Simple Experiments in Optics

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Introduction to Optical Components

1.1 Focal length of a lens

$$\frac{1}{f_\lambda} = (n_\lambda - 1)\left[\frac{1}{R_1} - \frac{1}{R_2} + \frac{(n_\lambda - 1)t_C}{n_\lambda R_1 R_2}\right]$$

n_λ λ R R

t

$$f_{\lambda B} = f_\lambda + \delta_2$$

$$\delta_2 = -f_\lambda t_C \left(\frac{n_\lambda - 1}{n_\lambda R_1}\right)$$

$$f_{\lambda B} = f_\lambda \left[1 - t_C \left(\frac{n_\lambda - 1}{n_\lambda R_1}\right)\right]$$

Experiment 1.1: $f_{\lambda B}$

n λ

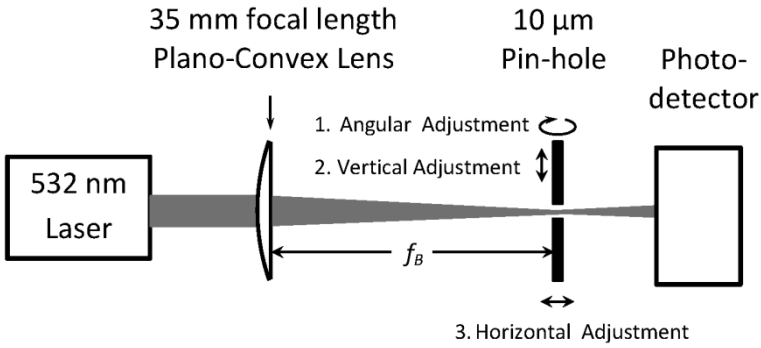
35 mm focal length
Plano-Convex Lens
10 µm
Pin-hole
Photo-
detector
1. Angular Adjustment
2. Vertical Adjustment
532 nm
Laser
f_B
3. Horizontal Adjustment

Figure 1.1

1.2 Focal length of a combination of two lenses

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

f f d

$$F = \frac{f_1 f_2}{(f_1 + f_2) - d}$$

F d f f

f F

$$F = \frac{f_{B2}}{\left(1 - \frac{d}{f_1}\right)}$$

f_{B2}

Experiment 1.2:

f f

d

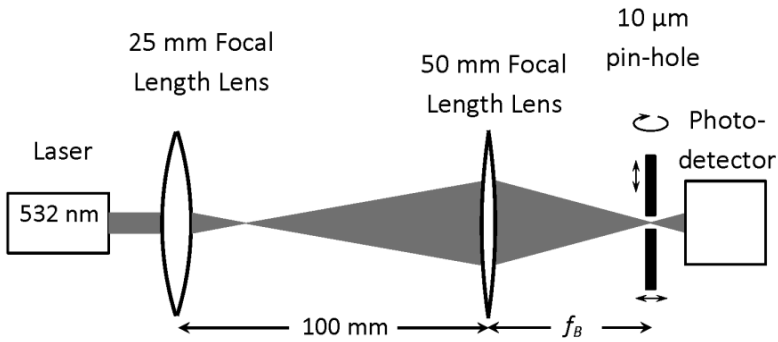
25 mm Focal
Length Lens
50 mm Focal
Length Lens
10 µm
pin-hole
Photo-
detector
Laser
532 nm
100 mm
f_B

Figure 1.2

f_{B2}

1.3 Spherical aberration of a lens

h f

$$LSA = \frac{h^2}{8fn(n-1)} \times$$

$$\left[\frac{n+2}{n-1}q^2 - 4(n+1)q + (3n+2)(n-1) + \frac{n^3}{n-1}\right]$$

n q

$$q = \frac{R_2+R_1}{R_2-R_1}$$

R R

R R

q

$$LSA = \frac{h^2}{8fn(n-1)}\left[(3n+2)(n-1) + \frac{n^3}{n-1}\right]$$

Experiment 1.3

n *f* *d*

h

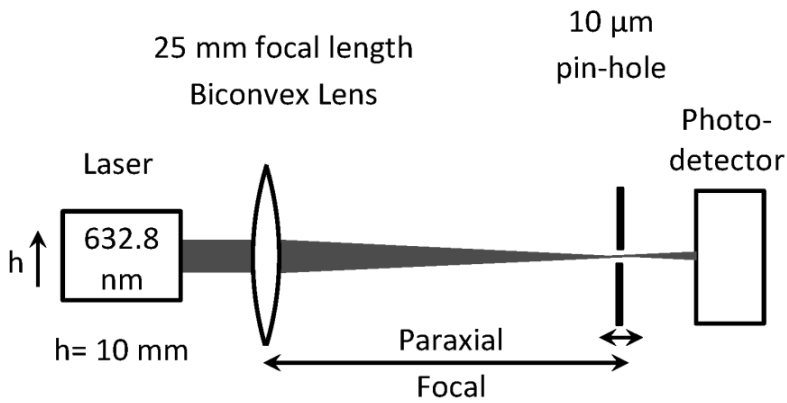
25 mm focal length
Biconvex Lens
10 µm
pin-hole
Photo-
detector
Laser
h
632.8
nm
h= 10 mm
Paraxial
Focal

Figure 1.3

h

h

1.4 Chromatic aberration of a lens

CA

n

$$\frac{1}{f} = (n-1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

CA

$$\frac{CA}{f} = \frac{n_2 - n_1}{n_m - 1}$$

n n λ λ
n λ
λ λ

Experiment 1.4: CA

CA

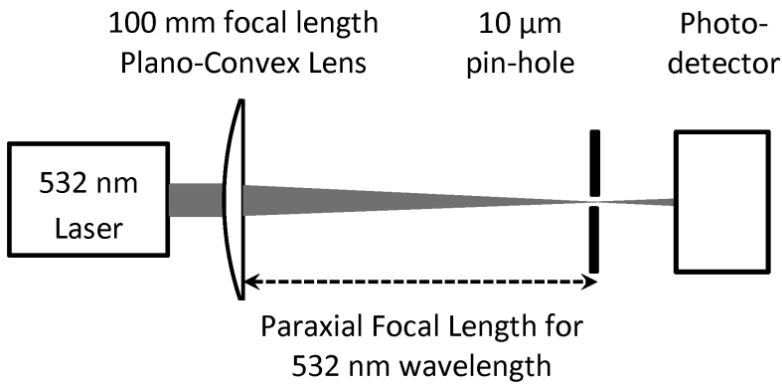
100 mm focal length
Plano-Convex Lens
10 µm
pin-hole
Photo-
detector
532 nm
Laser
Paraxial Focal Length for
532 nm wavelength

Figure 1.4

μ

μ