Computational Phyics Assignment 2

Dara Corr - 18483836

The aim of this assignment is to model the outputs from Young's famous two slit experiment that we will see in the 3rd year labs.

We use the following Formulae to plot the 1D image of the Intensity Pattern for the double slit experiment in Task 1:

$$I = I_0 \left[\frac{sin(\alpha)}{\alpha}\right]^2 [cos(\beta)]^2$$

where

$$\alpha = \frac{\pi a}{\lambda} sin(\theta)$$
$$\beta = \frac{\pi d}{\lambda} sin(\theta)$$

and

$$tan(\theta) = \frac{y}{L}$$

We are provided with several useful constants and measurements also. They are as follows: Tge slit width a = 0.09mm, the distance from slits to the screen L = 480mm, the distance between slits d = 0.4mm and the wavelength of the light λ = 670nm

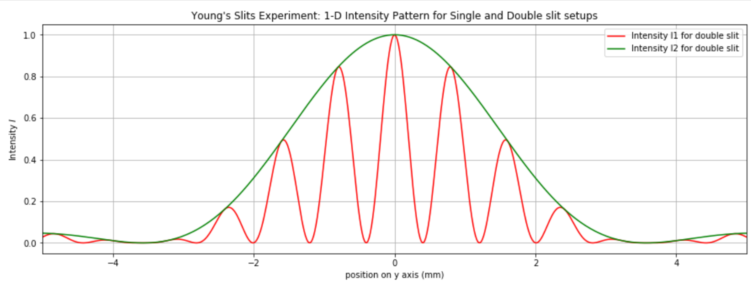
In Task 2, we are asked to plot the 1-D Intensity Pattern of light observed if we used just one slit. This can be obtained by removing the interference term from the equation for I as follows:

$$I = I_0 \left[\frac{sin(\alpha)}{\alpha}\right]^2$$

In Task 3 we alter the existing programme to model what the image on the viewing card would look like. This is done by assuming the 1-D pattern is repeated in a vertical direction. Thus it is possible to create a multidimensional array with each row containing the array I from task 1 and each row is the same. From this method I created a 2-D image made of a set of bands in y and z.

In the final task, task 4, I inlcuded diffraction in the z direction that was previously omitted by using the formula in Task 2 but changing the slit width a to the slit height b. I entered the resulting data into an array similar to the one produced in task3 and then transposed it since it would be acting on the z direction. Then multiplied this array with the one created in task3 and plotted it which resulted in the real image of the 2-D intensity pattern. The dots produced in this image resemble what would be seen on the viewing card during the experiment.

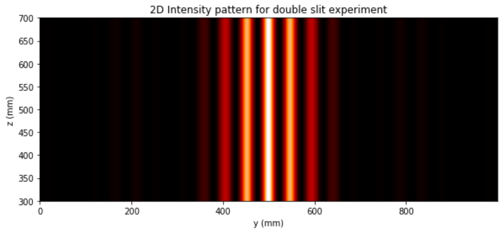
In [16]:
```
#import relevant libraries numpy and pyplot
import numpy as np
import matplotlib.pyplot as plt

#define constants in millimetres
L = 480 #distance from slit to the screen
a = 0.09 #slit width
d = 0.4 #distance between slits
Lambda = 670e-6 # wavelength of the light

#set limits for the angle theta
tmin = -1
tmax = 1


#define array to hold theta values
theta = np.linspace(np.deg2rad(tmin),np.deg2rad(tmax),1000)

#define y
y = np.tan(theta)*L

#define alpha and beta
alpha = ((np.pi*a)/Lambda)*np.sin(theta)
beta = ((np.pi*d)/Lambda)*np.sin(theta)

#define formula for intensity for double slit
I1 =((np.sin(alpha)/alpha))**2 * (np.cos(beta))**2


#define formula for intensity for single slit
I2 =((np.sin(alpha)/alpha))**2

#plotting
fig= plt.figure(figsize=(15,5)) #change plot size
plt.xlim(-5,5) #change x limits on graph
plt.plot(y,I1, "r", label='Intensity I1 for double slit') #plot double slit interference pattern
plt.plot(y,I2, "g", label='Intensity I2 for double slit') #plot single slit interference pattern
plt.title("Young's Slits Experiment: 1-D Intensity Pattern for Single and Double slit setups")
plt.xlabel("position on y axis (mm)")
plt.ylabel("Intensity $I$")
plt.grid()
plt.legend() #display legend
plt.show() #show graph
```



This is a plot of the 1D intensity pattern for the single slit and double slit setups of Young's Slits Experiment. For the Double slit, we see a pattern of peaks and troughs which is what is expected to be observed when doing the double slit experiment. The plot for the double slits lies just under the plot for the single slit which again is to be expected in the lab also.

In [4]:
```
#make a multi-dimensional array where each column entry specifies the light intensity at each point (y) on each line
#and each row corresponds to a new line in the image (z direction)
#each row of the matrix is the values of the Intensity from the interference pattern using the double slits along the y axis
#each row is copied down along matrix to produce the image
I_matrix = [I1 for i in range(1000)]


fig= plt.figure(figsize=(12,4))
plt.title("2D Intensity pattern for double slit experiment")
plt.xlabel("y (mm)")
plt.ylabel("z (mm)")
plt.ylim(300,700)
#displays the image of the matrix above which plots the 2-D Double slit Interference pattern as would be seen on the viewing card in the experiment
plt.imshow(I_matrix, cmap = 'gist_heat')
```

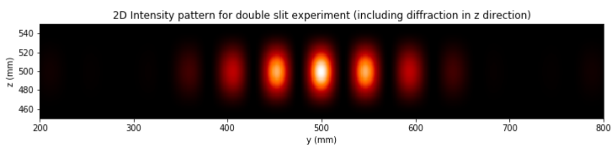
Out[4]: <matplotlib.image.AxesImage at 0xd25951dd8>



This plot gives us bands of interference fringe patterns that corresponds to the peaks and troughs seen in the plot for the 1-D interference using the double slits. This is similar to what I would expect to see on the viewing card in the lab while preforming this experiment. However I have not yet accounted for diffraction in the z-direction because of the height of the slits. In the next part I will be making this plot again and including the diffraction in the z direction due to the height of the slits.

In [21]:
```
z = np.tan(theta)*L
b = 0.4 #(mm) define slit width

alpha_z = ((np.pi*b)/Lambda)*np.sin(theta) #using alpha from part 2 here but replacing slit width with height

I_z =((np.sin(alpha_z)/alpha_z))**2 #use single slit formula to get diffraction in z direction from slit height

fig= plt.figure(figsize=(12,4))
plt.title("2D Intensity pattern for double slit experiment (including diffraction in z direction)")
plt.xlabel("y (mm)")
plt.ylabel("z (mm)")
plt.xlim(200,800)
plt.ylim(450,550)
I_matrix_z = [(I_z) for i in range(1000)] #using same technique as in part 3, create multidimensional array where each row is I_z

#since the diffraction due to slit height is along z direction, I transpose I_matrix_z before multiplying it by I_matrix
#so that the z diffraction takes place in the z axis
plt.imshow(np.transpose(I_matrix_z)*(I_matrix), cmap = 'gist_heat')
```

Out[21]: <matplotlib.image.AxesImage at 0xd264c12e8>



Here I have the real 2D intensity pattern for Young's Double Slit experiment. This factors in diffraction along the y axis as well as diffraction along the z axis. This is what I would expect to see on the viewing card when doing this experiment in the lab.