Fourier optics - 2f arrangement (Item No.: P2261101)

Curricular Relevance

Area of Expertise: Physics
Education Level: University
Topic: Light and Optics
Subtopic: Diffraction and Interference
Experiment: Fourier optics - 2f arrangement

Difficulty	Preparation Time	Execution Time	Recommended Group Size
Very difficult	3 Hours	1 Hour	2 Students

Additional Requirements:

Experiment Variations:

Keywords:

Fourier transform, lenses, Fraunhofer diffraction, index of refraction, Huygens' principle

Overview

Short description

Fourier optics is one of the major viewpoints for understanding classical optics. It refers to optical technologies which arise when the plane wave spectrum viewpoint is combined with the Fourier transforming property of lenses, to yield image processing devices analogous to the signal processing devices common in electronic signal processing. The hallmark of Fourier optics is the use of the spatial frequency domain as the conjugate of the spatial domain, and the use of terms and concepts from signal processing, such as: transform theory, spectrum, bandwidth, window functions, sampling, etc. In this experiment the electric field distribution of light in a specific plane (object plane) is Fourier transformed into the 2 f configuration.

Equipment

Position No.	Material	Order No.	Quantity
1	Optical base plate with rubber feet	08700-00	1
2	Experiment laser, green, 1 mW, 532 nm	08763-99	1
3	Adjusting support 35 x 35 mm	08711-00	2
4	Surface mirror 30 x 30 mm	08711-01	2
5	Magnetic foot for optical base plate	08710-00	7
6	Holder for diaphragms and beam splitters	08719-00	1
7	Lens, mounted, f +150 mm	08022-01	1
8	Lens, mounted, f +100 mm	08021-01	1
9	Lensholder for optical base plate	08723-00	2
10	Screen, white, 150x150 mm	09826-00	1
11	Diffraction grating,50 lines/mm	08543-00	1
12	Screen, with diffracting elements	08577-02	1
13	Achromatic objective 20x N.A.0.4	62174-20	1
14	Sliding device, horizontal	08713-00	1
15	xy shifting device	08714-00	2
16	Adapter ring device	08714-01	1
17	Pin hole 30 micron	08743-00	1
18	Ruler, plastic, 200 mm	09937-01	1

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Tasks

Investigation of the Fourier transform by a convex lens for different diffraction objects in a 2f set-up.
In the first part Fourier spectra of following three diffraction objects should be investigated:

1) Plane wave
2) Long slit with finite width
3) Grid.

Set-up and Procedure

Set-up and procedure

In the following, the pairs of numbers in brackets refer to the coordinates on the optical base plate in accordance with Fig. 1. These coordinates are intended to help with coarse adjustment. The recommended set-up height (beam path height) is about 130 mm.

- The E25x beam expansion system (magnetic foot at [1,6]) and the lens L0[1,3] are not to be used for the first beam adjustment.

- When adjusting the beam path with the adjustable mirrors M1[1,8] and M2 [1,1], the beam is set along the 1,xand 1,ycoordinates of the base plate.

- Now place the E25x [1,6] beam expansion system without its objective and pinhole, but equipped instead only with the adjustment diaphragm, in the beam path. Orient it such that the beam passes through the circular stops without obstruction.

- Now replace these diaphragms with the objective and the pinhole diaphragm. Move the pinhole diaphragm toward the focus of the objective. In the process, first ensure that a maximum of diffuse light strikes the pinhole diaphragm and later the expanded beam. Successively adjust the lateral positions of the objective and the pinhole diaphragm while approaching the focus in order to ultimately provide an expanded beam without diffraction phenomena.

- The L0[1,3] (f = +100 mm) is now positioned at a distance exactly equal to the focal length behind the pinhole diaphragm such that parallel light now emerges from the lens. No divergence of the light spot should occur with increasing separation. (testing for parallelism via the light spot diameter with a ruler at various distances behind the lens L0in a range of approximately 1 m).

- Place a plate holder P1[2,1] in the object plane.

- Position the lens L1[5,1] at the focus (f = 150 mm) and the screen SC [8,1] at the same distance behind the lens.

- Note the terms of the “object plane” at P1 (blue) and the “Fourier plane” at the screen SC (red).

Note
This combination of basic qualitative experiments shows in the first part (this experiment) the Fourier transformation for different diffraction objects. In the second part (Fourier optics – 4f Arrangement, LEP 2.6.12-00) it is shown how to use such a transformation to influence image properties. Since the time needed for set-up and adjustment of the optical components is quite long, it is strongly recommended to combine both experiments.

Theory and evaluation

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