rayleigh range z_{R1}, z_{R2} or z_R of this beam.

C) α_B (beam waist), α_f (spot size at focus), z_B (distance to beam waist) and z_f (distance to focus).

D) Draw the side view of the propagation along z (propagation axis), indicate on the graph the positions of z_B and z_R as well as the change of beam size (α_r) and radius of curvature (F_r).

Repeat A), B), C) and D) of the above if the transmitted beam is changed to $F_s \to \infty$ i.e., collimated beam, while other parameters are kept the same. Compare the parameters of α_r, F_r, z_R and z_B for the given convergent and collimated beams.

Solution : A) From Notes on free space propagation for ECE 474_Nisan 2012, using (G24) we get

$$\alpha_r = \left(\frac{k^2\alpha_s^4 F_s^2 - 2k^2\alpha_s^4 F_s z + 4F_s^2 z^2 + k^2\alpha_s^4 z^2}{k^2\alpha_s^2 F_s^2} \right)^{1/2} = 3.19 \text{ cm}$$

Then using (G28) of the same notes we get

$$F_r = -\frac{k^2\alpha_s^4 F_s^2 - 2k^2\alpha_s^4 F_s z + 4F_s^2 z^2 + k^2\alpha_s^4 z^2}{4F_s^2 z - k^2\alpha_s^4 F_s + k^2\alpha_s^4 z} = -971.5 \text{ m}$$

B) Using (G31) of Notes on free space propagation for ECE 474_Nisan 2012, we get

$$z_{R_1} = \frac{k^2\alpha_s^4 F_s - 2k\alpha_s^2 F_s^2}{4F_s^2 + k^2\alpha_s^4} = 30.27 \text{ m} \quad , \quad z_{R_2} = \frac{k^2\alpha_s^4 F_s + 2k\alpha_s^2 F_s^2}{4F_s^2 + k^2\alpha_s^4} = 778 \text{ m}$$

z_R in the case of a convergent beam is not meaningful.

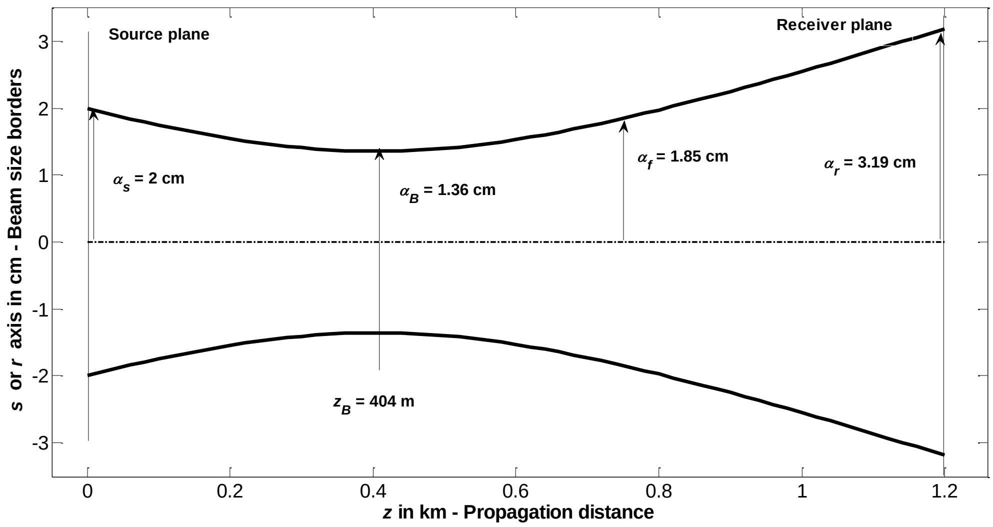
C) Using (G29) of the same notes, we get $z_B = \dfrac{k^2\alpha_s^4 F_s}{4F_s^2 + k^2\alpha_s^4} = 404$ m. z_f is simply

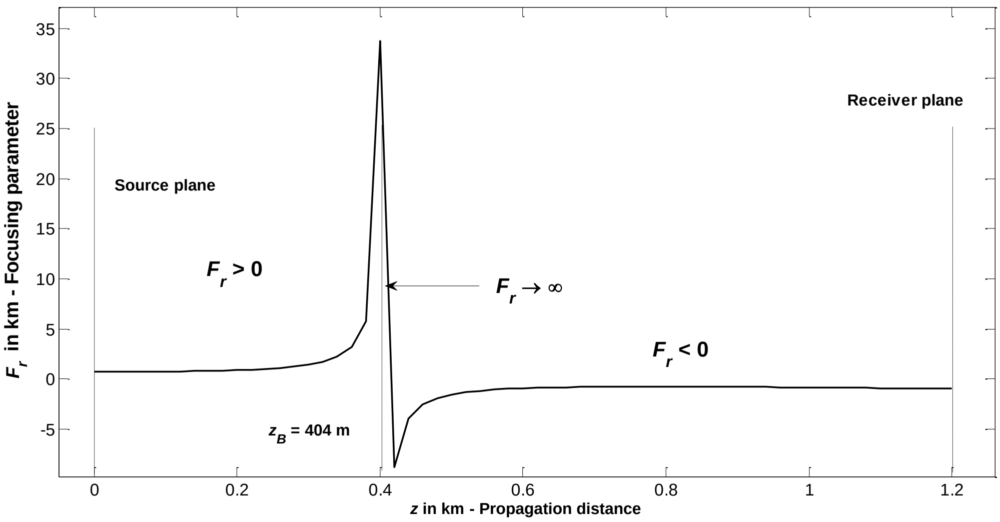
$z_f = F_s = 750$ m. Using (P6) of the notes, we get $\alpha_f = \dfrac{2F_s}{k\alpha_s} = 1.85$ cm. Using (G30) of the

notes,

we have $\alpha_B = \left(\dfrac{4\alpha_s^2 F_s^2}{4F_s^2 + k^2\alpha_s^4} \right)^{1/2} = 1.36$ cm.

D) The side views of propagation obtained from Beamsize.m and Focusingpram.m are shown below.





If we use collimated beam which means letting $F_s \to \infty$, then from (P20) of the notes

$$\alpha_r =_{F_s \to \infty} \left(\frac{k^2\alpha_s^4 F_s^2 - 2k^2\alpha_s^4 F_s z + 4F_s^2 z^2 + k^2\alpha_s^4 z^2}{k^2\alpha_s^2 F_s^2} \right)^{1/2} = \left(\frac{k^2\alpha_s^4 + 4z^2}{k^2\alpha_s^2} \right)^{1/2} = 3.15 \text{ cm}$$

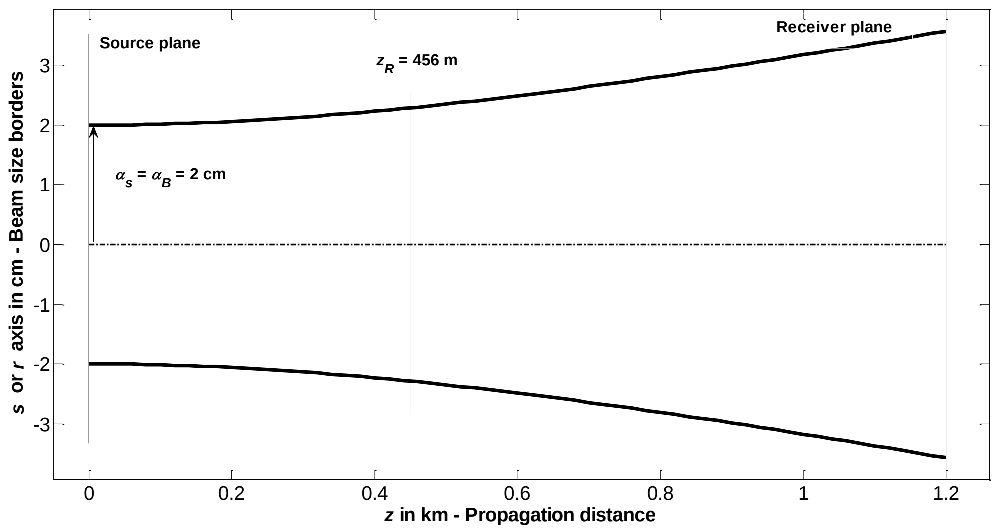
From (P21) of the notes

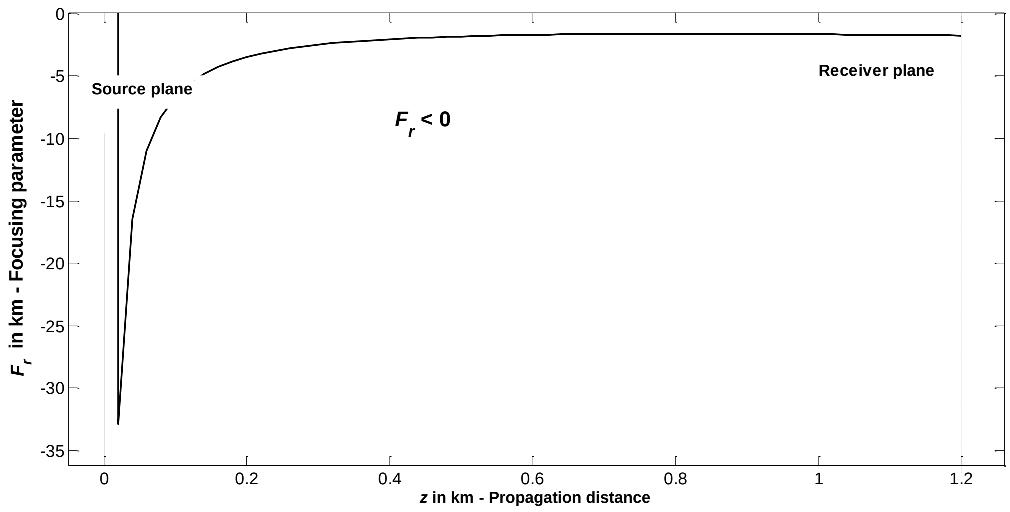
$$F_r =_{F_s \to \infty} \left(-\frac{k^2\alpha_s^4 F_s^2 - 2k^2\alpha_s^4 F_s z + 4F_s^2 z^2 + k^2\alpha_s^4 z^2}{4F_s^2 z - k^2\alpha_s^4 F_s + k^2\alpha_s^4 z} \right) = -\frac{k^2\alpha_s^4 + 4z^2}{4z} = -1747.7 \text{ m}$$

z_R is given by $z_R = 0.5k\alpha_s^2 = 456$ m

For a collimated beam $\alpha_B = \alpha_s$, $z_B = 0$, α_f and z_f are meaningless.

The variations α_r and F_r of along z axis are shown below





2. (30 Points) Answer the following questions as **True** or **False.** For the **False** ones give the correct answer or the reason. For the **True** ones justify your answer

a) Responsivity of a photodiode measures the efficiency : False since

$$\text{Efficiency} = \eta = \frac{\text{No ofelectron hole-pairs generated}}{\text{No of incident photons}} = \frac{I_p / q}{P_0 / h\nu}, \text{ whereas}$$

$$\text{Responsivity} = R = \frac{I_p}{P_0}$$

b) Spectral width of laser sources is wider than that of LED sources : False, since laser light sources have narrower spectral widths than those of LEDs.

c) PIN photodiode operates at higher wavelengths than APD photodiode : False, such a comparison is misleading. We can only say that the operating wavelength or the cut-off wavelength is determined by $\lambda_c = \frac{1.24}{E_g}$ where E_g is the material dependent energy gap.

d) In fibre attenuation increase with the length of the cable : True

$P_r = P_t \exp\left(-\alpha_p z\right)$, where α_p is the attenuation coefficient in Nepers per km.

e) The bandwidth of a single mode fibre is larger than multimode fibres : This is true, since in single mode fibre, intermodal dispersion (a band limiting factor) is absent.