

Çankaya University – ECE Department – ECE 646 (FE)

Student Name :

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Open book exam

Questions

1. (70 Points) For RPS_Int_APAV.m file (to be used together with ft_sh_phase_screen.m) available on course webpage, set the common source and propagation parameters as follows ;

$\alpha_{sx} = \alpha_{sy} = 1.5$ cm, $F_s \rightarrow \infty$, $C_n^2 = 10^{-15}$, $\lambda = 1.55$ μ m, L : 0.5 km, 1 km, 2 km, 5 km (additional settings of annular Gaussian are given in d).

Then run RPS_Int_APAV.m at two Dmat (aperture opening) values of 10 and 80, obtaining scintillation curves for the following beam types

- Gaussian beam,
- Cosh Gaussian beam with $D_{s\ell} = [60 \ -60]$,
- Cos Gaussian beam with $D_{s\ell} = [60j \ -60j]$,
- Annular Gaussian beam with $\alpha_{sx1} = \alpha_{sy1} = 1.5$ cm, $\alpha_{sx2} = \alpha_{sy2} = 1.2$ cm, $A_\ell = [1 \ -0.9]$

Calculate, what circular aperture radius numeric values correspond to Dmat settings of 10 and 80.

Make comparisons of the scintillation curves for different beams and different Dmat settings.

Send your scintillation figures to h.eyyuboglu@cankaya.edu.tr address.

Solution : The relevant graphs are given in Figs. 1.1 and 1.2

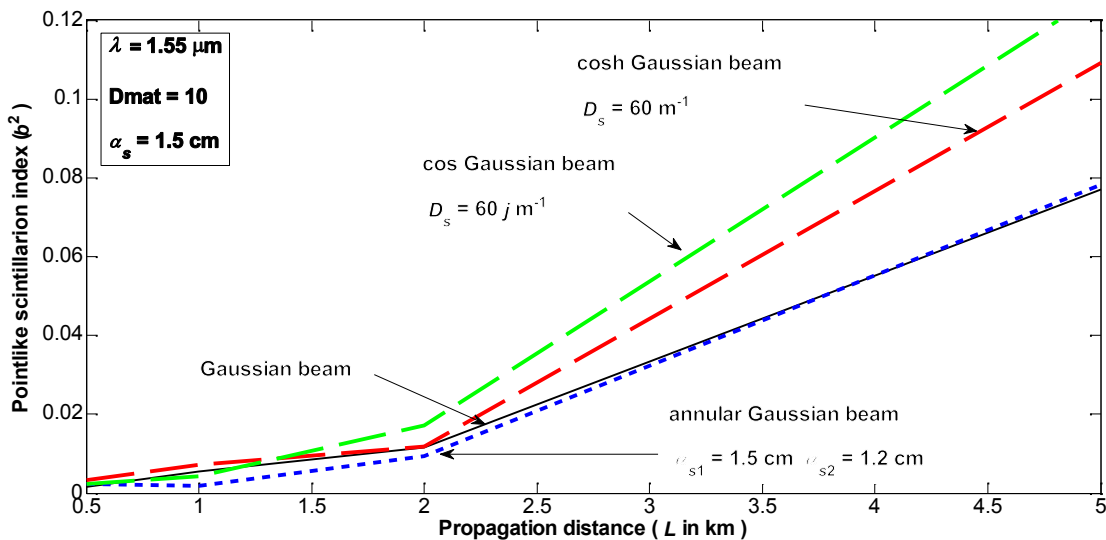


Fig. 1.1 Scintillation curves of beams ad Dmat = 10.

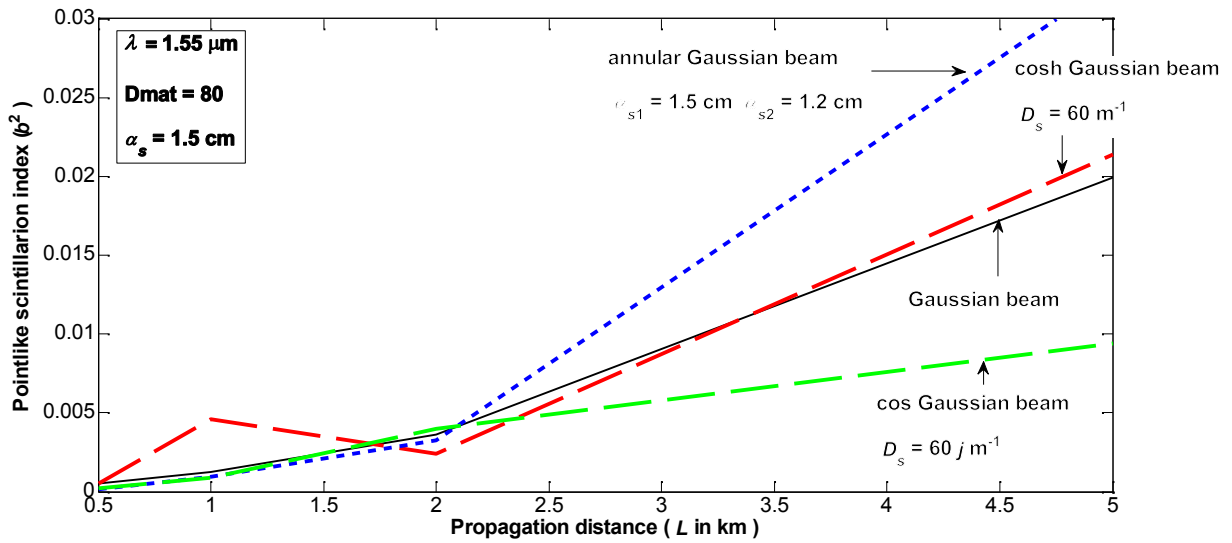


Fig. 1.1 Scintillation curves of beams at $D_{mat} = 80$.

Comments on Figs 1.1 and 1.2

- At the limit of pointlike scintillation, i.e., for $D_{mat} = 10$, in Fig. 1.1, lowest scintillation is exhibited by Gaussian and annular Gaussian beams, while the next is cosh Gaussian and the highest is cos Gaussian beam.
- For aperture averaged scintillation, i.e., for $D_{mat} = 80$, in Fig. 1.2, the situation is somewhat reversed. Here the lowest scintillation takes place for cos Gaussian beam, then comes Gaussian beam, next is cosh Gaussian beam and highest scintillation occurs for annular Gaussian beam.
- Comparison of Figs. 1.1 and 1.2 reveals the clear advantage of aperture averaged scintillation.

To estimate the corresponding circular aperture, we use line 54 of `RPS_Int_APAV.m` which is

$$d2 = 2.3438e-7 * L + 1.9531e-4$$

At propagation distances of L : 0.5 km, 1 km, 2 km, 5 km , we find $d2$ as follows

$$\begin{aligned}
 d2 &= 3.125 \times 10^{-4} \text{ m at } L = 0.5 \text{ km} \\
 d2 &= 4.2969 \times 10^{-4} \text{ m at } L = 1 \text{ km} \\
 d2 &= 6.6407 \times 10^{-4} \text{ m at } L = 2 \text{ km} \\
 d2 &= 14 \times 10^{-4} \text{ m at } L = 5 \text{ km}
 \end{aligned} \tag{1.1}$$

Below, we compute the corresponding circular receiver aperture radius and compare the numeric values to aperture averaging condition

$$\sqrt{\overbrace{0.5\lambda L/\pi}^{L=0.5 \text{ km}}} = 1.11 \text{ cm}, \quad \sqrt{\overbrace{0.5\lambda L/\pi}^{L=1 \text{ km}}} = 1.57 \text{ cm}, \quad \sqrt{\overbrace{0.5\lambda L/\pi}^{L=2 \text{ km}}} = 2.22 \text{ cm}, \quad \sqrt{\overbrace{0.5\lambda L/\pi}^{L=5 \text{ km}}} = 3.51 \text{ cm}$$

Dmat = 10

$$L = 0.5 \text{ km} : L_r = d2 \times \text{Dmat} = 3.125 \times 10^{-3} \text{ m}, \quad R_a = L_r / \sqrt{\pi} = 0.18 \text{ cm}$$

$$L = 1 \text{ km} : L_r = d2 \times \text{Dmat} = 4.2969 \times 10^{-3} \text{ m}, \quad R_a = L_r / \sqrt{\pi} = 0.24 \text{ cm}$$

$$L = 2 \text{ km} : L_r = d2 \times \text{Dmat} = 6.6407 \times 10^{-3} \text{ m}, \quad R_a = L_r / \sqrt{\pi} = 0.37 \text{ cm}$$

$$L = 5 \text{ km} : L_r = d2 \times \text{Dmat} = 14 \times 10^{-3} \text{ m}, \quad R_a = L_r / \sqrt{\pi} = 0.79 \text{ cm}$$

Dmat = 80

$$L = 0.5 \text{ km} : L_r = d2 \times \text{Dmat} = 2.5 \times 10^{-2} \text{ m}, \quad R_a = L_r / \sqrt{\pi} = 1.41 \text{ cm}$$

$$L = 1 \text{ km} : L_r = d2 \times \text{Dmat} = 3.44 \times 10^{-2} \text{ m}, \quad R_a = L_r / \sqrt{\pi} = 1.94 \text{ cm}$$

$$L = 2 \text{ km} : L_r = d2 \times \text{Dmat} = 5.31 \times 10^{-2} \text{ m}, \quad R_a = L_r / \sqrt{\pi} = 3 \text{ cm}$$

$$L = 5 \text{ km} : L_r = d2 \times \text{Dmat} = 11.2 \times 10^{-2} \text{ m}, \quad R_a = L_r / \sqrt{\pi} = 6.32 \text{ cm} \quad (1.2)$$

As seen from (1.2), at Dmat = 10, we have pointlike scintillation, but at Dmat = 80, we have aperture averaged scintillation.

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) Angular spectrum method evaluates scintillation by placing random phase screens at interval between the source and receiver planes : False, as explained on pages 1 – 3 of lecture notes entitled, “ECE 646_Notes on Angular Spectrum and RPS_HTE_Bahar 2014”, angular spectrum method is an alternative to the analytic solution of Huygens Fresnel integral. To evaluate scintillation, we must insert the random phase screens along the propagation path.

 - b) The semi analytic method is used to find scintillation via the extended Huygens Fresnel integral : True, as detailed in 4. Scintillation Formulation via Extended Huygens-Fresnel Integral of lecture notes entitled, “Notes of ECE 646_HTE_Bahar 2012”.

 - c) If the complex degree of coherence on the receiver transverse plane is flat, then we can say that the received beam is fully coherent : True, this means that all the points on the transverse plane are in phase coherence. If there is a curved surface (instead of a flat one), then it indicates the partial loss of coherence, i.e. the presence of partial coherence as explained in lecture_notes entitled, “Notes of ECE 646_HTE_Bahar 2012”.

 - d) Random phase screens are used to model the propagation in turbulent atmosphere : True, random phase screens are inserted along the propagation axis to model the accumulated effect of turbulence.

 - e) Apertured averaged scintillation is less than pointlike scintillation : True, as explained in 3. Pointlike and Aperture Averaged Scintillation of “ECE 646_Notes on Angular Spectrum and RPS_HTE_Bahar 2014”.

 - f) To approximate the results of random phase screen approach to the analytic ones, we have to make at least 100 realizations (runs) : In literature, for well approximated results, the number quoted is 500.