In this notebook, the data for Figure 7 is generated.

This is for two ferromagnetic materials joined together, with the DMI being on the top, bottom or both interfaces. We consider only DMI on the top and bottom of a Ir/Fe/Co/Pt stack.

In [1]:
```
import numpy as np
import matplotlib.pyplot as plt
from numpy.linalg import eig
from matplotlib.ticker import MaxNLocator
from matplotlib.ticker import StrMethodFormatter
from scipy.optimize import curve_fit
import sympy as sp
from sympy import expand, symbols
```

In [2]:
```
def MatrixM(H,A,Ms,a,gamma,laynum,D,k):
    A1,A2,A12=A
    gamma1,gamma2=gamma
    a1,a2=a
    M_s1,M_s2=Ms
    N1,N2=laynum
    D1,D2=D
    kx,kz=k
    SW=np.zeros((2*(N1+N2),2*(N1+N2)),dtype=np.complex128)
    nn=np.linspace(0,N1+N2-1,N1+N2)
    mu_0=4*np.pi*1e-7
    a_ave=(a1+a2)/2
    B_zee=mu_0*H
    B_dem1=mu_0*M_s1
    B_dem2=mu_0*M_s2
    B_DM1=2*D1/(a1*M_s1)
    B_DM2=2*D2/(a2*M_s2)
    B_ex1=2*A1/((a1**2)*M_s1)
    B_ex2=2*A2/((a2**2)*M_s2)
    B_ex12_1=2*A12/((a_ave**2)*M_s1)
    B_ex12_2=2*A12/((a_ave**2)*M_s2)
    k_ex1=2*( np.cos(a1*kx)+np.cos(a1*kz) )
    k_ex2=2*( np.cos(a2*kx)+np.cos(a2*kz) )
    k_DM1=np.sin(a1*kx)
    k_DM2=-np.sin(a2*kx)
    iG1=-1j*gamma1
    iG2=-1j*gamma2
    for nn in range(0,1):
        SW[0][0]=(1j*B_DM1*k_DM1)*iG1
        SW[0][1]=(B_zee+B_ex1*(5-k_ex1)+B_dem1)*iG1
        SW[0][3]=(-B_ex1)*iG1
        SW[1][0]=( -(B_zee+B_ex1*(5-k_ex1)) )*iG1
        SW[1][1]=( 1j*B_DM1*k_DM1 )*iG1
        SW[1][2]=B_ex1*iG1
        for nn in range(1,N1-1):
            SW[2*nn][2*(nn-1)+1]=(-B_ex1)*iG1
            SW[2*nn][2*nn+1]=(B_zee+B_ex1*(6-k_ex1)+B_dem1)*iG1
            SW[2*nn][2*(nn+1)+1]=(-B_ex1)*iG1
            SW[2*nn+1][2*(nn-1)]=B_ex1*iG1
            SW[2*nn+1][2*nn]=( -(B_zee+B_ex1*(6-k_ex1)) )*iG1
```

```python
            SW[2*nn+1][2*(nn+1)]=B_ex1*iG1
            for nn in range(N1-1,N1):
                SW[2*nn][2*(nn-1)+1]=(-B_ex1)*iG1
                SW[2*nn][2*nn+1]=(B_zee+B_ex1*(5-k_ex1)+B_dem1+B_ex12_1)*iG1
                SW[2*nn][2*(nn+1)+1]=(-B_ex12_1)*iG1
                SW[2*nn+1][2*(nn-1)]=B_ex1*iG1
                SW[2*nn+1][2*nn]=(-(B_zee+B_ex1*(5-k_ex1)+B_ex12_1))*iG1
                SW[2*nn+1][2*(nn+1)]=B_ex12_1*iG1
                for nn in range(N1,N1+1):
                    SW[2*nn][2*(nn-1)+1]=(-B_ex12_2)*iG2
                    SW[2*nn][2*nn+1]=(B_zee+B_ex2*(5-k_ex2)+B_dem2+B_ex12_2)*iG2
                    SW[2*nn][2*(nn+1)+1]=(-B_ex2)*iG2
                    SW[2*nn+1][2*(nn-1)]=B_ex12_2*iG2
                    SW[2*nn+1][2*nn]=(-(B_zee+B_ex2*(5-k_ex2)+B_ex12_2))*iG2
                    SW[2*nn+1][2*(nn+1)]=B_ex2*iG2
                    for nn in range(N1+1,N1+N2-1):
                        SW[2*nn][2*(nn-1)+1]=(-B_ex2)*iG2
                        SW[2*nn][2*nn+1]=(B_zee+B_ex2*(6-k_ex2)+B_dem2)*iG2
                        SW[2*nn][2*(nn+1)+1]=(-B_ex2)*iG2
                        SW[2*nn+1][2*(nn-1)]=B_ex2*iG2
                        SW[2*nn+1][2*nn]=( -(B_zee+B_ex2*(6-k_ex2)) )*iG2
                        SW[2*nn+1][2*(nn+1)]=B_ex2*iG2
                        for nn in range(N1+N2-1,N1+N2):
                            SW[2*nn][2*(nn-1)+1]=(-B_ex2)*iG2
                            SW[2*nn][2*nn]=1j*B_DM2*k_DM2*iG2
                            SW[2*nn][2*nn+1]=(B_zee+B_ex2*(5-k_ex2)+B_dem2)*iG2
                            SW[2*nn+1][2*(nn-1)]=B_ex2*iG2
                            SW[2*nn+1][2*nn]=( -(B_zee+B_ex2*(5-k_ex2)) )*iG2
                            SW[2*nn+1][2*nn+1]=1j*B_DM2*k_DM2*iG2
    return SW
# Frequency ----------------------------------------------------------------------------------
def FreqM(H,A,Ms,a,gamma,laynum,D,k,n):
    A1,A2,A12=A
    gamma1,gamma2=gamma
    a1,a2=a
    M_s1,M_s2=Ms
    N1,N2=laynum
    D1,D2=D
    kx,kz=k
    N1,N2=laynum
    SW=MatrixM(H,A,Ms,a,gamma,laynum,D,k)
```

```
    omegaGHz=[]
    w,v=eig(SW)
    omegaRaw = w
    idx1 = np.argsort(omegaRaw)
    omegaRaw = omegaRaw[idx1]
    omega=np.zeros(N1+N2, dtype = 'complex_')
    for ii in range (0,N1+N2):
        omega[ii]=omegaRaw[ii+N1+N2]
        omegaGHz=omega/1e9
    return omegaGHz[n].real
# dispersion curve ------------------------------------------------------------------------
def SWfreqkxM(H,A,Ms,a,gamma,laynum,D,MaxRe,n):
    A1,A2,A12=A
    gamma1,gamma2=gamma
    a1,a2=a
    M_s1,M_s2=Ms
    N1,N2=laynum
    D1,D2=D
    N1,N2=laynum
    Max,h=MaxRe
    omega1=np.zeros(int(2*Max/(h*1e6)+1))
    kx=np.linspace(-Max,Max, int(2*Max/(h*1e6)+1) )
    for ii in range (0, int(2*Max/(h*1e6)+1) ):
        omega1[ii]=FreqM(H,A,Ms,a,gamma,laynum,D,(kx[ii],0),n)
    return omega1
def xSWfreqkxM(MaxRe):
    Max,h=MaxRe
    Max0=Max/1e6
    return np.linspace(-Max0,Max0,int(2*Max0/h+1))
# Get eiganvector of SW matrix to obtain the mode profile ------------------------------------------
def ModAmpXM(H,A,Ms,a,gamma,laynum,D,k,n):
    A1,A2,A12=A
    gamma1,gamma2=gamma
    a1,a2=a
    M_s1,M_s2=Ms
    N1,N2=laynum
    D1,D2=D
    kx,kz=k
    N1,N2=laynum
    SW=MatrixM(H,A,Ms,a,gamma,laynum,D,k)
    w,v=eig(SW)
```

```python
    omegaRaw=w
    idx1 = np.argsort(omegaRaw)
    omegaRaw = omegaRaw[idx1]
    v = v[:,idx1]
    EigV=np.zeros((2*(N1+N2),N1+N2),dtype = 'complex_')
    for ii in range (0,(N1+N2)):
        for jj in range (0,2*(N1+N2)):
            EigV[jj][ii]=v[jj][ii+(N1+N2)]
    EigVx=np.zeros(((N1+N2),(N1+N2)),dtype=np.complex128)
    for ii in range (0,(N1+N2)):
        for jj in range (0,(N1+N2)):
            EigVx[ii][jj]=EigV[2*ii][jj]
            if abs(EigVx[ii][jj].real)>abs(EigVx[ii][jj].imag):
                EigVx[ii][jj]=EigVx[ii][jj].real
            else:
                EigVx[ii][jj]=EigVx[ii][jj].imag
    return EigVx[:,n].real
# layer number function --------------------------------------------------------
def xMobAmpM(laynum):
    N1,N2=laynum
    layers=np.linspace(1,(N1+N2),(N1+N2))
    return layers
# convert back to film thickness
def xMobthicknessM(a,laynum):
    a1,a2=a
    N1,N2=laynum
    layers=np.linspace(1,(N1+N2),(N1+N2))
    thickness=np.zeros(len(layers))
    for i in range (0,N1):
        thickness[i]=a1*layers[i]
        for i in range(N1,N1+N2):
            thickness[i]=a1*N1+(layers[i]-N1)*a2
    return thickness
def NModAmpXM(H,A,Ms,a,gamma,laynum,D,k,n):
    return ModAmpXM(H,A,Ms,a,gamma,laynum,D,k,n)/np.max( abs(ModAmpXM(H,A,Ms,a,gamma,laynum,D,k,n)) )
```

Here are the material parameters (written in the main text of the article too):

In [3]:
```
H_1=300*(1e3/(4*np.pi))  # A/m
D_1=(3.9e-3,-1.5e-3)    # J/m^2
a_1=(0.2866e-9,0.2506e-9)  # m
A_1=(18.8e-12,32.5e-12,27e-12)   # J/m
#A_1=(18.8e-12,32.5e-12,(18.8e-12+32.5e-12)/2)
Ms_1=(1.752e6,1.446e6)  # A/m
gamma_1=(29e9,31.2e9)  # Hz.rad/T
laynum_10_10=(10,10)   # layer number
k_1=20e6     # example wave number in per m
MaxRe_1=(30e6,1)
A_2=(25.65e-12,25.65e-12,25.65e-12)
Ms_2=(1.599e6,1.599e6)
gamma_2=(30.1e9,30.1e9)
a_2=(0.2686e-9,0.2686e-9)
```

In [ ]:
```
MaxRe_100=(100e6,4)
x=xSWfreqkxM(MaxRe_100)
y0=SWfreqkxM(H_1,A_1,Ms_1,a_1,gamma_1,laynum_10_10,D_1,MaxRe_100,0)
y1=SWfreqkxM(H_1,A_1,Ms_1,a_1,gamma_1,laynum_10_10,D_1,MaxRe_100,1)
y2=SWfreqkxM(H_1,A_1,Ms_1,a_1,gamma_1,laynum_10_10,D_1,MaxRe_100,2)
```

The k_x values probed (in units of $\mu\mathrm{m}^{-1}$) are:

In [11]:
```
counter=0
x0 = []
while counter < len(x):
    x0.append(x[counter])
    counter = counter + 1

print(x0)
```

```
[-100.0, -96.0, -92.0, -88.0, -84.0, -80.0, -76.0, -72.0, -68.0, -64.0, -60.0, -56.0, -52.0, -48.0, -4
4.0, -40.0, -36.0, -32.0, -28.0, -24.0, -20.0, -16.0, -12.0, -8.0, -4.0, 0.0, 4.0, 8.0, 12.0, 16.0, 20.0,
24.0, 28.0, 32.0, 36.0, 40.0, 44.0, 48.0, 52.0, 56.0, 60.0, 64.0, 68.0, 72.0, 76.0, 80.0, 84.0, 88.0, 92.
0, 96.0, 100.0]
```

The n=0 (quasiuniform) mode frequencies in GHz are:

In [12]:

```python
counter=0
y00 = []
while counter < len(y0):
    y00.append(y0[counter])
    counter = counter + 1

print(y00)
```

```
[26.28218643453064, 25.192336846973806, 24.120850695701115, 23.067695331102183, 22.03289386462919, 21.016
540188301327, 20.018817700841282, 19.040022769294843, 18.080594266259975, 17.141150927001714, 16.22253878
8365238, 15.325891614492251, 14.452707977897417, 13.60494948298836, 12.785165309556746, 11.99664837563575
4, 11.243627041343139, 10.531491593879819, 9.867043596079897, 9.258733733009747, 8.716814701904296, 8.253
279216561728, 7.8813960193054085, 7.614651611679288, 7.465041133063337, 7.440982490201939, 7.545524269081
15, 7.775629655221711, 8.12289251727552, 8.575329499068348, 9.11946589392493, 9.742044769926643, 10.43108
5243033055, 11.176346468913657, 11.969389642305728, 12.803425110759834, 13.673074531685845, 14.5741215273
58736, 15.503285203426625, 16.458028448461512, 17.43640177443053, 18.436918776413904, 19.458457912208612,
20.500185424236257, 21.561494916705282, 22.64195991943652, 23.741296533346915, 24.859333895665053, 25.995
990720604077, 27.15125657534807, 28.325176862488185]
```

The n=1 (first exchange PSSW) mode frequencies/dispersion in GHz are:

In [13]:

```python
counter=0
y10 = []
while counter < len(y1):
    y10.append(y1[counter])
    counter = counter + 1

print(y10)
```

```
[320.66869784138294, 319.99382809610063, 319.35050622022027, 318.7386778422274, 318.15829065418006, 317.6
092944154997, 317.091640956095, 316.6052841790239, 316.1501800627057, 315.7262866626234, 315.33564112707
3, 314.9719746262648, 314.64148249664083, 314.3420540975182, 314.0736578829342, 313.83626438708717, 313.6
2984622382675, 313.4543780860361, 313.3098367447296, 313.196201048043, 313.1134519200583, 313.06157235947
114, 313.04054743815766, 313.05036429966754, 313.09101215752867, 313.16248229355824, 313.2647680560826, 3
13.39786485800784, 313.561770174904, 313.75648354305093, 313.9820065572681, 314.2383428688771, 314.525498
18345756, 314.8434802585723, 315.1922989014662, 315.57196596660566, 315.98249535317143, 316.4239030024595
5, 316.89620689512566, 317.399427048362, 317.93358551287025, 318.49870636971326, 319.0948157270208, 319.7
2194171640643, 320.3801144892807, 321.06936621281903, 321.7897310657736, 322.5412452338976, 323.323946905
12643, 324.1378762644122, 324.9830754881251]
```

The n=2 (second exchange PSSW) mode frequencies in GHz are:

In [14]:
```
counter=0
y20 = []
while counter < len(y2):
    y20.append(y2[counter])
    counter = counter + 1

print(y20)
```

```
[1280.1666857744235, 1279.5826685329127, 1279.025818430522, 1278.4961353386946, 1277.9936191548663, 1277.5182698007302, 1277.0700872204309, 1276.6490713789217, 1276.2552222603713, 1275.8885398666903, 1275.5490242161102, 1275.2366753417512, 1274.9514932904644, 1274.6934781215748, 1274.4626299057945, 1274.2589487241585, 1274.082434667072, 1273.933087833447, 1273.8109083298905, 1273.7158962699323, 1273.648051773427, 1273.607374965931, 1273.5938659782169, 1273.6075249458545, 1273.6483520088314, 1273.716347311282, 1273.8115110013125, 1273.933843230846, 1274.0833441555524, 1274.260013934943, 1274.4638527323866, 1274.6948607153263, 1274.9530380555218, 1275.238384929361, 1275.5509015182786, 1275.890588009209, 1276.2574445951448, 1276.6514714757657, 1277.0726688581358, 1277.5210369574645, 1277.9965759979784, 1278.4992862138163, 1279.0291678501053, 1279.586221163938, 1280.1704464255974, 1280.7818439197788, 1281.420413946894, 1282.0861568244327, 1282.779072888461, 1283.4991624951533, 1284.2464260224056]
```

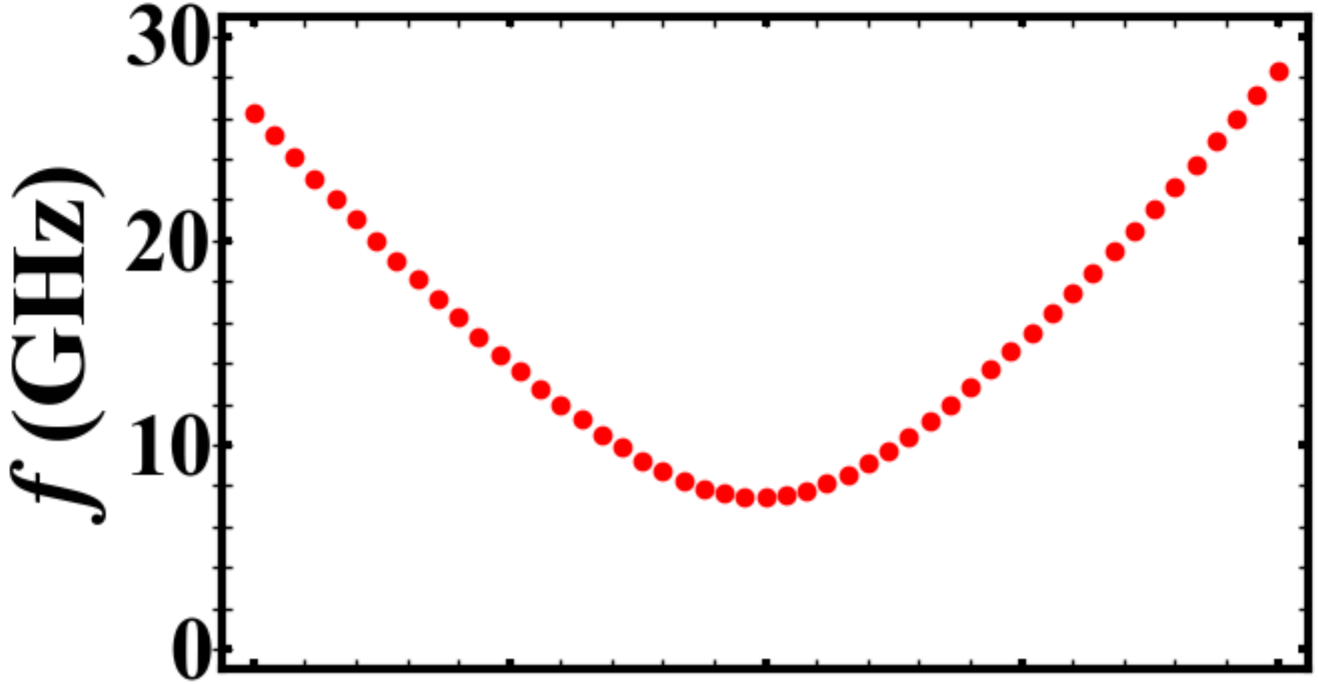
Making plots of the dispersion relations:

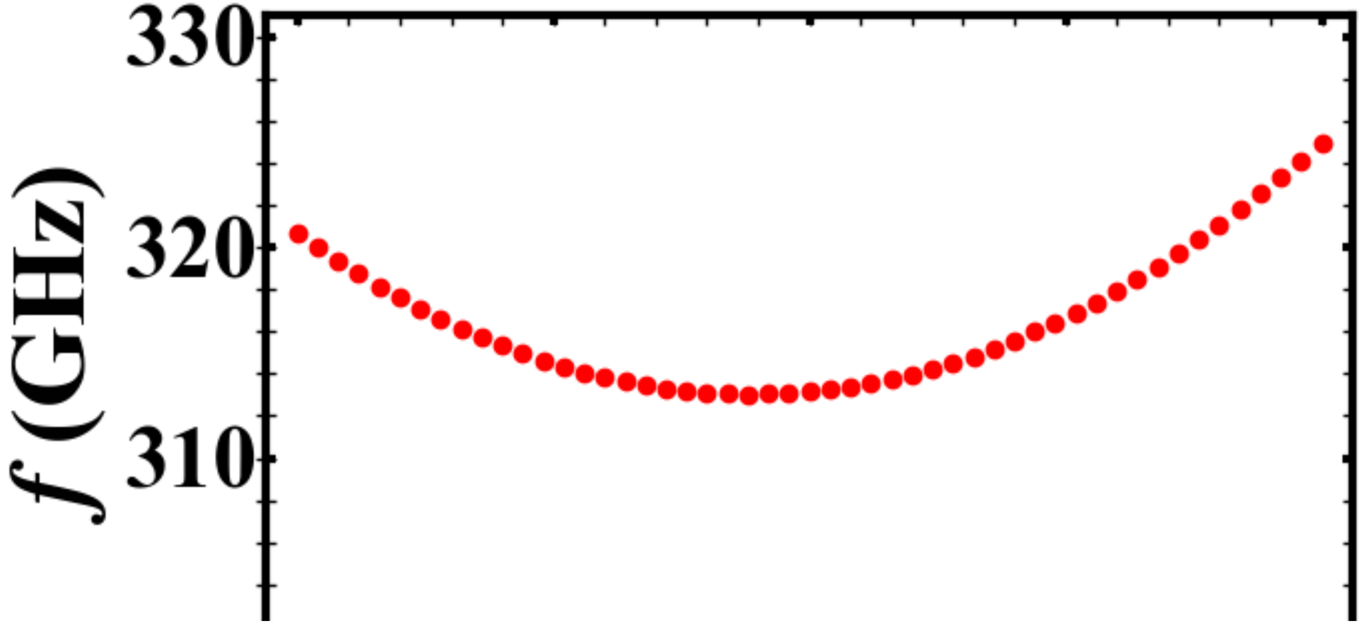
In [7]:

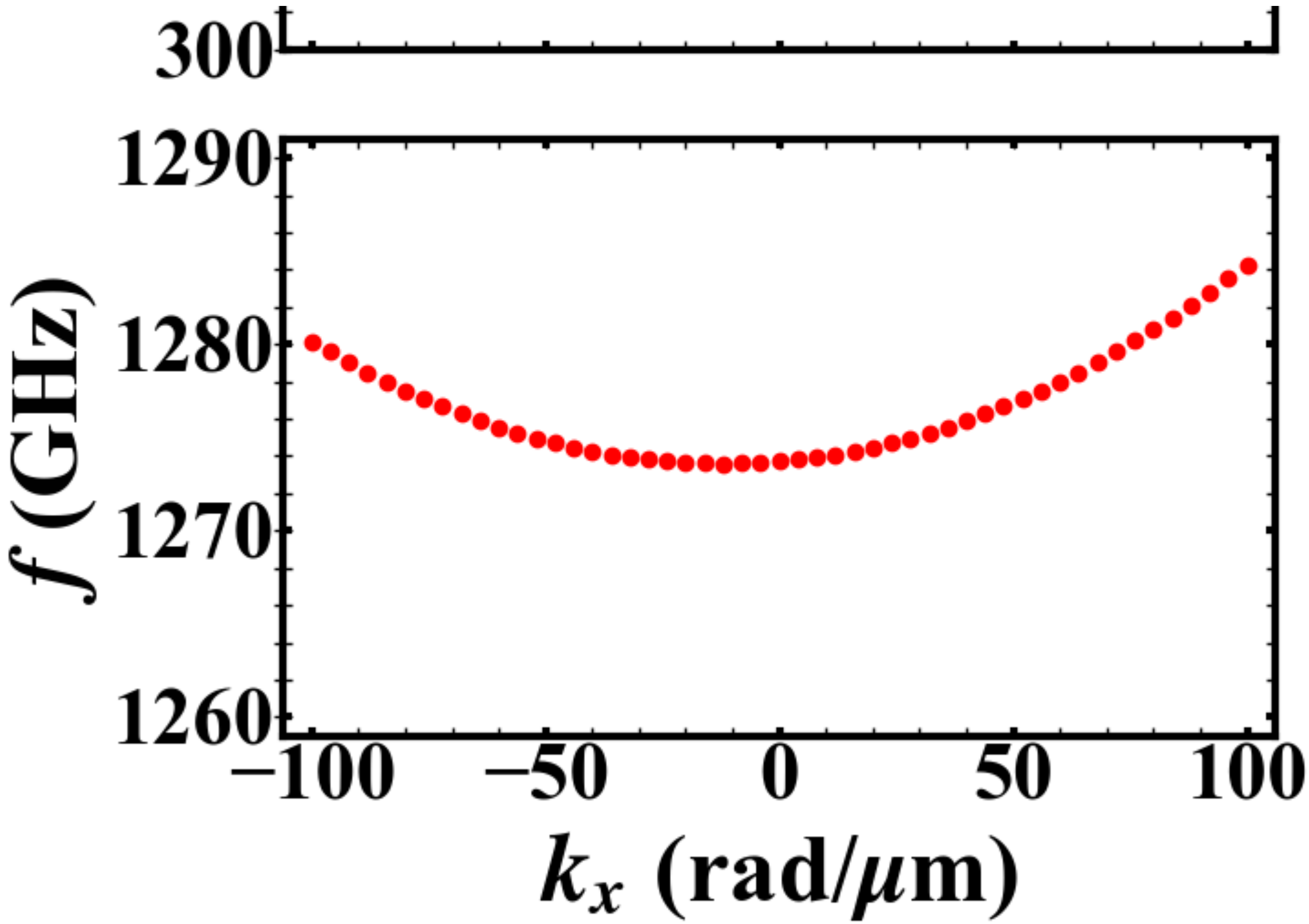
```
MaxRe_100=(100e6,4)
x=xSWfreqkxM(MaxRe_100)
y0=SWfreqkxM(H_1,A_1,Ms_1,a_1,gamma_1,laynum_10_10,D_1,MaxRe_100,0)
y1=SWfreqkxM(H_1,A_1,Ms_1,a_1,gamma_1,laynum_10_10,D_1,MaxRe_100,1)
y2=SWfreqkxM(H_1,A_1,Ms_1,a_1,gamma_1,laynum_10_10,D_1,MaxRe_100,2)

plt.rcParams["font.weight"] = "bold"
plt.rcParams["font.family"] = "Times New Roman"
plt.rcParams['mathtext.fontset'] = 'custom'
plt.rcParams['mathtext.it'] = 'STIXGeneral:italic'
plt.rcParams['mathtext.bf'] = 'STIXGeneral:italic:bold'
fig, (ax1,ax2,ax3) = plt.subplots(3, 1, sharex=True,figsize=(7, 14))
fig.subplots_adjust(hspace=0.15)
#fig.suptitle('Spin waves modes Ir/Fe/Co/Pt',fontsize=20)
ax1.plot(x,y0,'o',color='red', label='n=0',linewidth=1)
ax1.set_ylabel(r'$\mathbf{f}$ (GHz)',weight='bold',fontsize=38)
#ax1.set_xlabel('Normalized $S_x$',fontsize=15)
ax1.set_ylim([-1,31])

ax1.set_yticks([0,10,20,30])
ax1.tick_params(axis='y', right=True,direction='in',width=3,labelsize=32)
sec1 = ax1.secondary_yaxis(location=0)
sec1.set_yticks(np.linspace(0,30,16),labels=None)
sec1.tick_params(axis='y',right=True,direction='in',width=1,labelleft=False)
thd1 = ax1.secondary_yaxis(location='right')
thd1.set_yticks(np.linspace(0,30,16),labels=None)
thd1.tick_params(axis='y',direction='in',width=1,labelright=False)
ax1.tick_params(axis='y',direction='in',labelsize=32)
ax1.set_xticks([-100,-50,0,50,100],labels=None)
ax1.tick_params(axis='x',direction='in', top=True,width=3,labelbottom=False)
sec1 = ax1.secondary_xaxis(location='bottom')
sec1.set_xticks(np.linspace(-100,100,21),labels=None)
sec1.tick_params(axis='x',direction='in',width=1,labelbottom=False)
thd1 = ax1.secondary_xaxis(location='top')
thd1.set_xticks(np.linspace(-100,100,21),labels=None)
thd1.tick_params(axis='x',direction='in',width=1,labeltop=False)

plt.setp(ax1.spines.values(), lw=3)
#ax1.legend(fontsize=15)
ax2.plot(x,y1,'o',color='red', label='n=1',linewidth=1)
```

```
#ax2.set_ylabel('Layer index',fontsize=25)
#ax2.set_xlabel('Normalized $S_x$',fontsize=15)
ax2.set_ylim([329,331])
#ax2.set_xlim([0.99865,1.00005])
ax2.set_ylabel(r'$\mathbf{f}$ (GHz)',weight='bold',fontsize=38)

ax2.set_yticks([300,310,320,330])
ax2.tick_params(axis='y', right=True,direction='in',width=3,labelsize=32)
sec2 = ax2.secondary_yaxis(location=0)
sec2.set_yticks(np.linspace(300,330,16),labels=None)
sec2.tick_params(axis='y',right=True,direction='in',width=1,labelleft=False)
thd2 = ax2.secondary_yaxis(location='right')
thd2.set_yticks(np.linspace(300,330,16),labels=None)
thd2.tick_params(axis='y',width=1,direction='in',labelright=False)
ax2.tick_params(axis='y',direction='in',labelsize=32)
ax2.set_xticks([-100,-50,0,50,100],labels=None)
ax2.tick_params(axis='x', direction='in',top=True,width=3,labelbottom=False)
sec2 = ax2.secondary_xaxis(location='bottom')
sec2.set_xticks(np.linspace(-100,100,21),labels=None)
sec2.tick_params(axis='x',direction='in',width=1,labelbottom=False)
thd2 = ax2.secondary_xaxis(location='top')
thd2.set_xticks(np.linspace(-100,100,21),labels=None)
thd2.tick_params(axis='x',direction='in',width=1,labeltop=False)

plt.setp(ax2.spines.values(), lw=3)
#ax2.legend(fontsize=15)
ax3.plot(x,y2,'o',color='red',label='n=2',linewidth=1)
#ax3.set_ylabel('Layer index',fontsize=25)
#ax3.set_xlabel('Normalized $S_x$',fontsize=15)

ax3.set_ylim([1259,1291])
ax3.set_xlim([-106,106])

ax3.set_ylabel(r'$\mathbf{f}$ (GHz)',weight='bold',fontsize=38)
ax3.set_xlabel(r'$\mathbf{k_x}$ (rad/$\mathbf{\mu}$m)',weight='bold',fontsize=38)

ax3.set_yticks([1260,1270,1280,1290])
ax3.tick_params(axis='y',direction='in', right=True,width=3,labelsize=32)
sec3 = ax3.secondary_yaxis(location=0)
sec3.set_yticks(np.linspace(1260,1290,16),labels=None)
sec3.tick_params(axis='y',direction='in',right=True,width=1,labelleft=False)
```

```
thd3 = ax3.secondary_yaxis(location='right')
thd3.set_yticks(np.linspace(1260,1290,16),labels=None)
thd3.tick_params(axis='y',direction='in',width=1,labelright=False)
ax3.tick_params(axis='y',direction='in',labelsize=32)
ax3.set_xticks([-100,-50,0,50,100])
ax3.tick_params(axis='x',direction='in', top=True,width=3,labelsize=32)
sec3 = ax3.secondary_xaxis(location='bottom')
sec3.set_xticks(np.linspace(-100,100,21),labels=None)
sec3.tick_params(axis='x',direction='in',width=1,labelbottom=False)
thd3 = ax3.secondary_xaxis(location='top')
thd3.set_xticks(np.linspace(-100,100,21),labels=None)
thd3.tick_params(axis='x',direction='in',width=1,labeltop=False)

plt.setp(ax3.spines.values(), lw=3)
#ax2.legend(fontsize=15)
plt.show()
```


30
20
10
0
f (GHz)


330
320
310
f (GHz)

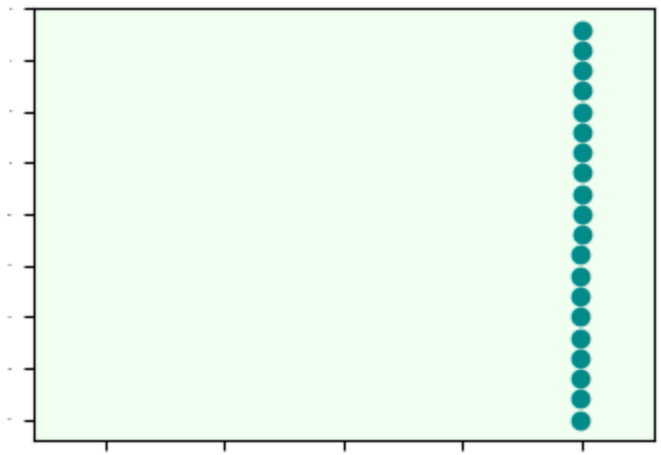


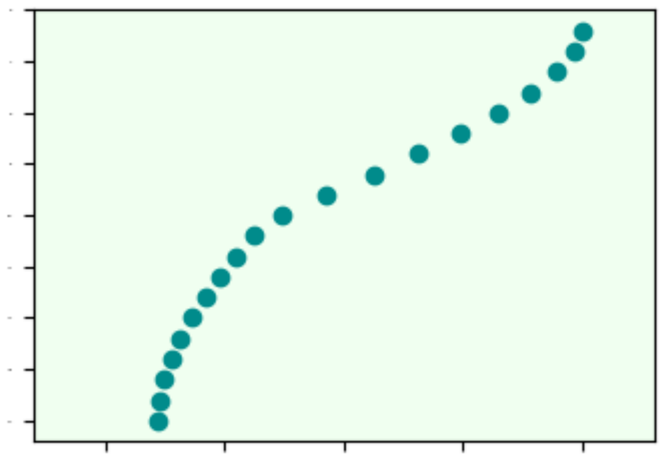
The corresponding mode profiles through the film thickness are drawn below:

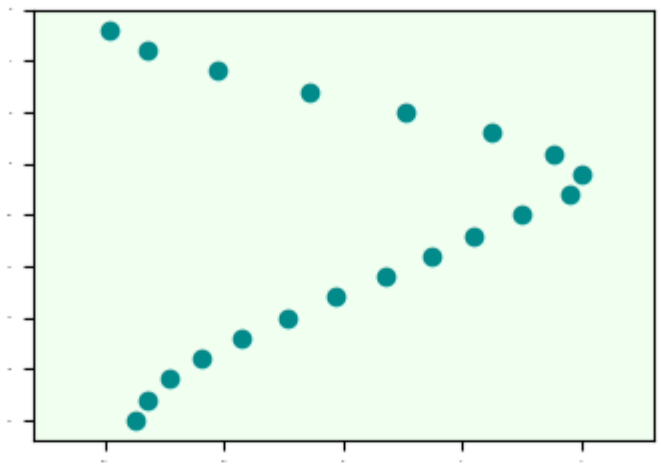
In [5]:

```
#NModAmpXM(H,A,Ms,a,gamma,laynum,D,k,n)
y=xMobAmpM(laynum_10_10)
x0=NModAmpXM(H_1,A_1,Ms_1,a_1,gamma_1,laynum_10_10,D_1,(50e6,0),0)
x1=NModAmpXM(H_1,A_1,Ms_1,a_1,gamma_1,laynum_10_10,D_1,(50e6,0),1)
x2=NModAmpXM(H_1,A_1,Ms_1,a_1,gamma_1,laynum_10_10,D_1,(50e6,0),2)

fig, (ax1,ax2,ax3) = plt.subplots(3, 1, sharex=True,figsize=(4, 14))
fig.subplots_adjust(hspace=1)
#fig.suptitle('Spin waves modes Ir/Fe/Co/Pt',fontsize=20)
ax1.plot(x0,y,'o',color='darkcyan', label='n=0',linewidth=1)
#ax1.plot(np.zeros(len(x)), y0,'--',color='black',linewidth=1)
#ax1.set_ylabel('$\Delta f$ (GHz)',fontsize=32)
#ax1.set_xlabel('Normalized $S_x$',fontsize=15)
ax1.set_ylim([21,0])
ax1.set_xlim([-1.1,1.1])
ax1.tick_params(axis='y', labelsize=0)
ax1.tick_params(axis='x', labelsize=0)
ax1.set_facecolor("honeydew")
#ax1.xaxis.set_ticks(np.arange(0.9985, 1.00061, 0.0006))
#ax1.legend(fontsize=15)
ax2.plot(x1,y,'o',color='darkcyan', label='n=1',linewidth=1)
#ax2.set_ylabel('Layer index',fontsize=25)
#ax2.set_xlabel('Normalized $S_x$',fontsize=15)
#ax2.xaxis.set_ticks(np.arange(0.9985, 1.00061, 0.0006))
ax2.set_ylim([21,0])
ax2.set_xlim([-1.1,1.1])
#ax2.set_ylabel('$\Delta f$ (GHz)',fontsize=32)
ax2.tick_params(axis='y',labelsize=0)
ax2.tick_params(axis='x', labelsize=0)
ax2.set_facecolor("honeydew")
#ax2.legend(fontsize=15)
ax3.plot(x2,y,'o',color='darkcyan',label='n=2',linewidth=1)
#ax3.set_ylabel('Layer index',fontsize=25)
#ax3.set_xlabel('Normalized $S_x$',fontsize=15)
#ax2.xaxis.set_ticks(np.arange(0.9985, 1.00061, 0.0006))
ax3.set_ylim([21,0])
ax3.set_xlim([-1.3,1.3])
#ax3.set_ylabel('$\Delta f$ (GHz)',fontsize=32)
ax3.tick_params(axis='y',labelsize=0)
ax3.tick_params(axis='x', labelsize=0)
```

```
#ax3.set_xlabel('$k_x$ (rad/$\mu$m)',fontsize=32)
#ax2.legend(fontsize=15)
ax3.set_facecolor("honeydew")
plt.show()
```







In [ ]:
```
1
```