Fourier optics

Arbeitsgruppe Roskos
Physikalisches Institut
Fachbereich Physik
Johann Wolfgang Goethe-Universität
Frankfurt am Main

Supervisor: Anastasiya Rysiavets
Office: Phys. _0.215
Experiment: Phys. 1.213
Tel.: 069 798 47209
E-Mail: rysiavets@physik.uni-frankfurt.de

Experimental supervision and Protokoll in English.

Preparation before conducting experiment

- Paraxial light propagation and diffraction
- Grating diffraction
- 2D Fourier transformation; Fourier transforming properties of lens
- Image construction using lens systems

Experiments

1. Fourier transforming properties of lens: periodic objects

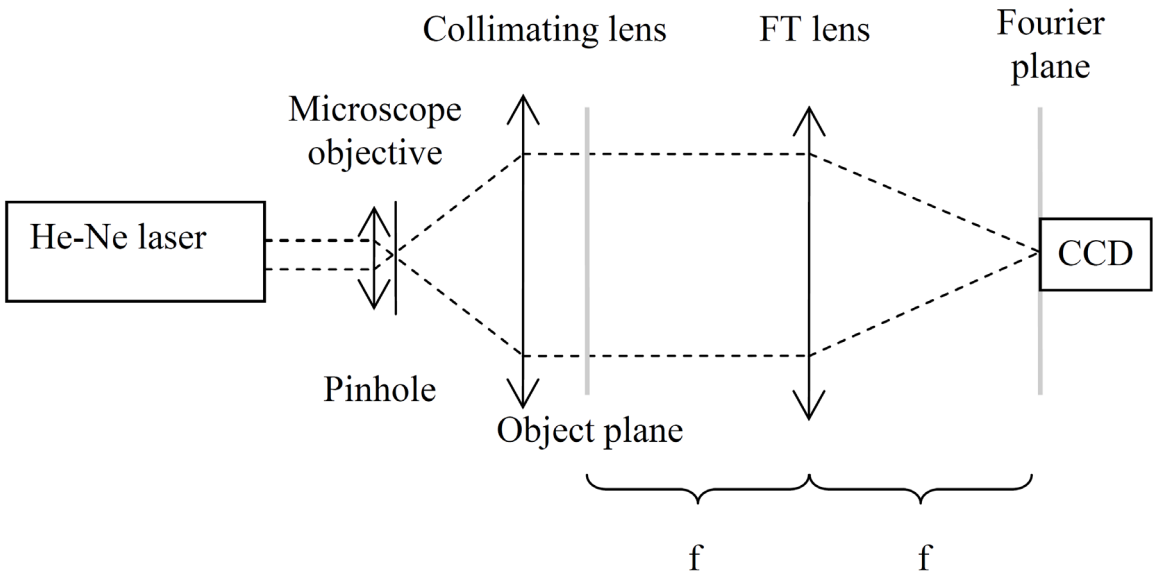

Fig. 1. Optical setup for observation of 2D Fourier images of objects.

Build the optical setup shown in Fig. 1. Observe by eye the formation of the Fourier image for an appropriate grating. Place the CCD camera in the Fourier plane. Here you can use the single point without any object to center the horizontal x-position and fine tune the longitudinal z-position. Note that a filter wheel is provided to reduce the intensity to avoid saturation of the CCD.

Record Fourier transform images of following objects: several gratings with different grating constants and filling factors, 2D mesh.

Calibrate the pixel spacing of the CCD, using an image with well-defined structure and shifting the camera by a known amount (using the micrometer screw on the translation stage). For an appropriate grating, use the known period of the grating and spacing of the Fourier peaks to calculate an independent estimate the wavelength of the laser.

2. Spatial filtering

Build the setup for imaging as shown in Fig.2. Record images of selected objects:

- without spatial filtering,
- with the slit (low-pass filter) in the Fourier plane for different slit widths
- with the wire (high-pass filter) in the Fourier plane, centred on the beam axis

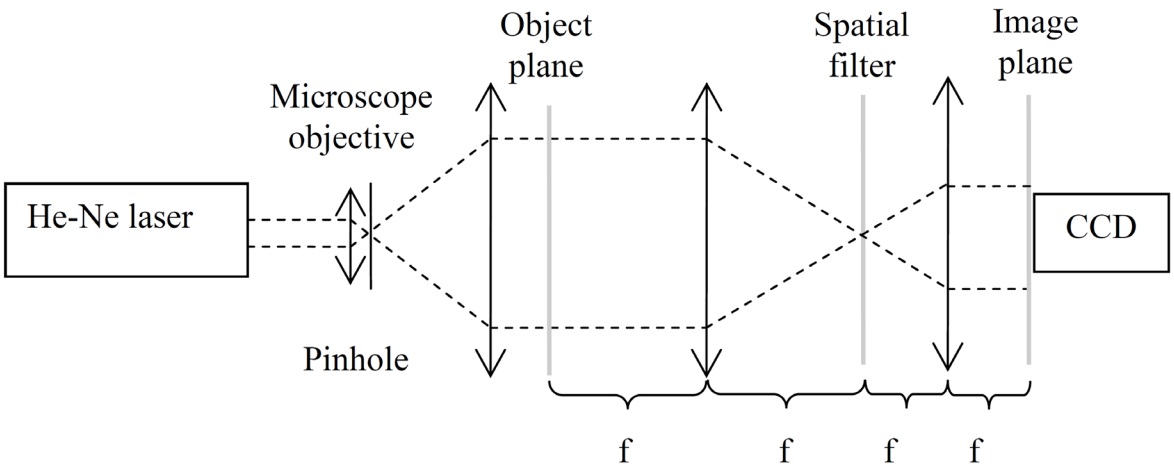

Fig. 2. Optical setup for observation of re-imaged objects after filter in Fourier plane.

Required content for experimental report

- Describe the 2D Fourier transformation and how it is achieved with lenses.
- Present recorded Fourier images and explain main features.
- Deduce the laser wavelength from the diffraction formula and Fourier peak spacing for a known grating.
- Present results of spatial filtering
- Give a summary of your experiments; outline its main features and limitations.

Additional advice for conducting experiments

In order to minimize aberrations of optical system it is very important to stay on optical axis. Therefore, before starting carefully check the alignment of lenses and iris'. Use the CCD exposure time and absorption filters to keep the CCD image intensity in an appropriate range.

The measurement PC computer also contains programs for numerical 2D Fourier transform. After experiments you can compare optically and numerically calculated Fourier images.

Literature for preparation/report

- Joseph W. Goodman, Introduction to Fourier Optics.
- E. Hecht, Optik.
- D. G. Feitelson, Optical Computing: A Survey for Computer Scientists, MIT Press, 1988.