

Reto F3001C

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```
%Code Variables
%Sizes
sXs = [1000,930,475,405];
sYs = [325,235,955,730];

%Paths
SuperiorPath = "../Phase4V2/Sweeps/Matlab/";
FundamentalPath = "../Phase3/Sweeps/Matlab/";

%Modes
Superior = "Waveguide%i_%i_532_Mode%i";
Fundamental = "Waveguide%i_%i_1596";
ModesSup = [15,9,19,12];

warning('off','MATLAB:polyfit:RepeatedPointsOrRescale')
```

Waveguide selector:

```
sel = 2;
nmodes = ModesSup(sel);
mode = 9;
disp("Selected waveguide:")
```

Selected waveguide:

```
disp("    Size: "+num2str(sXs(sel))+ "x" +num2str(sYs(sel)));
```

Size: 930x235

```
disp("    Mode: "+num2str(mode));
```

Mode: 9

Waveguide Summary:

```
disp("Waveguide: "+num2str(sXs(sel))+ "x" +num2str(sXs(sel))+ ", mode: "+num2str(ModesSup(sel)));
```

Waveguide: 930x930, mode: 9

Fundamental Mode Data (1596nm):

```
file = sprintf(Fundamental,sXs(sel)*1000,sYs(sel)*1000);
load(FundamentalPath+file);
wgFundamental = waveguide(lambda,neff);
l = wgFundamental.lambdaData;
w = wgFundamental.omegaData;
```

```
neff = wgFundamental.neffData;
```

Ranges:

```
disp("Lambda Ranges: "+num2str(min(l))+ "-" +num2str(max(l))+ "");
```

Lambda Ranges: 1.53-1.596

```
disp("Omega Ranges: "+num2str(min(w))+ "-" +num2str(max(w))+ "");
```

Omega Ranges: 1181049869.7706-1231997119.0548

Neff vs ω/λ

```
disp("Function neff( $\lambda$ ):");
```

Function neff(λ):

```
disp(wgFundamental.nefflStr);
```

0.000030705937210545883396094896* $l.^{30}$ -0.000238501771845040964285106222* $l.^{29}$ +0.000498347405939057221113674956* $l.^{28}$ -0.000798347405939057221113674956* $l.^{27}$ +0.001098347405939057221113674956* $l.^{26}$ -0.001398347405939057221113674956* $l.^{25}$ +0.001698347405939057221113674956* $l.^{24}$ -0.001998347405939057221113674956* $l.^{23}$ +0.002298347405939057221113674956* $l.^{22}$ -0.002598347405939057221113674956* $l.^{21}$ +0.002898347405939057221113674956* $l.^{20}$ -0.003198347405939057221113674956* $l.^{19}$ +0.003498347405939057221113674956* $l.^{18}$ -0.003798347405939057221113674956* $l.^{17}$ +0.004098347405939057221113674956* $l.^{16}$ -0.004398347405939057221113674956* $l.^{15}$ +0.004698347405939057221113674956* $l.^{14}$ -0.004998347405939057221113674956* $l.^{13}$ +0.005298347405939057221113674956* $l.^{12}$ -0.005598347405939057221113674956* $l.^{11}$ +0.005898347405939057221113674956* $l.^{10}$ -0.006198347405939057221113674956* $l.^{9}$ +0.006498347405939057221113674956* $l.^{8}$ -0.006798347405939057221113674956* $l.^{7}$ +0.007098347405939057221113674956* $l.^{6}$ -0.007398347405939057221113674956* $l.^{5}$ +0.007698347405939057221113674956* $l.^{4}$ -0.007998347405939057221113674956* $l.^{3}$ +0.008298347405939057221113674956* $l.^{2}$ -0.008598347405939057221113674956* $l.^{1}$ +0.008898347405939057221113674956

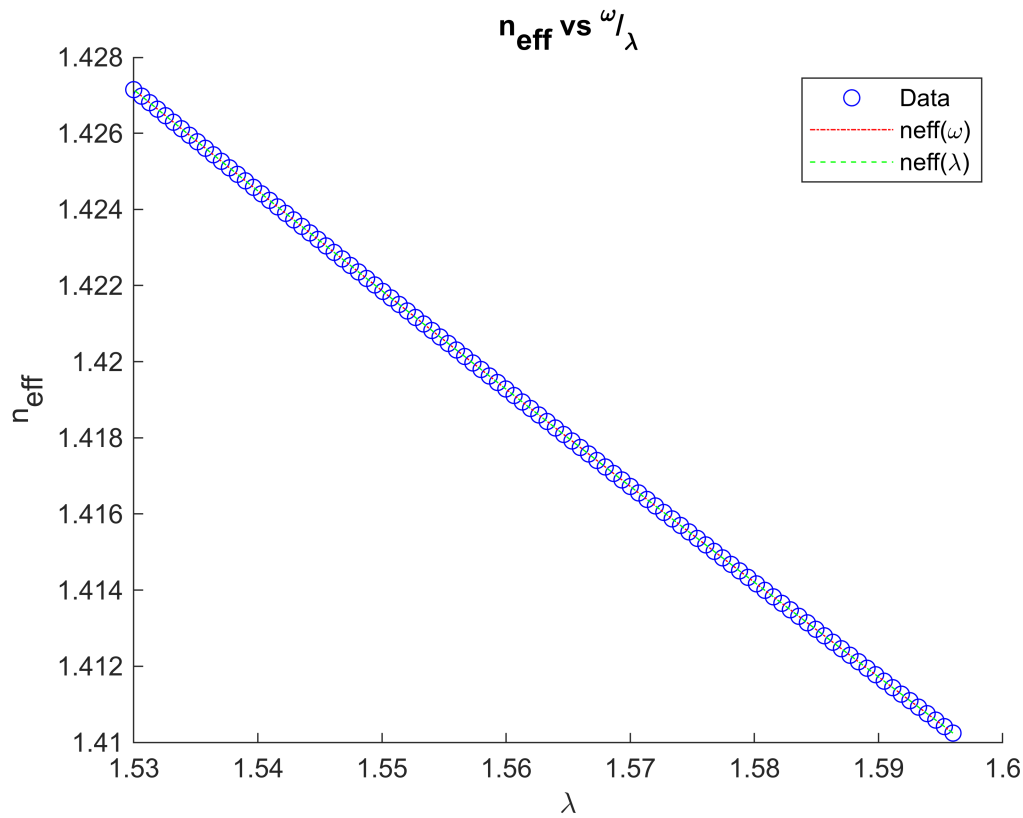
```
disp("Function neff( $w$ ):");
```

Function neff(w)

```
disp(wgFundamental.neffwStr);
```

8.502026705724635180928932788110e-273* $w.^{30}$ -1.173671773238715913640420574474e-262* $w.^{29}$ +4.6150751111664728138346912e-251* $w.^{28}$ -1.173671773238715913640420574474e-240* $w.^{27}$ +4.6150751111664728138346912e-229* $w.^{26}$ -1.173671773238715913640420574474e-218* $w.^{25}$ +4.6150751111664728138346912e-207* $w.^{24}$ -1.173671773238715913640420574474e-196* $w.^{23}$ +4.6150751111664728138346912e-185* $w.^{22}$ -1.173671773238715913640420574474e-174* $w.^{21}$ +4.6150751111664728138346912e-163* $w.^{20}$ -1.173671773238715913640420574474e-152* $w.^{19}$ +4.6150751111664728138346912e-141* $w.^{18}$ -1.173671773238715913640420574474e-130* $w.^{17}$ +4.6150751111664728138346912e-119* $w.^{16}$ -1.173671773238715913640420574474e-108* $w.^{15}$ +4.6150751111664728138346912e-97* $w.^{14}$ -1.173671773238715913640420574474e-86* $w.^{13}$ +4.6150751111664728138346912e-75* $w.^{12}$ -1.173671773238715913640420574474e-64* $w.^{11}$ +4.6150751111664728138346912e-53* $w.^{10}$ -1.173671773238715913640420574474e-42* $w.^{9}$ +4.6150751111664728138346912e-31* $w.^{8}$ -1.173671773238715913640420574474e-20* $w.^{7}$ +4.6150751111664728138346912e-09* $w.^{6}$ -1.173671773238715913640420574474e+01* $w.^{5}$ +4.6150751111664728138346912e+10* $w.^{4}$ -1.173671773238715913640420574474e+19* $w.^{3}$ +4.6150751111664728138346912e+28* $w.^{2}$ -1.173671773238715913640420574474e+37* $w.^{1}$ +4.6150751111664728138346912e+46

```
figure;
hold on
title("n_{eff} vs  $\omega/\lambda$ ");
plot(l,neff,'bo',l,wgFundamental.neffwFun(w),'r-.',l,wgFundamental.nefflFun(l),'g--');
legend(["Data","neff( $\omega$ )","neff( $\lambda$ )"]);
xlabel("\lambda");
ylabel("n_{eff}");
hold off
```



Subfunctions (k, dw, Vg, d2w, D)

```
disp("Function k(w):");
```

Function k(w):

```
disp(wgFundamental.kwStr);
```

```
w.*(8.502026705724635180928932788110e-273*w.^30-1.173671773238715913640420574474e-262*w.^29+4.6150751111664728138340e-251*w.^28-1.173671773238715913640420574474e-262*w.^27+4.6150751111664728138340e-251*w.^26-1.173671773238715913640420574474e-262*w.^25+4.6150751111664728138340e-251*w.^24-1.173671773238715913640420574474e-262*w.^23+4.6150751111664728138340e-251*w.^22-1.173671773238715913640420574474e-262*w.^21+4.6150751111664728138340e-251*w.^20-1.173671773238715913640420574474e-262*w.^19+4.6150751111664728138340e-251*w.^18-1.173671773238715913640420574474e-262*w.^17+4.6150751111664728138340e-251*w.^16-1.173671773238715913640420574474e-262*w.^15+4.6150751111664728138340e-251*w.^14-1.173671773238715913640420574474e-262*w.^13+4.6150751111664728138340e-251*w.^12-1.173671773238715913640420574474e-262*w.^11+4.6150751111664728138340e-251*w.^10-1.173671773238715913640420574474e-262*w.^9+4.6150751111664728138340e-251*w.^8-1.173671773238715913640420574474e-262*w.^7+4.6150751111664728138340e-251*w.^6-1.173671773238715913640420574474e-262*w.^5+4.6150751111664728138340e-251*w.^4-1.173671773238715913640420574474e-262*w.^3+4.6150751111664728138340e-251*w.^2-1.173671773238715913640420574474e-262*w.^1+4.6150751111664728138340e-251*w.^0);
```

```
disp("Function dk(w)/dw:");
```

Function dk(w)/dw:

```
disp(wgFundamental.dkwdwStr);
```

```
(8.502026705724635180928932788110e-273*w.^30*(31)-1.173671773238715913640420574474e-262*w.^29*(30)+4.6150751111664728138340e-251*w.^28*(28)-1.173671773238715913640420574474e-262*w.^27*(27)+4.6150751111664728138340e-251*w.^26*(26)-1.173671773238715913640420574474e-262*w.^25*(25)+4.6150751111664728138340e-251*w.^24*(24)-1.173671773238715913640420574474e-262*w.^23*(23)+4.6150751111664728138340e-251*w.^22*(22)-1.173671773238715913640420574474e-262*w.^21*(21)+4.6150751111664728138340e-251*w.^20*(20)-1.173671773238715913640420574474e-262*w.^19*(19)+4.6150751111664728138340e-251*w.^18*(18)-1.173671773238715913640420574474e-262*w.^17*(17)+4.6150751111664728138340e-251*w.^16*(16)-1.173671773238715913640420574474e-262*w.^15*(15)+4.6150751111664728138340e-251*w.^14*(14)-1.173671773238715913640420574474e-262*w.^13*(13)+4.6150751111664728138340e-251*w.^12*(12)-1.173671773238715913640420574474e-262*w.^11*(11)+4.6150751111664728138340e-251*w.^10*(10)-1.173671773238715913640420574474e-262*w.^9*(9)+4.6150751111664728138340e-251*w.^8*(8)-1.173671773238715913640420574474e-262*w.^7*(7)+4.6150751111664728138340e-251*w.^6*(6)-1.173671773238715913640420574474e-262*w.^5*(5)+4.6150751111664728138340e-251*w.^4*(4)-1.173671773238715913640420574474e-262*w.^3*(3)+4.6150751111664728138340e-251*w.^2*(2)-1.173671773238715913640420574474e-262*w.^1*(1)+4.6150751111664728138340e-251*w.^0*(0));
```

```
disp("Function Vg(w):");
```

Function Vg(w):

```
disp(wgFundamental.vgwStr);
```

```
(3*10^8)./(8.502026705724635180928932788110e-273*w.^30*(31)-1.173671773238715913640420574474e-262*w.^29*(30)+4.6150751111664728138340e-251*w.^28*(28)-1.173671773238715913640420574474e-262*w.^27*(27)+4.6150751111664728138340e-251*w.^26*(26)-1.173671773238715913640420574474e-262*w.^25*(25)+4.6150751111664728138340e-251*w.^24*(24)-1.173671773238715913640420574474e-262*w.^23*(23)+4.6150751111664728138340e-251*w.^22*(22)-1.173671773238715913640420574474e-262*w.^21*(21)+4.6150751111664728138340e-251*w.^20*(20)-1.173671773238715913640420574474e-262*w.^19*(19)+4.6150751111664728138340e-251*w.^18*(18)-1.173671773238715913640420574474e-262*w.^17*(17)+4.6150751111664728138340e-251*w.^16*(16)-1.173671773238715913640420574474e-262*w.^15*(15)+4.6150751111664728138340e-251*w.^14*(14)-1.173671773238715913640420574474e-262*w.^13*(13)+4.6150751111664728138340e-251*w.^12*(12)-1.173671773238715913640420574474e-262*w.^11*(11)+4.6150751111664728138340e-251*w.^10*(10)-1.173671773238715913640420574474e-262*w.^9*(9)+4.6150751111664728138340e-251*w.^8*(8)-1.173671773238715913640420574474e-262*w.^7*(7)+4.6150751111664728138340e-251*w.^6*(6)-1.173671773238715913640420574474e-262*w.^5*(5)+4.6150751111664728138340e-251*w.^4*(4)-1.173671773238715913640420574474e-262*w.^3*(3)+4.6150751111664728138340e-251*w.^2*(2)-1.173671773238715913640420574474e-262*w.^1*(1)+4.6150751111664728138340e-251*w.^0*(0));
```

```
disp("Function d2k(w)/dw:");
```

Function d2k(w)/dw:

```
disp(wgFundamental.d2kwdw2Str);
```

```
(8.502026705724635180928932788110e-273*w.^29*(930)-1.173671773238715913640420574474e-262*w.^28*(870)+4.615075111166
```

```
disp("Function D(w):");
```

```
Function D(w):
```

```
disp(wgFundamental.DwStr);
```

```
-(w.^2/(2*pi*3*10^8)).*((8.502026705724635180928932788110e-273*w.^29*(930)-1.173671773238715913640420574474e-262*w.
```

```
subplot(2,3,1);  
plot(1,neff,'bo',1,wgFundamental.neffwFun(w),'r-.',1,wgFundamental.nefflFun(1),'g--');  
title("n_{eff} vs \omega/\lambda");  
subplot(2,3,2);  
plot(1,wgFundamental.kwFun(w),'b');  
title("k(\omega)");  
subplot(2,3,3);  
plot(1,wgFundamental.dkwdwFun(w),'b');  
title("^{dk(\omega)}/{d\omega}");  
subplot(2,3,4);  
plot(1,wgFundamental.vgwFun(w),'b');  
title("V_g(\omega)");  
subplot(2,3,5);  
plot(1,wgFundamental.d2kwdw2Fun(w),'b');  
title("^{d^2k(\omega)}/{d\omega^2}");  
subplot(2,3,6);  
plot(1,wgFundamental.DwFun(w),'b');  
title("D(\omega)");
```



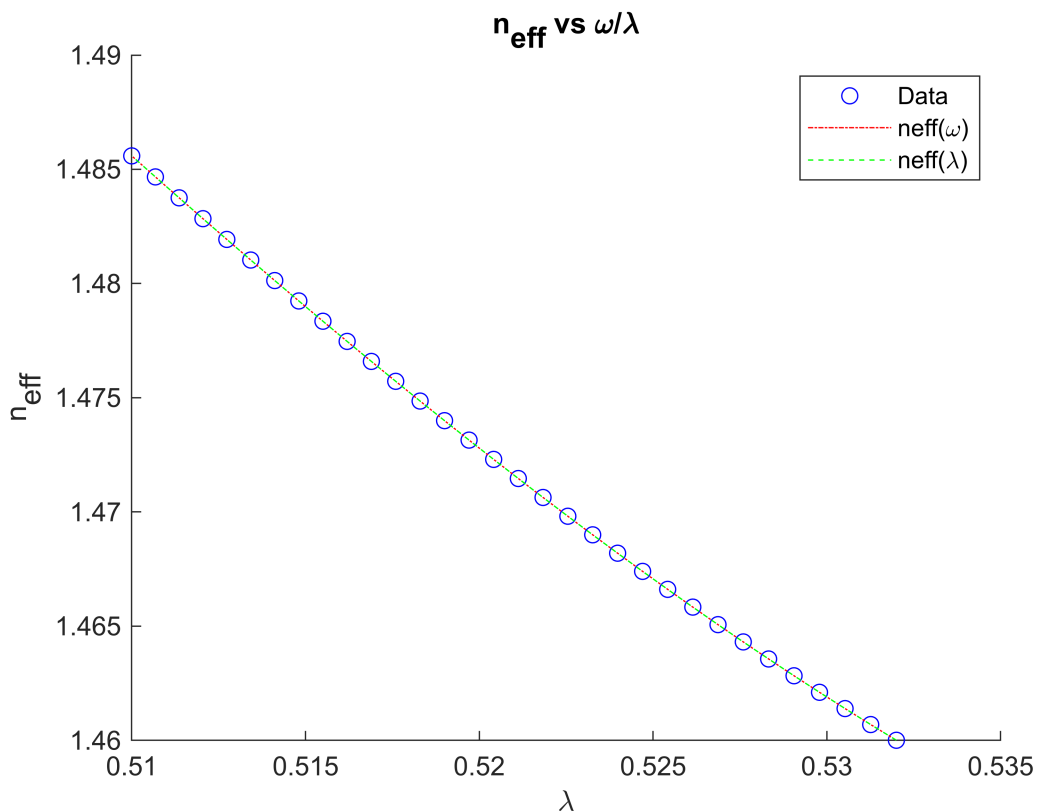
```
disp("Function neff(w):");
```

```
Function neff(w):
```

```
disp(wgSuperior.neffwStr);
```

```
4.015345414268300587716790703345e-283*w.^30-3.327695710241664041153433773091e-273*w.^29+3.9115791504676442757384743
```

```
figure;  
hold on  
title("n_{eff} vs \omega/\lambda");  
plot(l,neff,'bo',l,wgSuperior.neffwFun(w),'r-.',l,wgSuperior.nefflFun(l),'g--');  
legend(["Data","neff(\omega)","neff(\lambda)"]);  
xlabel("\lambda");  
ylabel("n_{eff}");  
hold off
```



Subfunctions (k, dw, Vg, d2w, D)

```
disp("Function k(w):");
```

```
Function k(w):
```

```
disp(wgSuperior.kwStr);
```

```
w.*(4.015345414268300587716790703345e-283*w.^30-3.327695710241664041153433773091e-273*w.^29+3.9115791504676442757384743
```

```
disp("Function dk(w)/dw:");
```

Function dk(w)/dw:

```
disp(wgSuperior.dkwdwStr);
```

```
(4.015345414268300587716790703345e-283*w.^30*(31)-3.327695710241664041153433773091e-273*w.^29*(30)+3.91157915046764
```

```
disp("Function Vg(w):");
```

Function Vg(w):

```
disp(wgSuperior.vgwStr);
```

```
(3*10^8)./(4.015345414268300587716790703345e-283*w.^30*(31)-3.327695710241664041153433773091e-273*w.^29*(30)+3.9115
```

```
disp("Function d2k(w)/dw2:");
```

Function d2k(w)/dw2:

```
disp(wgSuperior.d2kwdw2Str);
```

```
(4.015345414268300587716790703345e-283*w.^29*(930)-3.327695710241664041153433773091e-273*w.^28*(870)+3.911579150467
```

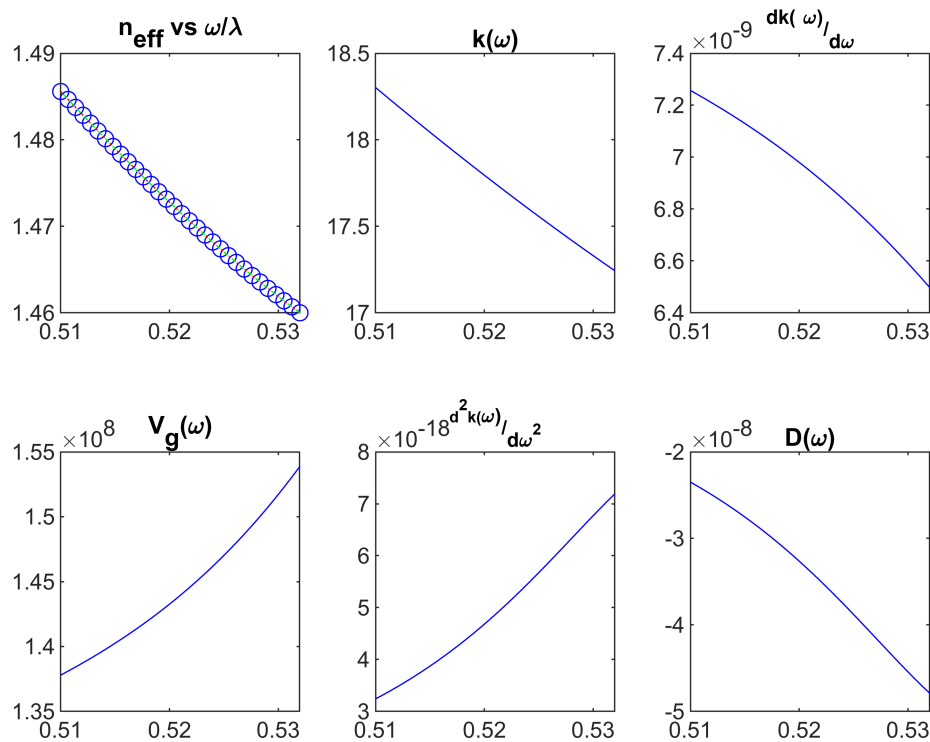
```
disp("Function D(w):");
```

Function D(w):

```
disp(wgSuperior.DwStr);
```

```
-(w.^2/(2*pi*3*10^8)).*((4.015345414268300587716790703345e-283*w.^29*(930)-3.327695710241664041153433773091e-273*w.
```

```
subplot(2,3,1);  
plot(1,neff,'bo',1, wgSuperior.neffwFun(w), 'r-.', 1, wgSuperior.nefflFun(1), 'g--');  
title("n_{eff} vs \omega/\lambda");  
subplot(2,3,2);  
plot(1, wgSuperior.kwFun(w), 'b');  
title("k(\omega)");  
subplot(2,3,3);  
plot(1, wgSuperior.dkwdwFun(w), 'b');  
title("^{dk(\omega)}/{d\omega}");  
subplot(2,3,4);  
plot(1, wgSuperior.vgwFun(w), 'b');  
title("V_g(\omega)");  
subplot(2,3,5);  
plot(1, wgSuperior.d2kwdw2Fun(w), 'b');  
title("^{d^2k(\omega)}/{d\omega^2}");  
subplot(2,3,6);  
plot(1, wgSuperior.DwFun(w), 'b');  
title("D(\omega)");
```



Load Waveguide Simple:

```
file = sprintf(Fundamental,sXs(sel)*1000,sYs(sel)*1000);
load(FundamentalPath+file);
wgFundamental = waveguide(lambda,neff);
file = sprintf(Superior,sXs(sel),sYs(sel),mode);
load(SuperiorPath+file);
wgSuperior = waveguide(lambda,neff);
```

K's comparing

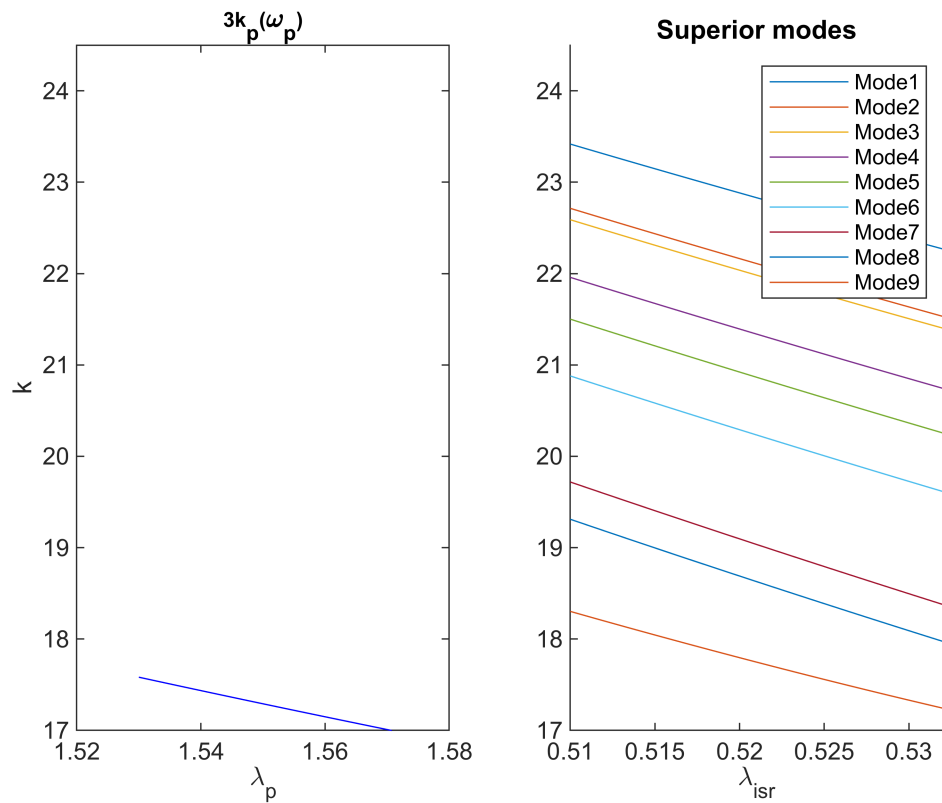
```
file = sprintf(Fundamental,sXs(sel)*1000,sYs(sel)*1000);
load(FundamentalPath+file);
wgFundamental = waveguide(lambda,neff);
l = wgFundamental.lambdaData;
w = wgFundamental.omegaData;
neff = wgFundamental.neffData;
figure;
subplot(1,2,1)
plot(l,wgFundamental.kwFun(w).*3,'b');
leg = {};
title("3k_p(\omega_p)"); xlabel("\lambda_p"); ylabel("k");
```



```

ylim([17 24.5]);
subplot(1,2,2)
hold on
for i = 1:nmodes
    file = sprintf(Superior,sXs(sel),sYs(sel),i);
    load(SuperiorPath+file);
    wgSuperior = waveguide(lambda,neff);
    l = wgSuperior.lambdaData;
    w = wgSuperior.omegaData;
    plot(l,wgSuperior.kwFun(w));
    leg(end+1) = {"Mode"+num2str(i)};
end
legend(leg);
ylim([17 24.5]);
title("Superior modes"); xlabel("\lambda_{isr}");
hold off

```



Find degenerate photon that allow momentum and energy conservation

```

size=50;

lpLim = [min(wgFundamental.lambdaData) max(wgFundamental.lambdaData)];
lpLim = [min(wgSuperior.lambdaData) max(wgSuperior.lambdaData)];
lp = linspace(lpLim(1),lpLim(2),size);

```

```

wp = 2.*pi.*3.*10.^8./lp;
ws = wp./3;
leg = {};

file = sprintf(Fundamental,sXs(sel)*1000,sYs(sel)*1000);
load(FundamentalPath+file);
wgFundamental = waveguide(lambda,neff);

figure
hold on

dk0s = [];

for i = 1:nmodes
    file = sprintf(Superior,sXs(sel),sYs(sel),i);
    load(SuperiorPath+file);
    wgSuperior = waveguide(lambda,neff);
    %Nota w 10^8 es 10^14

    dk = wgSuperior.kwFun(wp)-(3*wgFundamental.kwFun(ws));

    if(min(dk)<=0 && max(dk)>=0)
        dk0s = [dk0s i];
    end

    plot(lp,dk);
    leg(end+1) = {"Mode"+num2str(i)};
end

if ~isequal(dk0s,[])
    strDk0s = sprintf('Modo %i,',dk0s);
    strDk0s = "Modos con dK=0: "+strDk0s(1:end-1);
else
    strDk0s = "Ningun modo con dK=0";
end

disp(strDk0s)

```

Ningun modo con dK=0

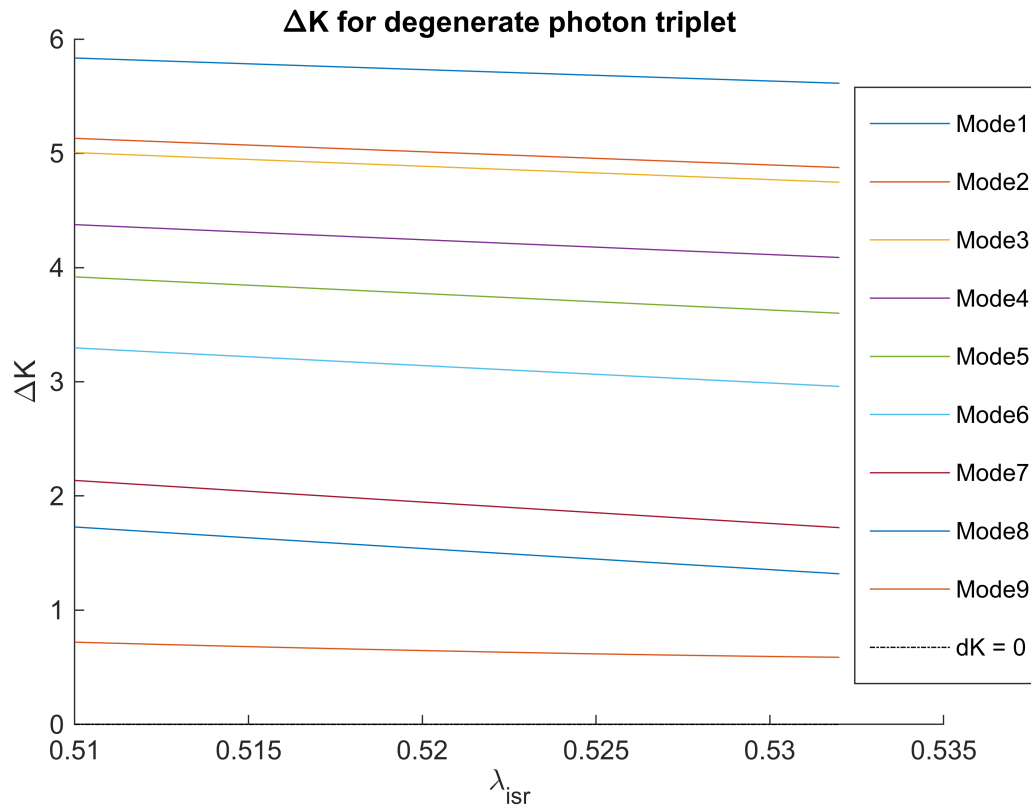
```

plot([lpLim(1),lpLim(2)],[0,0],'k-.')
leg(end+1) = {"dK = 0"};

legend(leg);
title("\DeltaK for degenerate photon triplet");
ylabel("\DeltaK"); xlabel("\lambda_{isr}");

legend("Position", [0.8256,0.15841,0.16964,0.70952])

```



Phase Matching

```

switch nmodes
case 15
    m = 5;n = 3;
case 9
    m = 3;n = 3;
case 19
    m = 5;n = 4;
case 12
    m = 4;n = 3;
end

file = sprintf(Fundamental,sXs(sel)*1000,sYs(sel)*1000);
load(FundamentalPath+file);
wgFundamental = waveguide(lambda,neff);

lpLim = [min(wgFundamental.lambdaData) max(wgFundamental.lambdaData)];
lpLim = [min(wgSuperior.lambdaData) max(wgSuperior.lambdaData)];
li = 1.53;
size=50;

wp = linspace(2.*pi.*3.*10.^8./lpLim(1),2.*pi.*3.*10.^8./lpLim(2),size);
dw = linspace(1e8,-1e8,size);

```

```
[WP,DW] = meshgrid(wp,dw);
wi = (2.*pi.*3.*10.^8./li);
wr = DW+(WP-wi)/2;
ws = WP-wi-wr;
```

```
disp("Pump wavelength: "+num2str(lpLim(1))+ "-" + num2str(lpLim(2)));
```

Pump wavelength: 0.51-0.532

```
disp("Photon wavelength: "+num2str(lphLim(1))+ "-" + num2str(lphLim(2)));
```

Photon wavelength: 1.53-1.596

```
figure
for i = 1:nmodes
    file = sprintf(Superior,sXs(sel),sYs(sel),i);
    load(SuperiorPath+file);
    wgSuperior = waveguide(lambda,neff);
    %Nota w 10^8 es 10^14
    DK = wgSuperior.kwFun(WP)-(wgFundamental.kwFun(wi)+wgFundamental.kwFun(wr)+wgFundamental.kwFun(ws));
    subplot(m,n,i)
    contour(2.*pi.*3.*10.^8./wp,dw.*10^6,DK,[0 0], 'b', 'LineWidth',2);
    title("M "+num2str(i));
    ylabel("\omega");
end
sgtitle("Waveguide "+num2str(sXs(sel))+ "x" + num2str(sYs(sel))+ " with \lambda_i = "+num2str(li))
```

Waveguide 930x235 with $\lambda_i = 1.53$

