

Fourier Optics

Physics 150/126L Spring 2025

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Introduction

In this lab we will explore how far-field diffraction from a coherently illuminated object is closely approximated by the Fourier transform of the object's transmission function.

Assembling the optical configuration

Begin by collimating $\lambda = 635$ nm laser light from the single-mode optical fiber tip using a 105 mm focal length lens. Set up your mask holder so that the object mask is illuminated axially with the collimated light. Remove any lens that is attached to the Raspberry Pi camera.

We will use two optical configurations for this experiment. For the first (A), place a lens with focal length $f_1 = 105$ mm so that there is a distance f_1 from the object mask to the lens, and also a distance f_1 from the lens to the camera sensor. The camera should be mounted on a 3-axis roller bearing stage.

For the second configuration (B), replace the camera on the 3-axis stage with an adjustable iris diaphragm. Then place a lens with focal length $f_2 = 50$ mm so that there is a distance f_2 from the iris to the lens, and also a distance f_2 from the lens to the camera sensor.

Measurements

1. [Configuration A] Use a mask with vertical lines spaced 0.254 mm apart as your object. Calculate the spacing between dots in the Fourier plane using f_1 and λ . Verify this spacing using your camera in the Fourier plane.
2. [Configuration A] Replace the object with the two dimensional grid having 0.127 mm period in both directions. Count the number of dots in x and y at the Fourier plane. How does the intensity decay of the Fourier plane dot pattern in the x and y directions compare with that at 45° to the axes? Why?
3. [Configuration B] Use the mask with 0.254 mm vertical line spacing as your object. Close the iris diaphragm slowly. What happens to the image seen by the camera? Replace the

iris diaphragm in the Fourier plane with the slide having a small centered dot. What happens to the image?

4. [Configuration B] Move the mask with 0.254 mm line spacing to the Fourier plane, where the iris diaphragm and dot slide used to be. Explain the image you see on the camera. Predict and verify the dot spacing.
5. [Configuration A] Repeat measurement 1, but use the lens having focal length f_2 instead of f_1 .