Determining the focal lengths at collecting lenses through autocollimation

Objects of the experiment

- Determination of the focal length of a collecting lens by the method of autocollimation.

Principles

The focal length of lenses can be determined by a variety of means. The basis for the different procedures are the laws of imaging.

In this experiment the method of autocollimination is used to determine the focal length of a collecting or convergent lens. This method makes use of the reversibility of the ray path for incident parallel light propagated along the axis and for rays through the focal point:

The parallel light beam is reflected by a mirror behind the lens so that the image of an object is viewed right next to that object (Fig. 1). The distance d between the object and the lens is varied until the object and the image are exactly the same size. Then, the focal length is given by:

$$f = d \qquad (I)$$

Apparatus

1 Incandescent lamp 6 V / 30 W	450 51
1 Lamp housing with cable	450 60
1 Aspherical condenser with diaphragm holder	460 20
1 Transformer 6 V / 12 V	521 210
1 Lens in frame f = +150 mm	460 08
1 Lens in frame f = +300 mm	460 09
1 Pair of objects for investigating images	461 66
1 Plane mirror with ball joint	460 28
1 Small optical bench	460 43
1 Stand base, V-shaped, 20 cm	300 02
3 Leybold multiclamp	301 01
1 Steel tape measure, l = 2 m/78"	311 77

Setup

- Set up the lamp with the aspherical condenser on the optical bench as depicted in Fig. 1.
- Position the lens f = +150 mm in such a manner that the light passes through the lens along the optical axis. The distance between the lens and the diaphragm holder of lamp should be in the order of magnitude of the expected focal length.
- Insert the transparency with the grid pattern (object) and a white sheet of paper (screen to observe the image of the object) according Fig. 1 into the diaphragm holder of the lamp. Both the white paper and transparency should cover half of the condenser lens.
- Arrange the mirror behind the lens. The plane of the mirror should be inclined slightly (around 1° to 3°) with respect to the plane of the lens. The distance between the lens and the mirror can be chosen to be less then the focal length.

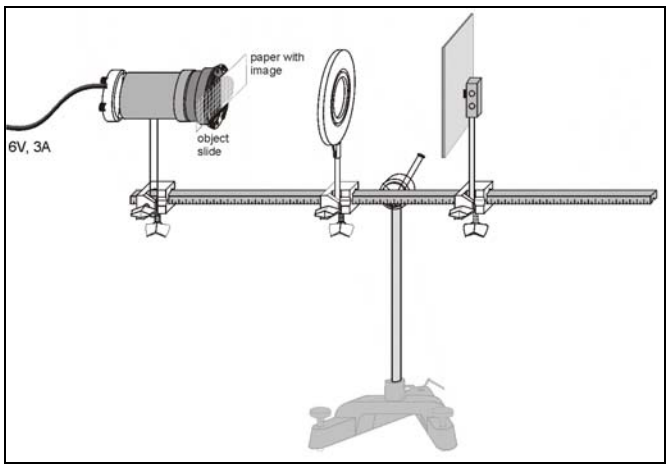

Fig. 1: Schematic diagram of the experimental setup.

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Carrying out the experiment

The experiment should be performed in a darkened room.

- Position the lens f = +150 mm about the expected focal length apart from the diaphragm holder of the lamp.
- Shift the mirror towards the lens until the distance between lens and mirror is in the order of magnitude of half of the expected focal length. A diffuse image of the grid pattern should occur adjacent to the original on the white paper in the diaphragm holder.
- Vary the distance of the lens until a sharp image of the object can be observed on the white paper in the diaphragm holder. It might be necessary to adjust the positions of the mirror and the lens until the image has the same size as the original.
- Measure the distance d between lens and object plane (image plane) with the steel tape measure.
- Repeat the experiment with other lenses.

Measuring example

Table. 1: Comparison of the measured and given focal length

Focal length f / mm given	+300	+150	+200*	+100*
Focal length f / mm measured	295	151	198	101

**Lenses from experiment P5.1.2.1*

Evaluation and results

If the light emitted by a illuminated (or luminous) object arranged in the focal plane of a convergent lens is incident as a parallel light beam on a planer mirror positioned behind the lens, it is reflected in the opposite direction as parallel light behind the lens refracted towards the focus. Thus an image of the original object is produced in the plane of the lens (principle of determination of the focal length by autocollimation).

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