Project – December 2021

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"Double slit experiment" can be considered as one of the earliest experiments that supported quantum mechanical principles. It demonstrated that light and matter can display characteristics of both classically defined waves and particles. This experimental setup is commonly referred to as the "Slit experiment" because it can be done either using a single or double slit.

Single and Double slit diffraction in 1-Dimension

Part A: For the single slit

- The phase difference between the wavelets from the first and the last sources is:

  $$\emptyset = \frac{2.\pi\ .\mathrm{a}.\sin\theta}{\lambda};$$

  Where Angle to the furthest away point from the central maximum is 'θ', the wavelength is 'λ' and the slit width is 'a'.

- $\beta = \frac{\emptyset}{2} = \frac{\pi\ .\mathrm{a}.\sin\theta}{\lambda};$

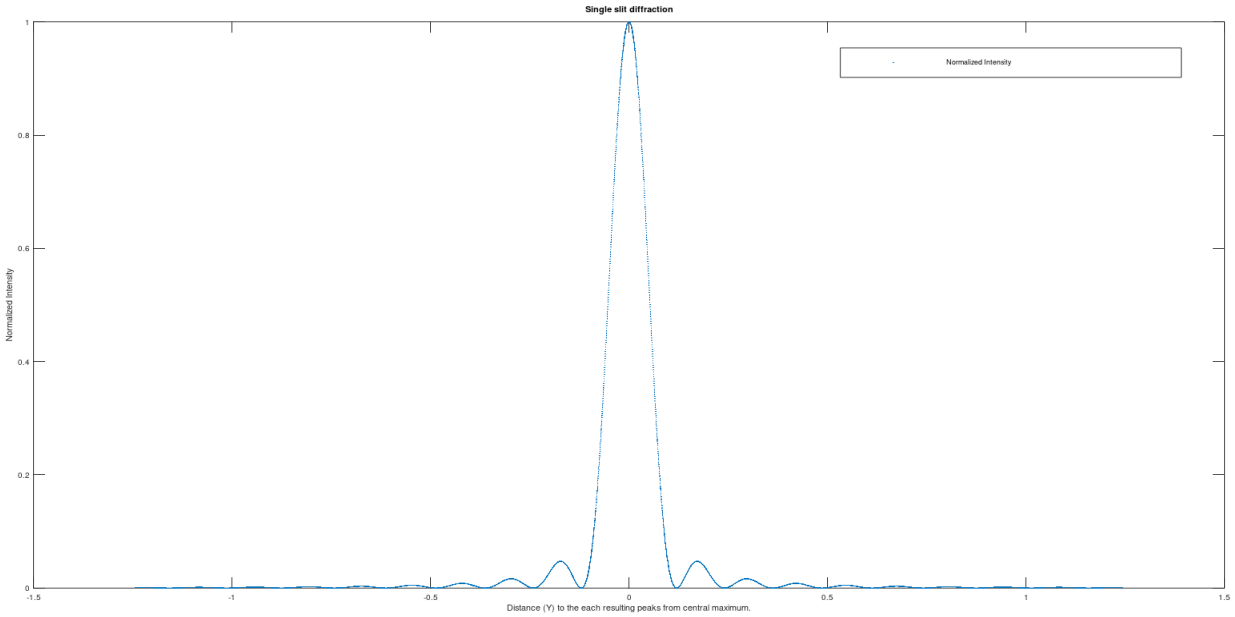
- If the intensity at the central maximum is I_o; then the intensity at a any given point on the plane can be written as;

  $$\frac{I}{I_o} = \left(\frac{\sin\beta}{\beta}\right)^2$$
  $$I = I_o\left(\frac{\sin\beta}{\beta}\right)^2$$

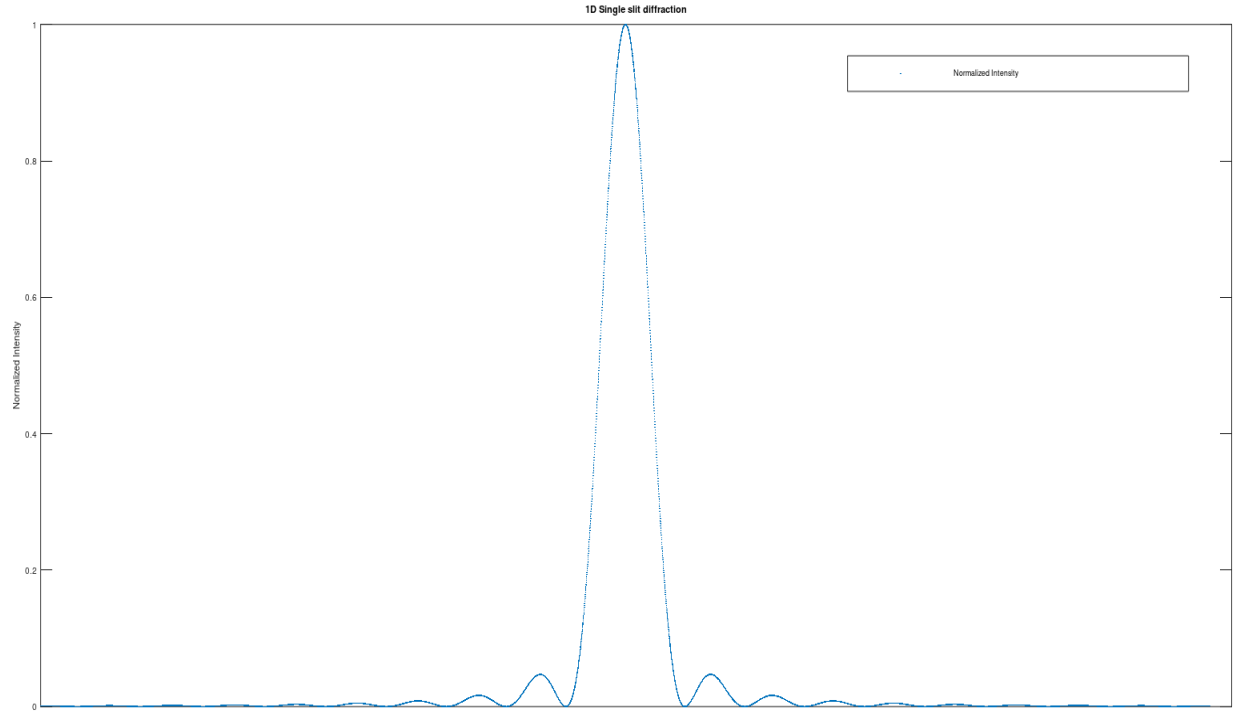
- Distance (Y) to the each resulting peaks (or any point) from central maximum can be calculated using $Y = D.\tan(\theta_m)$;
  where $(-\theta \leq \theta_m \leq +\theta)$

  Slit width = 12 μm
  Wavelength of the light ray = 480 nm
  Distance from the slit to the screen = 3 m
  Angle to the furthest away point from the central maximum = $\pi/8$

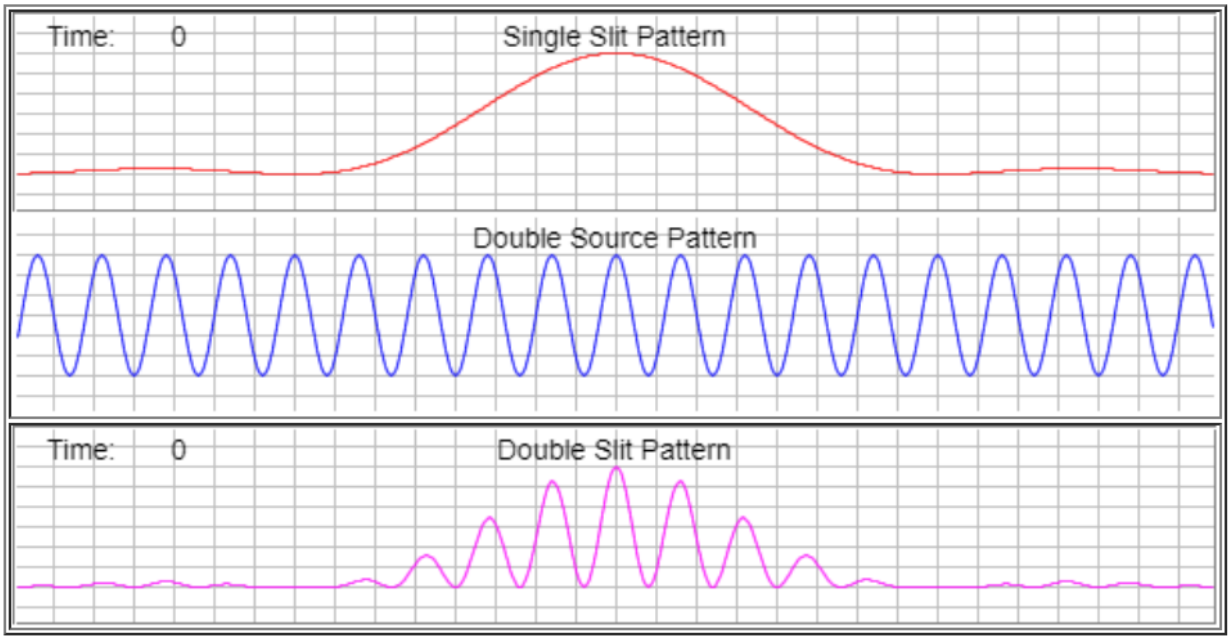
Intensity pattern for single slit diffraction (2D).



Intensity pattern for single slit diffraction (1D).



Part B: For the double slit



The overall intensity of the double-slit pattern can be obtained by multipling the source intensity by the diffracted single-slit intensity; wave interference.

- The phase difference between the wavelets from the first and the last sources is:

$$\emptyset = \frac{2.\pi .\text{b}.\sin\theta}{\lambda};$$

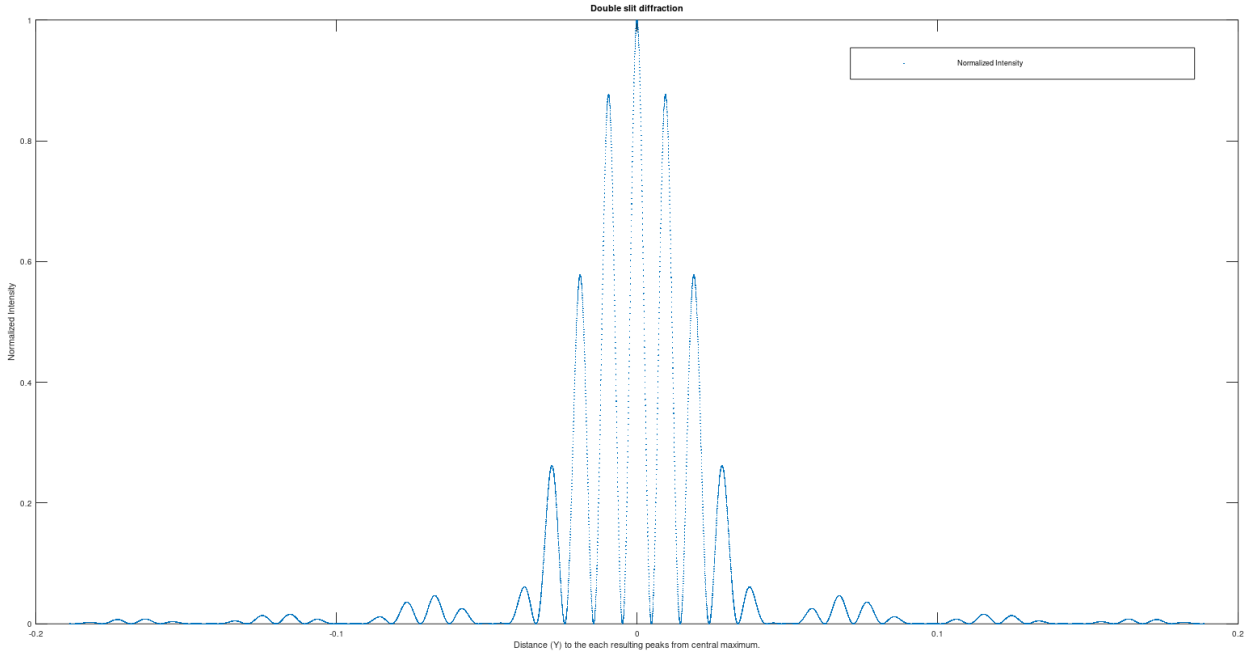
Where distance between two slits is 'b'.

- $\delta = \frac{\emptyset}{2} = \frac{\pi .\text{a}.\sin\theta}{\lambda}$;
- The resulting equation for intensity can be written as;

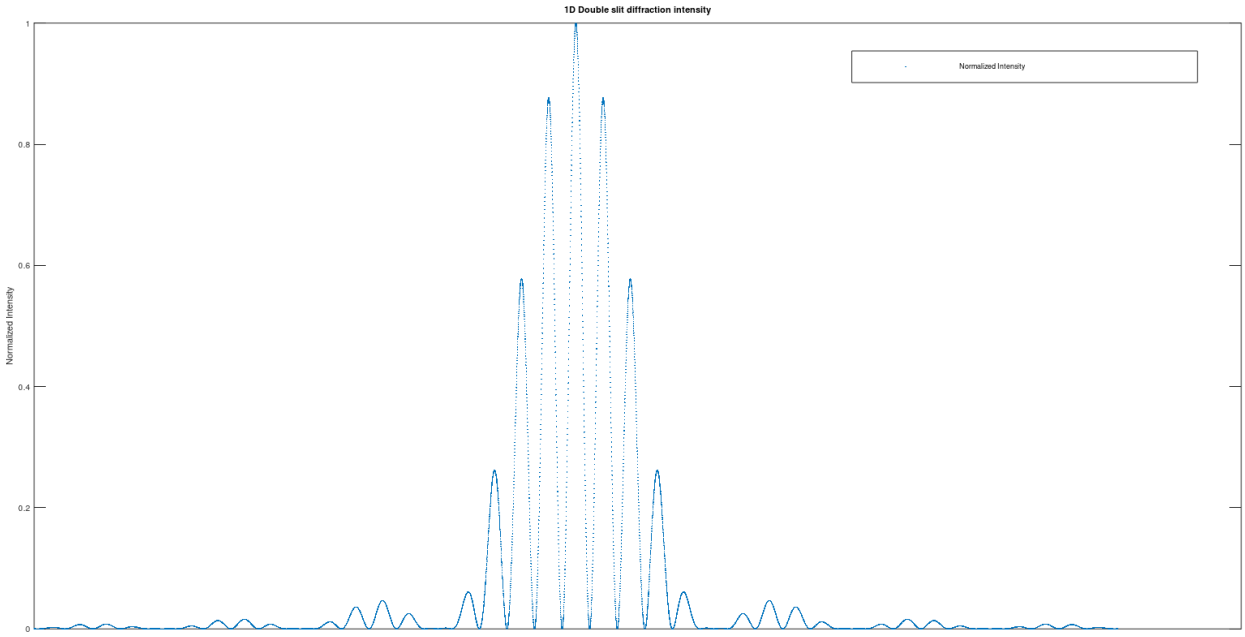
$$I = I_o(\cos\delta)^2\left(\frac{\sin\beta}{\beta}\right)^2$$

Slit width = 30 μm
Distance between two slits = 0.15 mm
Wavelength = 480 nm
Distance from the slit to the screen = 3 m
Angle to the furthest away point from the central maximum = $\pi/50$

Intensity pattern for double slit diffraction (2D).



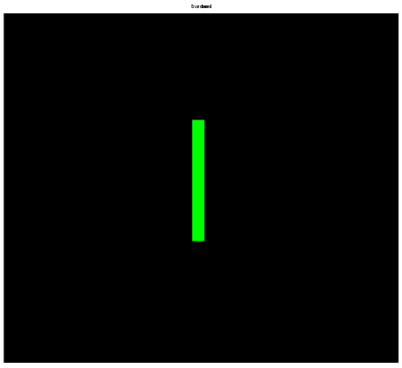
Intensity pattern for double slit diffraction (1D).



Single and Double slit diffraction in 2-Dimensions

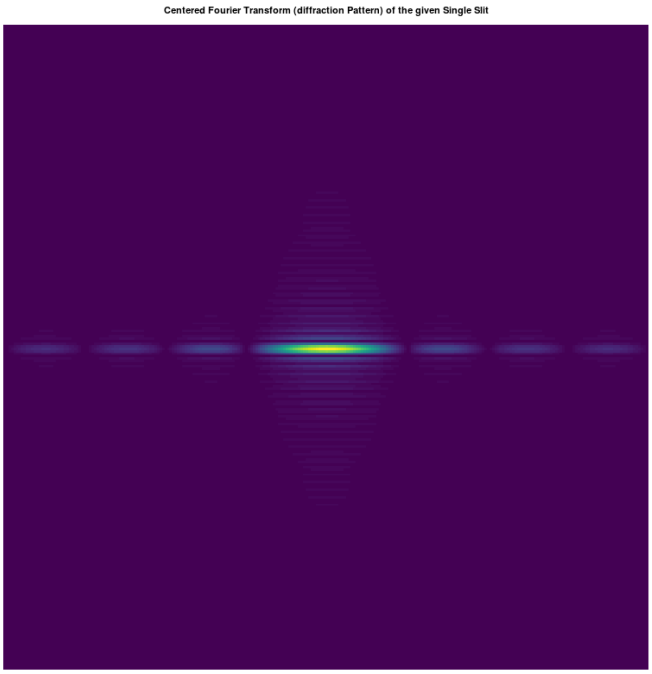
Extract a single bit-map layer from the image provided.

Extracted green channel image.



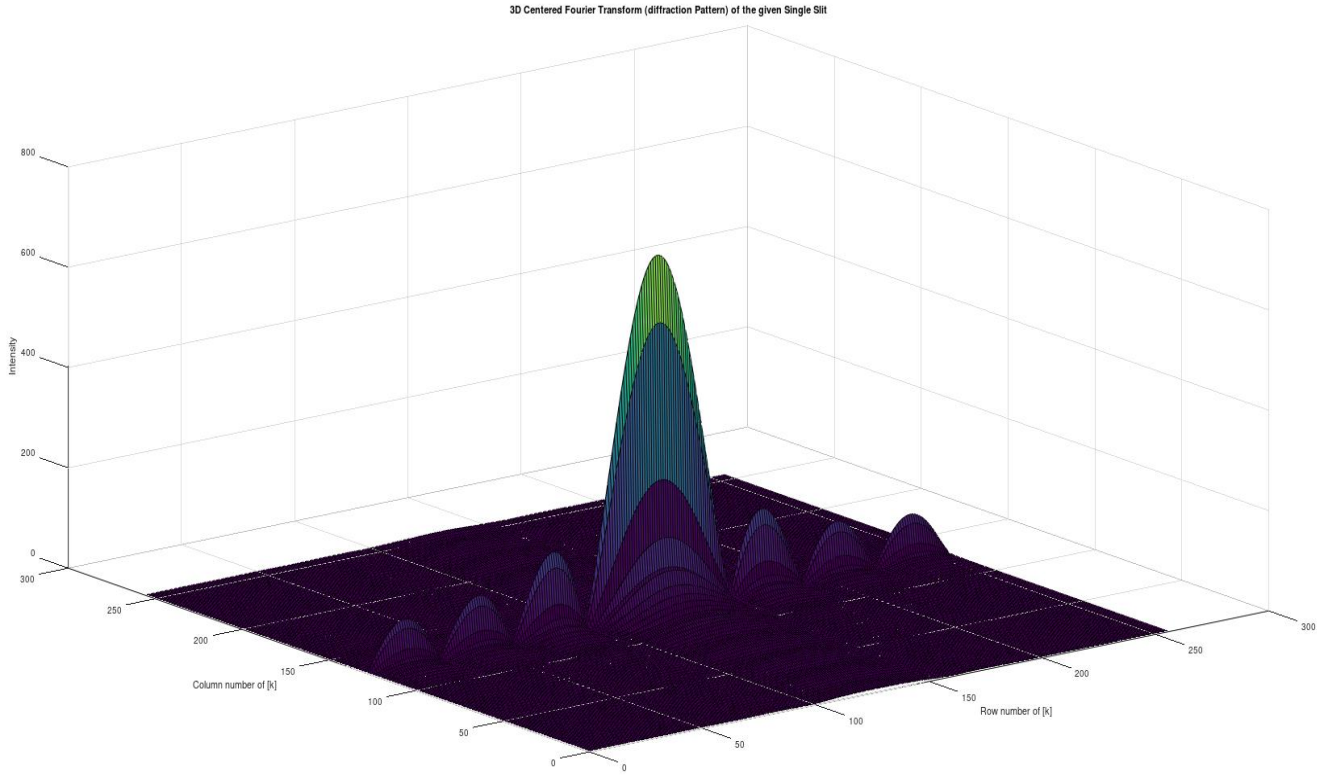
Obtain the 2D far field diffraction pattern for the single slit.

Centered Fourier Transform (diffraction Pattern) of the given single Slit.

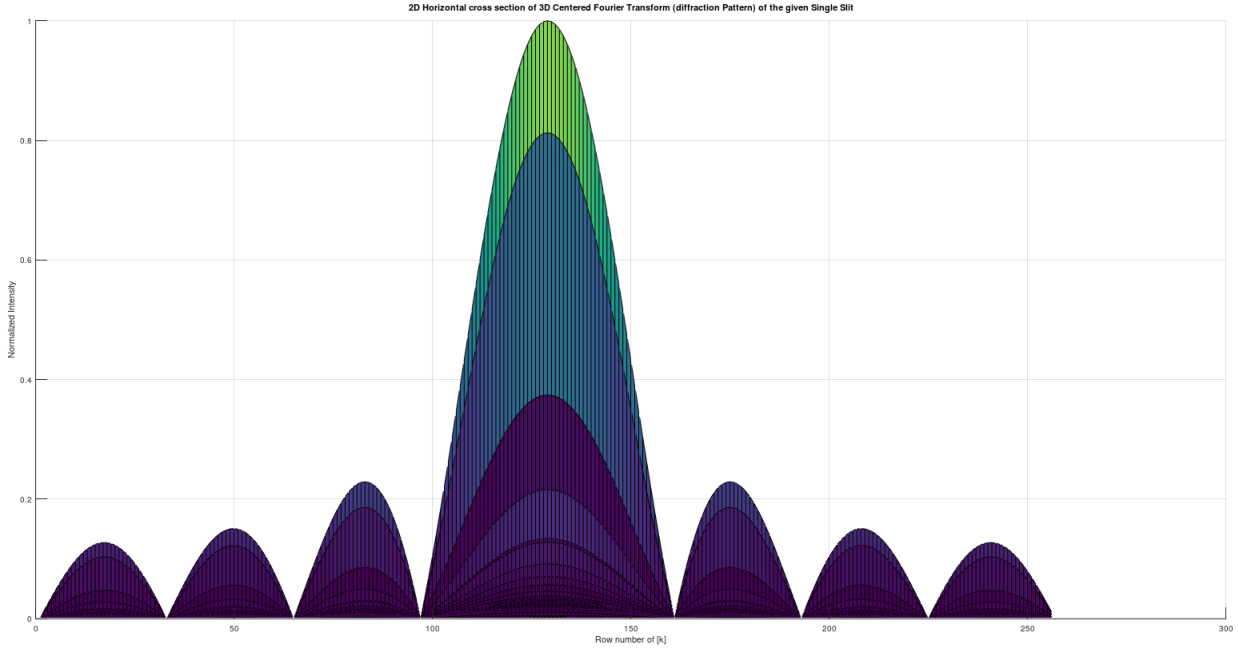


Obtain a horizontal cross section of the line where the intensity pattern can be observed.

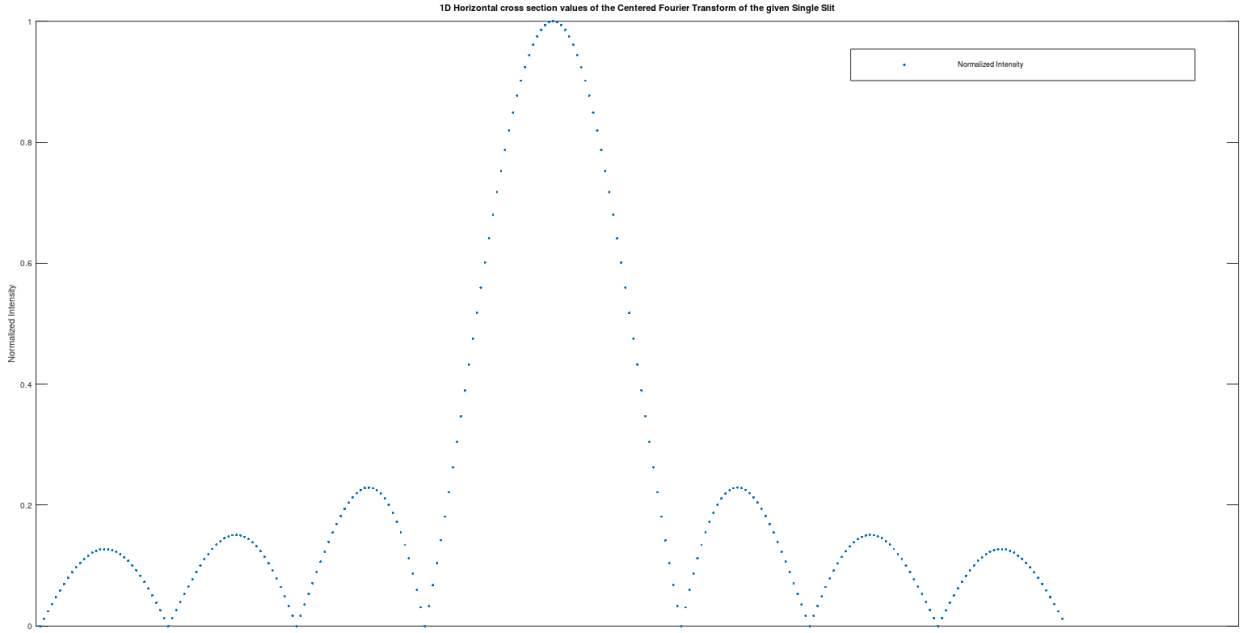
3D Centered Fourier Transform (diffraction Pattern) of the given Single Slit.



Horizontal cross section of 3D Centered Fourier Transform (diffraction Pattern) of the given Single Slit.



Horizontal cross section of the Centered Fourier Transform of the given Single Slit.



Comparison with the plot obtained.

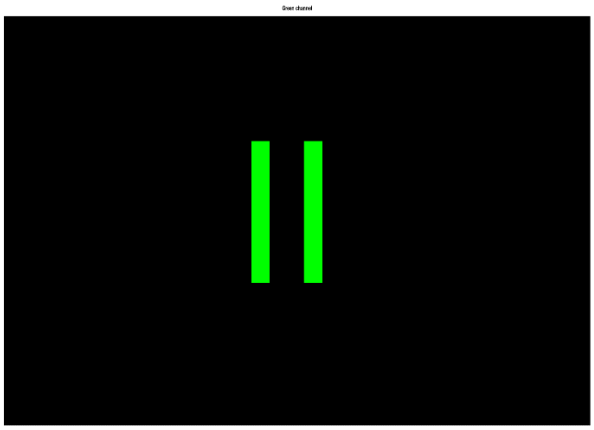
Both plots are roughly similar; but the deviation presented in the '1D plot in Problem 2 Question 5' is because of the binary scale of the given image. If considered the image as a matrix, it can be represented as a 256*256 matrix in decimal scale. In this matrix, the highest values are presented in the column 129; which can be physically observe from the above 3D plot also.

And there are only 256 data points presented in that column also which each of them assigned to total of 256 rows.
So, when considering this information; there are only 256 discrete data presented to be plot when considering the given single slit image in Problem 2.

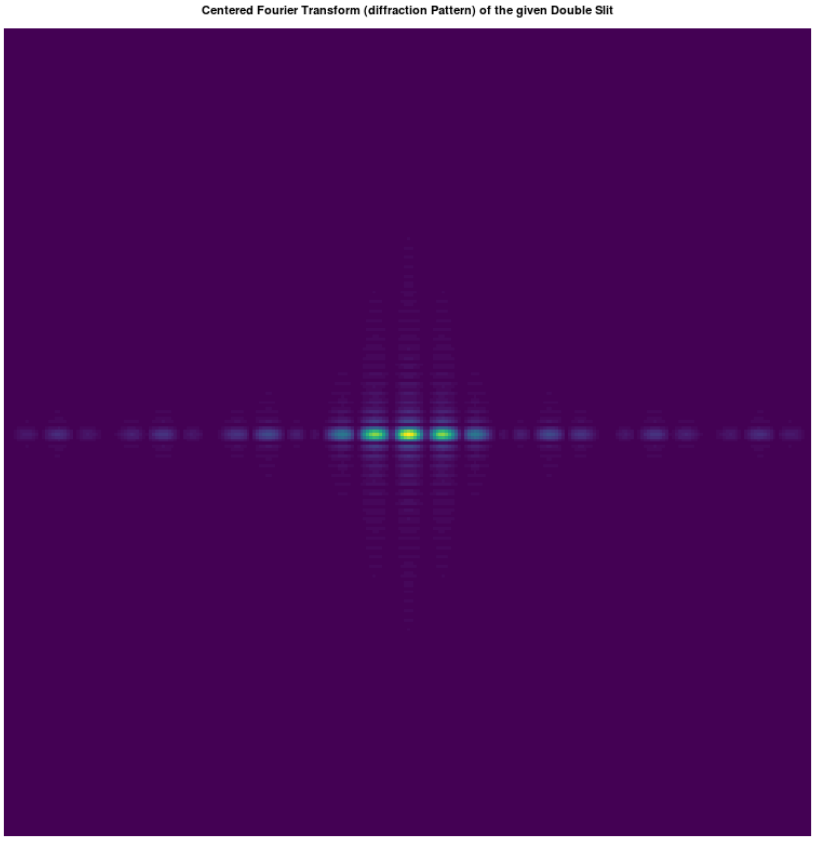
But in Problem 1; the range of 'θ' was break in to different pieces which the space between each two values was $1 \times 10^{-5}\pi$ (step size). Which is a very small value hence the data points that can be observed from the final equation is much greater than 256.
So, the 1D plot of the Problem 1 is much smoother than above plot.

Double slit diffraction pattern using the provided image ('double_slit.bmp').

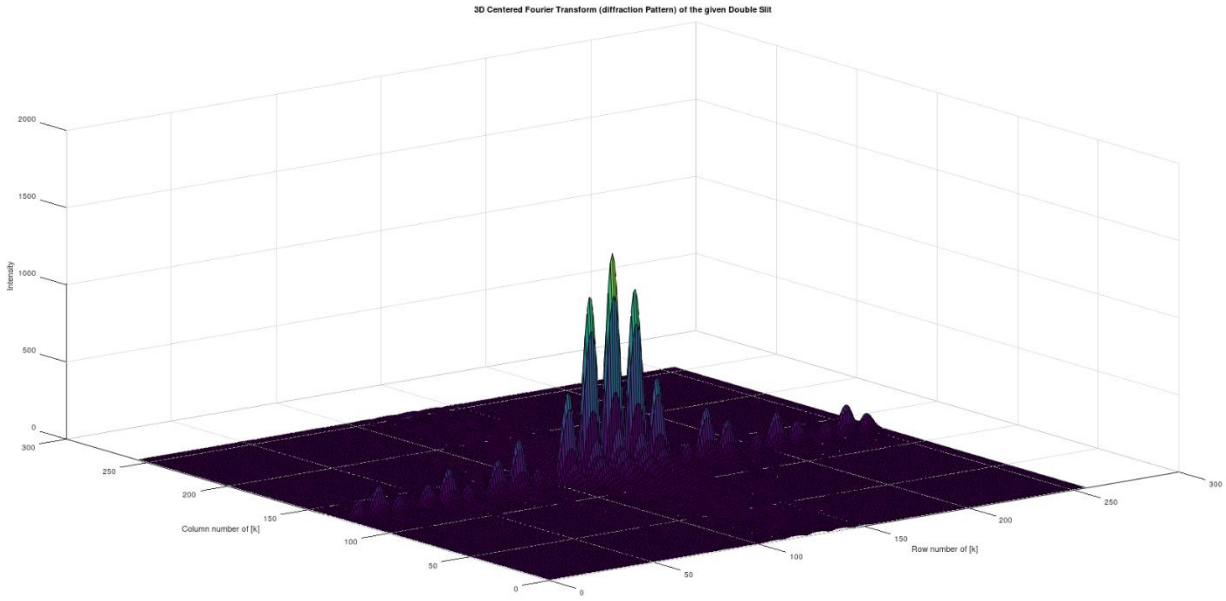
Extracted green channel image.



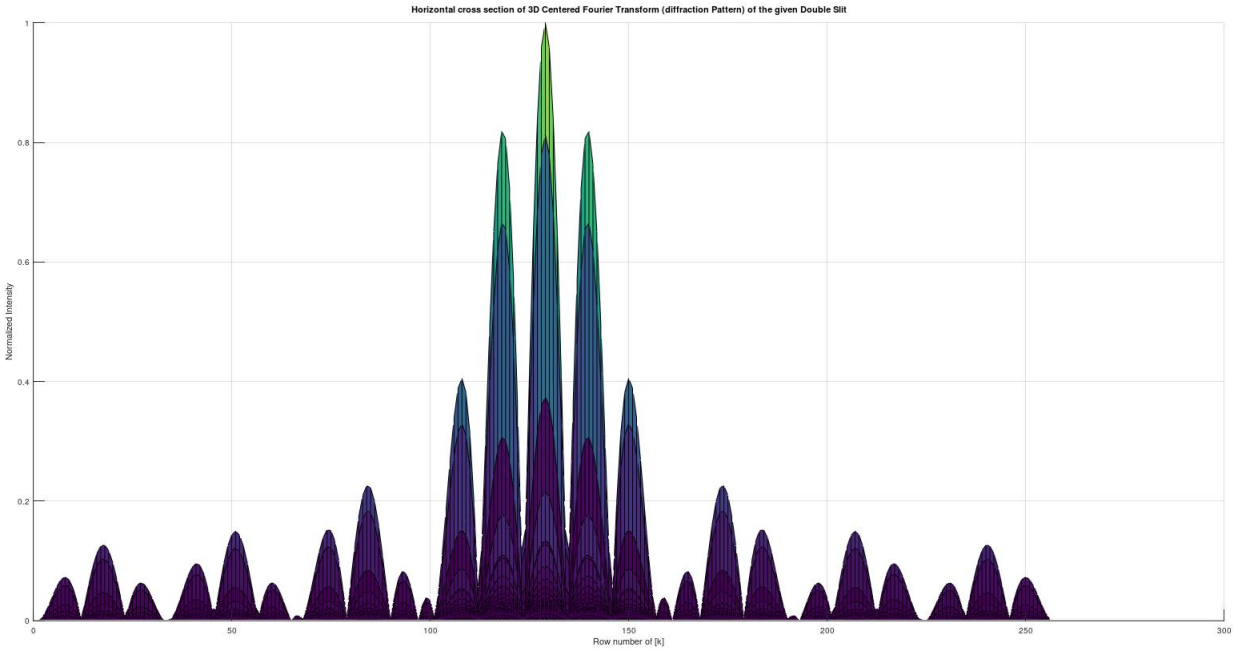
Centered Fourier Transform (diffraction Pattern) of the given Double Slit.



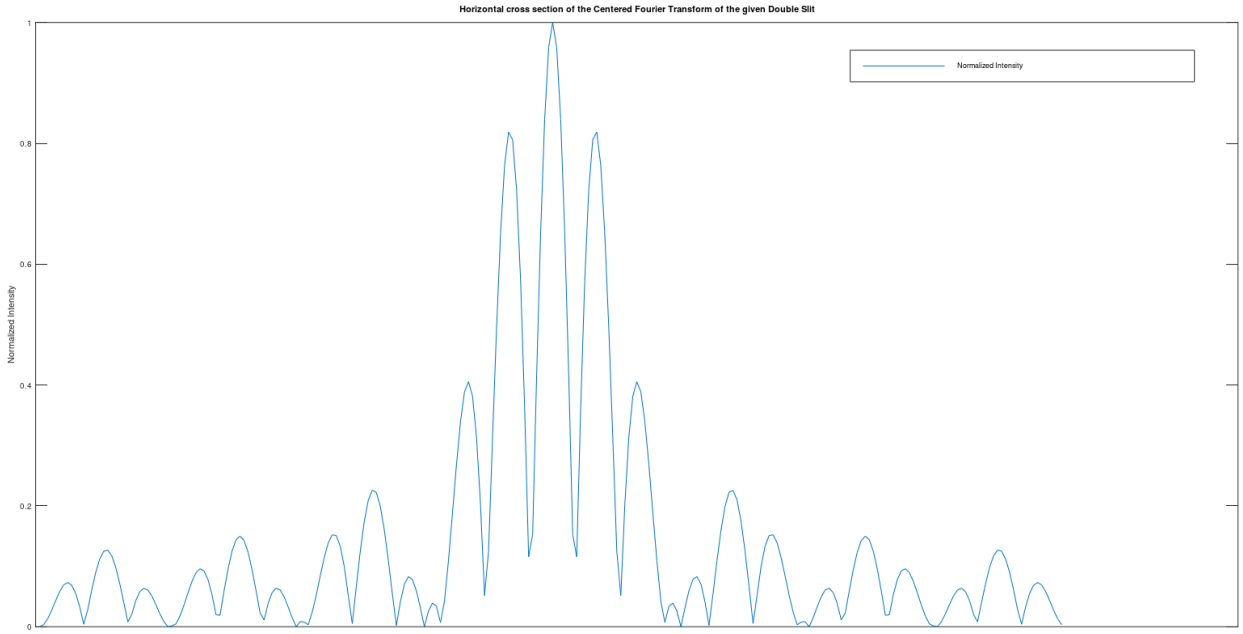
3D Centered Fourier Transform (diffraction Pattern) of the given Double Slit.



Horizontal cross section of 3D Centered Fourier Transform (diffraction Pattern) of the given Double Slit.



Horizontal cross section of the Centered Fourier Transform of the given Double Slit.



The dot plot is unrecognizable since most of the data points are extremely closer. Hence the points were plot as above.

Comparison of the plots obtained.

Similarly, to the explanation in above 'Question VII for single slit diffraction plots'; the deviation of the both 1D plots obtain from Problem 2 & 1 for double slit, occurs because of the lack of data points presented in 'Problem 2 1D double slit diffraction plot'.