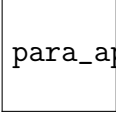


1 Assignment 1: Projection Error

1.1 Implementation

1.2 Resultat

1.2.1 A: Paraxial Approximation

 para_approx.pdf

With Paraxial Approximation focus point always becomes 0.15 m, independent of where on the lens a beam parallel with the optic normal axis refract on the lens. Mean while without the approximation it will drift further away from the lens when the standard beam closes the edge of the lens.


write

down

difference

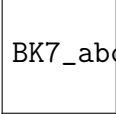
[placeholder]

1.2.2 B: Material Replacement

 BK7_index.pdf

When plotting BK7 refraction index compared to wavelength of the incoming light, the graph shows that $\Delta 0.0025$ in index between lowest value $400nm$ and highest $700nm$. The function is close to linear at the high spectrum, which is worth noting.

1.2.3 C: Chromatic Aberrations

 BK7_abo.pdf

Applying the BK7 material on the none Paraxial Approximated function, gives us an Δ in focus point of close to 0.00028. Generally close to 0.15

1.3 Conclusion and Commentary

Replacement material *BK7* has the properties to almost bring focus back to 0.15, where it was when we applied Paraxial Approximation. Conclusion with the new material we can easily apply Paraxial Approximation without too large errors in calculations, depending on specification limitations of course.

2 Assignment 2: Laser Pulse

2.1 Implementation

2.2 Resultat

2.2.1 A: Numeric Solution

2.2.2 B: Differential Plot

N.pdf

2.3 Conclusion and Commentary

A Implementation R Code

A.1 Assignment I:

```
1
2 R <- 0.15 #Radius
3 D <- 0.1 #Diameter of lens
4 n1 <- 1.0 #Refraction index
5 n2 <- 1.5 #Refraction index
6 #Gaussian function (Radius,Height,incoming refraction index, material refraction index, Use approximation BOOLEAN)
7 Gaussian <- function(r,h,n1,n2,b){
8     a1 = 0 #Paraxial Approximation
9     if(!b){
10         a1 = alph1(h,r) #None Approximated Angle
11     }
12     a2 = alph2(r,a1,n1,n2)
13     f = r*sin(a2)/cos(a2)+r
14     return(f)
15 }
16
17 #Refraction angle to norm of surface
18 alph2 <- function(r,a1,n1,n2){
19     a2 = asin(sin(a1)*(n1/n2))
20     return(a2)
21 }
22 #Light angle without Paraxial Approximation to norm of surface
23 alph1 <- function(h,r){
24     a1 = asin(h/r)
25     return(a1)
26 }
27
28 #Refraction index calculation of Glass material BK7
29 BK7n <- function(x){
30     a1 = 2.271176
31     a2 = -9.700709*(10^-3)*(10^-6)^-2
32     a3 = 0.0110971*(10^-6)*(10^-6)^2
33     a4 = 4.622809*(10^-5)*(10^-6)^4
34     a5 = 1.616105*(10^-5)*(10^-6)^6
35     a6 = -8.285043*(10^-7)*(10^-6)^8
36     n2 = a1+a2*x^2+a3*x^(-2)+a4*x^(-4)+a5*x^(-6)+a6*x^(-8)
37     n = a1;
38     n = abs(sqrt(as.complex(n2)));
39     return(n);
40 }
41 par(mfrow = c(2,3));
42
43 #Paraxoide Approximation applied
44 Gauss_Approx <- function(x) Gaussian(R,x,n1,n2,TRUE);
45 fa <- Vectorize(Gauss_Approx);
46 plot.function(fa, from=0, to=D/2, xlab="Hight", ylab="Focus_Point",
47     ylim=c(fa(0)-0.01,0.20));
48
49 #No Paraxoide Approximation
50 Gauss <- function(x) Gaussian(R,x,n1,n2,FALSE);
51 f <- Vectorize(Gauss);
52 plot.function(f,from=0,to=D/2, add=TRUE, col="red");
53
54 #Write to file
55 pdf("para_approx.pdf", width=7, height=5)
56 plot.function(fa, from=0, to=D/2, xlab="Hight", ylab="Focus_Point",
57     ylim=c(fa(0)-0.01,0.20));
58 plot.function(f,from=0,to=D/2, add=TRUE, col="red");
59 dev.off()
60
61 #BK7n Reflection index
62 n2v <- Vectorize(BK7n);
63 plot.function(n2v, from=(400/(10^9)), to=(700/(10^9)), ylab="Reflection_Index", xlab="Wavelength");
64
65 #Write to file
66 pdf("BK7_index.pdf", width=7, height=5)
67 plot.function(n2v, from=(400/(10^9)), to=(700/(10^9)), ylab="Reflection_Index", xlab="Wavelength");
68 dev.off()
```

A.2 Assignment II:

```

1 dev.off()
2
3 #BK7 replace material of lens
4 h <- 0.025;
5 f_chrom <- function(x){
6     f = Gaussian(R, h, n1, BK7n(x), FALSE);
7     return(f)
8 }
9 v_chrom <- Vectorize(f_chrom);
10 plot.function(v_chrom, from=(400/(10^9)), to=(700/(10^9)), xlab="", ylab="");
11
12 #Write to file
13 pdf("BK7_abo.pdf", width=7, height=5)
14 plot.function(v_chrom, from=(400/(10^9)), to=(700/(10^9)), xlab="", ylab="");
15 dev.off()
16
17 #Assignment no. 2
18 L <- 0.2 #Length
19 D <- 0.008 #Diameter
20 tb <- 200/10^6 #pulse duration
21 tau <- 230/10^6 #Lifespan
22 N0 <- 1.4*10^20 #Number of Ions cm^-3
23 sigma <- 2.8/10^23 #
24 c <- 299792458 #Speed of Light m/s
25
26 V <- L*pi*(D/2)^2; #cavity Volyme
27 B <- sigma*c/V; #Probability of stimulated emission ion and photon
28
29 N_inf <- 0.01*N0;
30 P <- N_inf/tau; #Pump strength
31
32 #Assignment 2:b definitions
33 R1 <- 1;
34 R2 <- 0.05;
35 tb <- 200/10^6;
36
37 tau_c <- function(r1,r2) { #Lifespan in cavity for photons
38     tau_r = -2*L/(c*(log(r1)+log(r2)));
39     return(tau_r)
40 }
41
42
43 #Differential eqvations:
44 N_prim <- function(N, Phi){ #Number of Ions
45     y = P-B*N*Phi-N/tau;
46     return(y)
47 }
48
49 Phi_prim <- function(Phi, N) { #
50     y = B*V*N*(Phi+1)-Phi/tau_c(R1,R2);
51     return(y)
52 }
53
54
55 Solv <- function(f0, f_prim, g_prim, t){
56     h = (t[1]-t[2]);
57     f = rep(0, length(t));
58     g = rep(0, length(t));
59     f[1] <- (f0[1]);
60     g[1] <- (f0[2]);
61     for(i in as.single(1:length(t))){
62         f[i+1] = f[i] - f_prim(f[i],g[i])*h;
63         g[i+1] = g[i] - g_prim(g[i],f[i])*h;
64     }
65     return(f);
66 }
67
68 N <- function(x){
69     return(Solv(c(N0,0), N_prim, Phi_prim, x))
70 }
71 Phi <- function(x){
72     return(Solv(c(0,N0), Phi_prim, N_prim, x))
73 }
74 x0 = N(seq(0, 0.0002, length=20));

```

```

75 x1 = Phi(seq(0, 0.0002, length=20));
76 print("N");
77 print(x0);
78 print("Phi");
79 print(x1);
80 plot(x0);
81 plot(x1);
82
83 #Write to file #1
84 pdf("para_approx.pdf", width=7, height=5)
85 plot.function(fa, from=0, to=D/2, xlab="Hight", ylab="Focus Point",
86             ylim=c(fa(0)-0.01,0.20));
87 plot.function(f,from=0,to=D/2, add=TRUE, col="red");
88 dev.off()
89
90 #Write to file #2
91 pdf("BK7_index.pdf", width=7, height=5)
92 plot.function(n2v, from=(400/(10^9)), to=(700/(10^9)), ylab="Reflection Index", xlab="Wavelength");
93 dev.off()
94
95 #Write to file #3
96 pdf("BK7_abo.pdf", width=7, height=5)
97 plot.function(v_chrom, from=(400/(10^9)), to=(700/(10^9)), xlab="", ylab="");
98 dev.off()
99
100
101
102 #Write to file #4
103 pdf("N.pdf", width=7, height=5)
104 plot(x0)
105 dev.off()

```