

3.2 Theta Modulation and Pseudo-Color Encoding

Figure 8 Schematic of experimental setup

1: Bromine Tungsten Lamp S (LLC-3) 2,5,7: Lens Holder (SZ-08) 3: Lens L₁ (f'=150 mm) 4: Theta (θ) Modulation Plate P_1 6: Paper Clamp P_2 (SZ-50) 8: Lens L₂ (f'=150 mm)
9: White Screen P₃ (SZ-13)
10,11,12, 14,15: General carrier
13: x-translation Carrier
16: 1.0 m Rail

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Experimental Procedures:

Note: It is recommended to conduct this experiment in a dimly lit environment.

- 1) Refer to Figure 8 and place the white light source at the front-most end of the rail.
- 2) Place lens L_1 and the paper clamp (SZ-50, containing a piece of white paper) on the rail. Position the paper clamp approximately 60 cm away from the light source (i.e. the light bulb inside the lamp housing). Adjust lens L_1 to form a clear image of the filament on the paper plane P_2 of the paper clamp. Lock the carrier holding the paper clamp and temporarily remove the paper clamp.
- 3) Mount the theta modulation plate onto a lens holder (SZ-08) with the image pattern upside down and place it behind lens L_1 . Position lens L_2 behind the paper clamp's carrier. Place the white screen at the farthest end of the rail. If space available, it is recommended to place the screen beyond the rail to maximize the distance between the screen and the theta modulation plate, enlarging the theta plate image.
- 4) Adjust the positions of the theta modulation plate, lens L_2 , and the white screen to produce a clear and enlarged image of the theta modulation plate on the screen.
- Remount the paper clamp to its carrier. A spectral pattern should now be visible on the paper. Carefully adjust the paper clamp's position for the sharpest spectral pattern (see Figure 9).

- 6) Use a sharp pin to pierce holes in the paper. Focus only on the first-order spectrum (and the second-order spectrum, if available). Note: The zero-order spectrum generates the entire image and should not be used. Observe the image portions on the screen as each hole is made. After determining the Fourier spectrum corresponding to each image portion, replace the paper with a new sheet. (This step is intended to identify the grating directions of the three areas on the theta plate.)
- 7) Carefully pierce holes at specific points on the tiny spectra to filter single colors. For example, create holes to observe the sky as blue, the building as red, and the ground as green (or other color selections of your choice). Refer to Figure 10 for guidance. Replace the white screen with a ground glass (if available) or thinner paper for better observation, viewing the image from the back side.



Figure 9 Spectral pattern



Figure 10 Experiment result

3.3 Optical image addition and subtraction

- Note: Due to the limited rail length, please position the laser head as far forward as possible on the rail. Specifically, mount the laser head to the leftmost side of the laser head mount (SZ-42) and ensure its carrier is placed at the extreme end of the rail.
- A. Construct the 4f optical path
 - 1) Refer to Figure 1 and position these components along the rail: laser head, beam expander (f = 6.2 mm) and collimation lens (f = 225 mm).
 - Adjust the laser, beam expander, and collimation lens to ensure the beam is: a) collimated, b) parallel to the rail and c) propagating along the central line of the rail.

 Place these components behind the collimation lens in the order shown in Figure 1: a) object: a plate with two separated slits (one vertical, one horizontal), b) two Fourier Transform (FT) lenses (f = 150 mm) and c) white screen.

Align the centers of all components with the beam center and set the distances between them as indicated in Figure 1.

Note: To adjust the object horizontally, use an x-adjustable carrier for it.

4) Once all components are positioned and aligned, the 4f optical path is complete.



Figure 11 Schematic of the experimental optical path

B. Grating filtering

- Referring to Figure 11, place the 1-D grating (100 *l/mm*) on the back focal plane of Lens L₁ (i.e. the middle plane between the two FT lenses, or plane P₂), also the carrier of the grating should be *x*-adjustable,
- 2) Observe image on the white screen (plane P_3); if the image is not clear, slightly adjust the positions of the object or/and the screen,
- 3) Shift the 1-D grating horizontally (using *x*-translation of the carrier), observe the $+1^{st}$ order image of pattern *A* (the vertical slit) and the -1^{st} image of pattern *B* (the horizontal slit) on the screen,
- Carefully shift the 1-D grating, make the centers of the two images coincident. If not, try to finely shift the object horizontally.
- C. Observe images addition and subtraction

Continuously and finely shift the 1-D grating in one direction, the results of A+B and A-B can be observed alternatively; as the bright overlapping area is observed for A+B case while the dark overlapping area is for A-B case as shown in Figure 12. If more than one bright or dark fringes are observed within the overlapping area, the grating needs to be moved slightly back or forth along the optical path around the spectral plane in order to get only one bright or dark fringe within the overlapping area, at this time, the addition or subtraction result is optimal.



Figure 12 Experiment results of addition and subtraction operations

Note: If a complete dark overlapping area cannot be achieved for *A*-*B* case, it may be due to the following reasons:

- a) The illumination on object plane for *A* and *B* are not even;
- b) The calculation for f_0 and b is not correct, causing non-overlapping of their centers;
- c) Optical path is not properly aligned (i.e. the grating is not located exactly on the spectral plane).