PHYS 3038 Optics
L8 More on Geometrical Optics
Reading Material: Ch6.3-6.5

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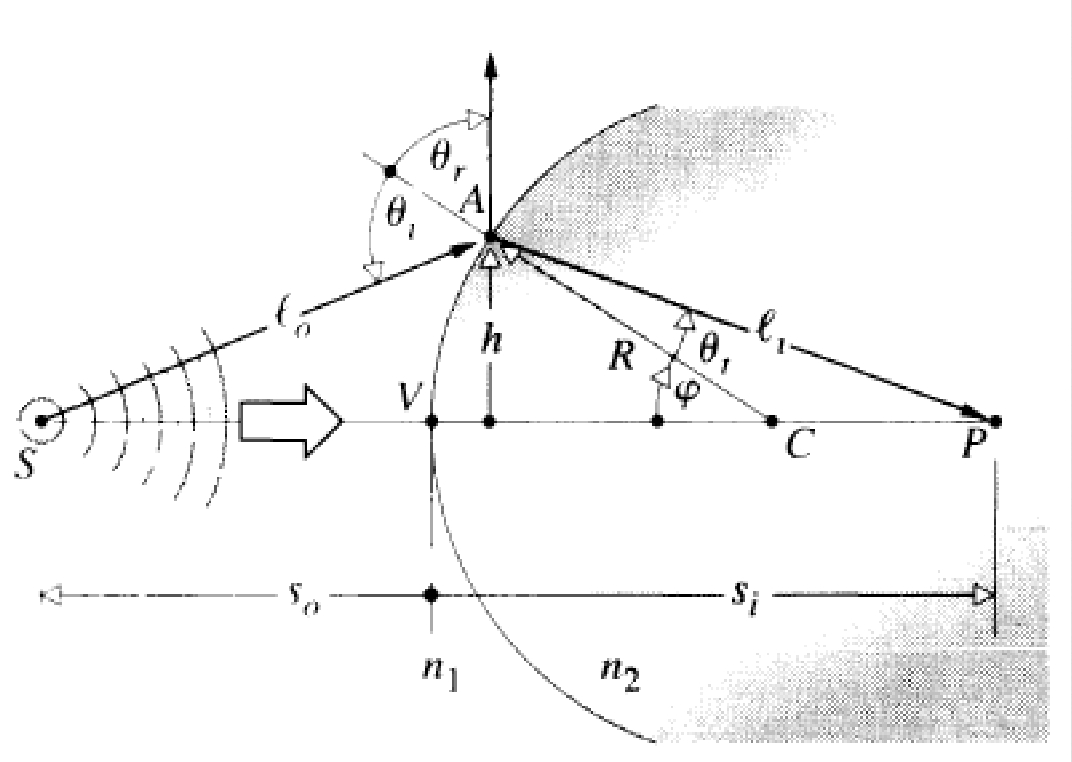
2015, the Year of Light

6.3 Aberrations

- Monochromatic aberrations
  - Spherical aberration
  - Coma
  - Astigmatism
  - Field curvature
  - Distoration
- Chromatic aberrations

Spherical Aberration



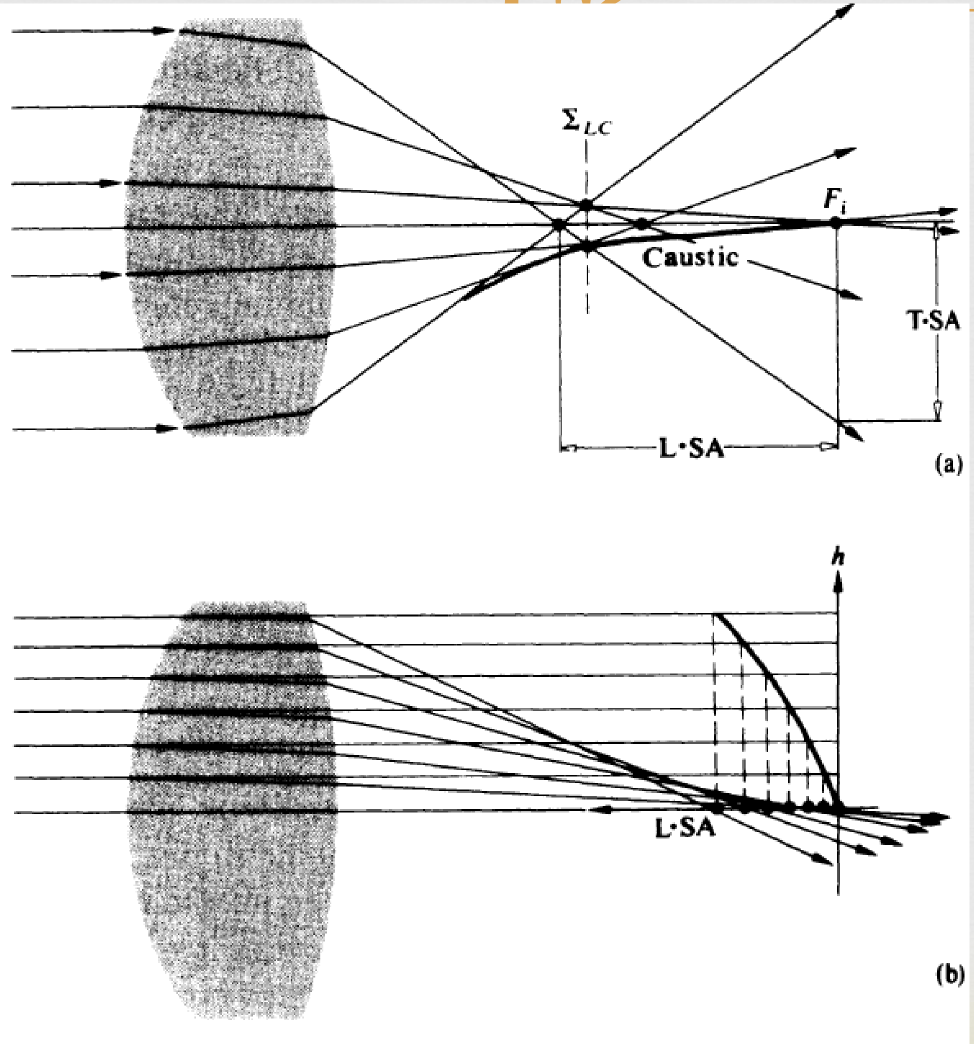
Paraxial condition $\sin\varphi \cong \varphi$

$$\frac{n_1}{S_o} + \frac{n_2}{S_1} = \frac{n_2 - n_2}{R}$$

$$\sin\varphi = \varphi - \frac{\varphi^3}{3!} + \frac{\varphi^5}{5!} - \frac{\varphi^7}{7!} + \cdots$$

$$\frac{n_1}{S_o} + \frac{n_2}{S_1} = \frac{n_2 - n_2}{R} + h^2\left[\frac{n_1}{2S_o}\left(\frac{1}{S_o} + \frac{1}{R}\right)^2 + \frac{n_2}{2S_i}\left(\frac{1}{R} - \frac{1}{S_i}\right)^2\right]$$

L.SA & T.SA



Wavefront Abeerration

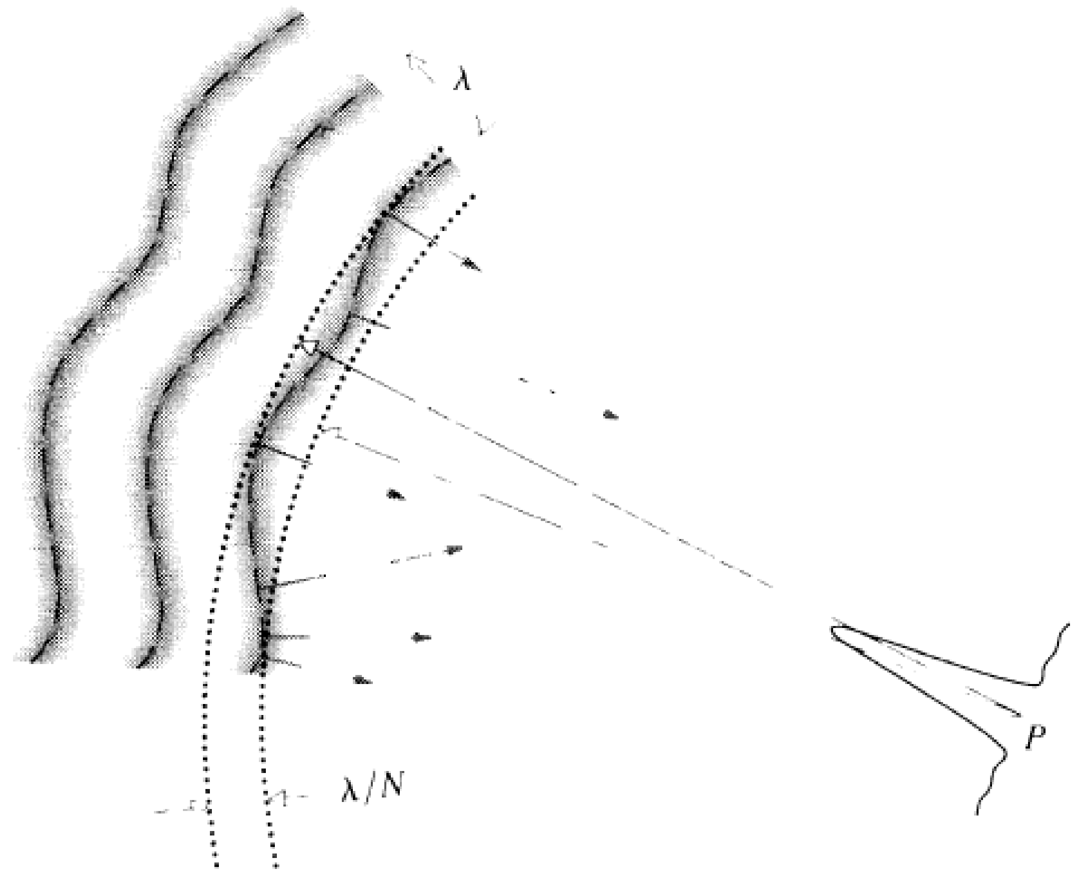
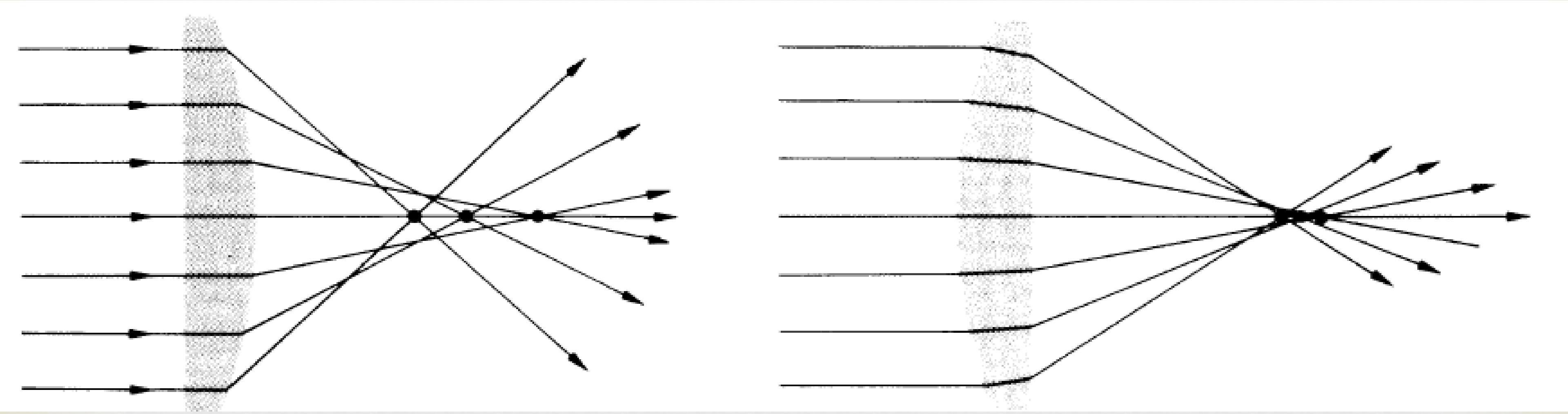


Figure 6.15 Since this wavefront deviates from a portion of a sphere (converging to the Gaussian image point), it is said to be aberrated. The extent of that deviation measured peak-to-peak is an indication of how far from perfection the image will be.

Lens Alignment for minimizing SA



Huygens Points

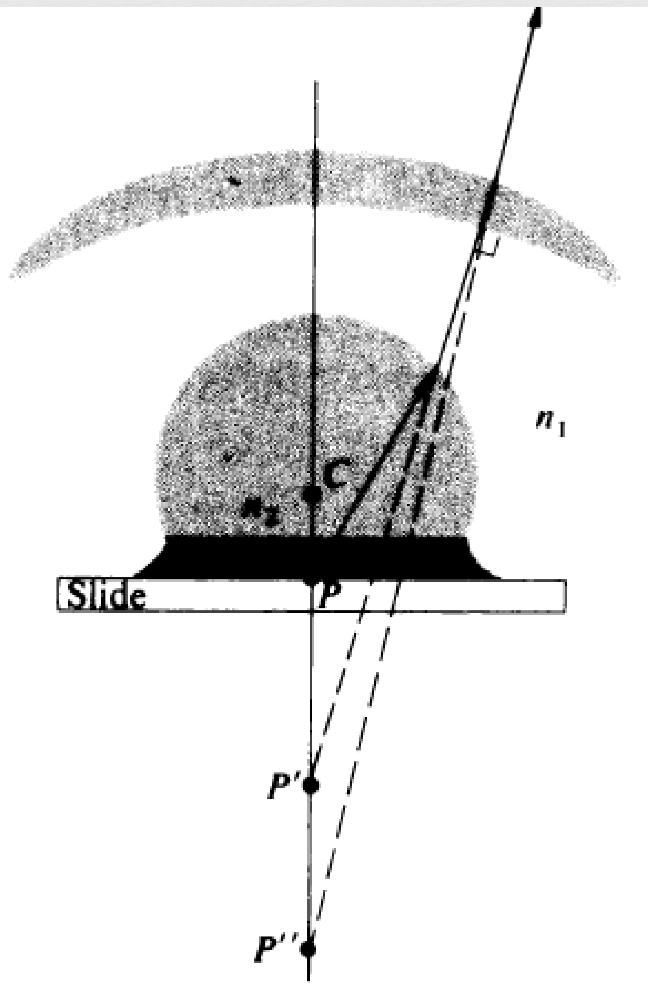
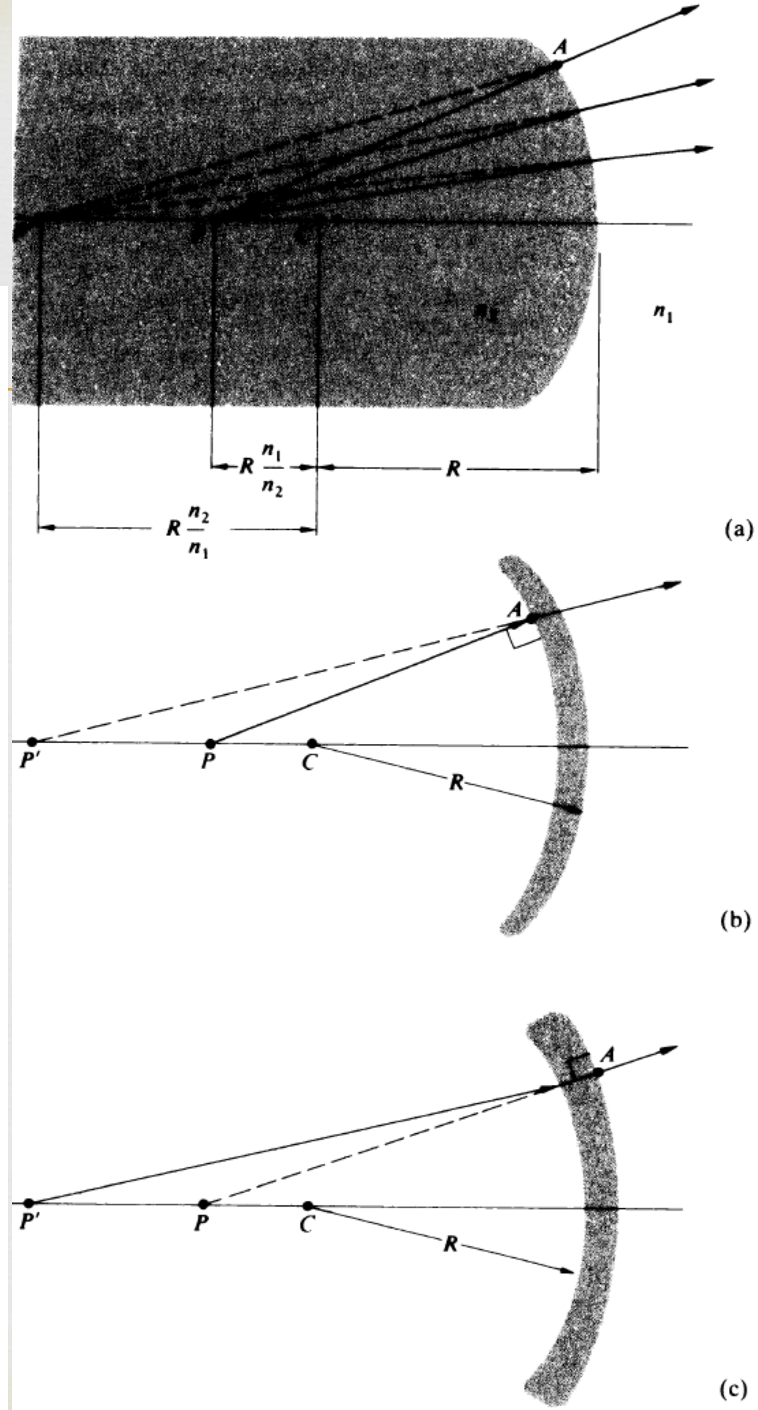
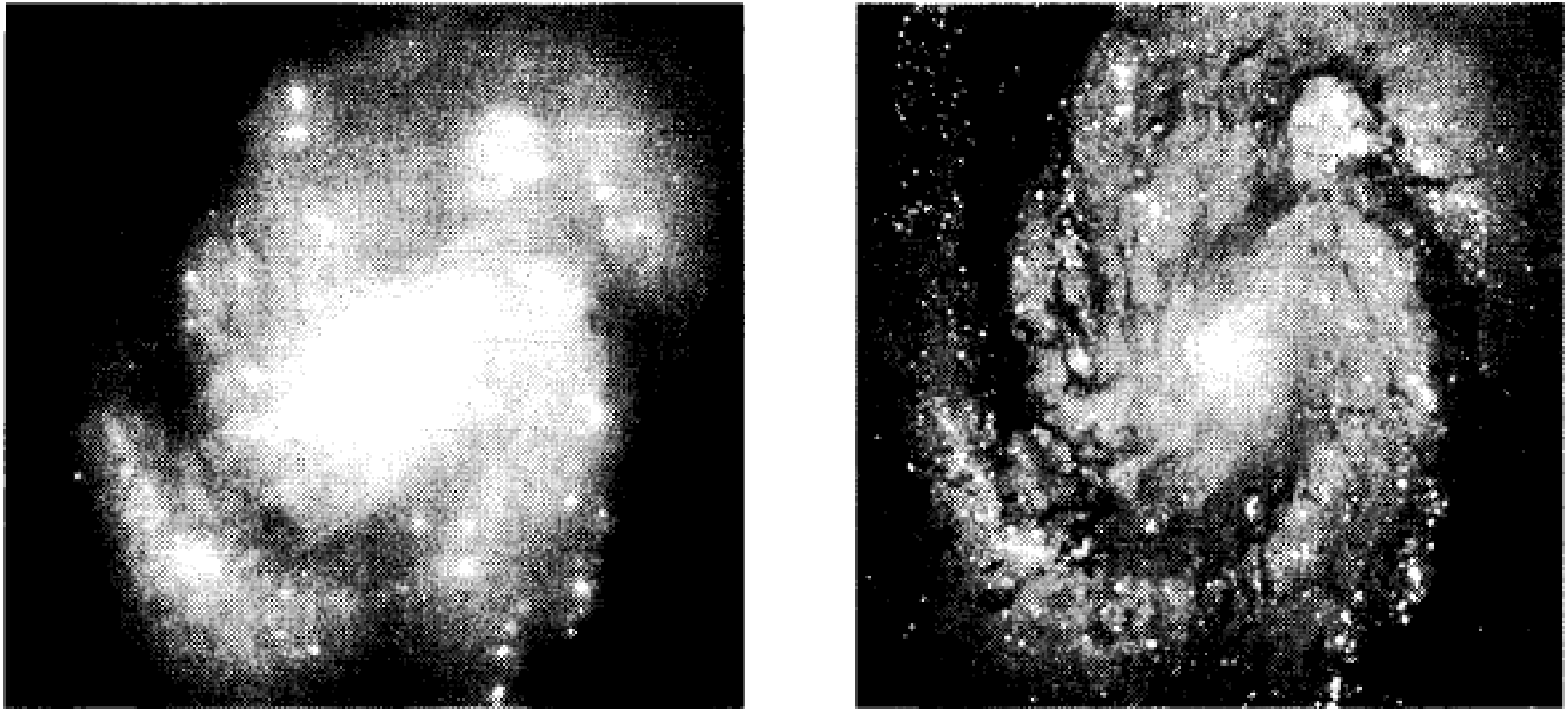


Figure 6.18 An oil-immersion microscope objective.



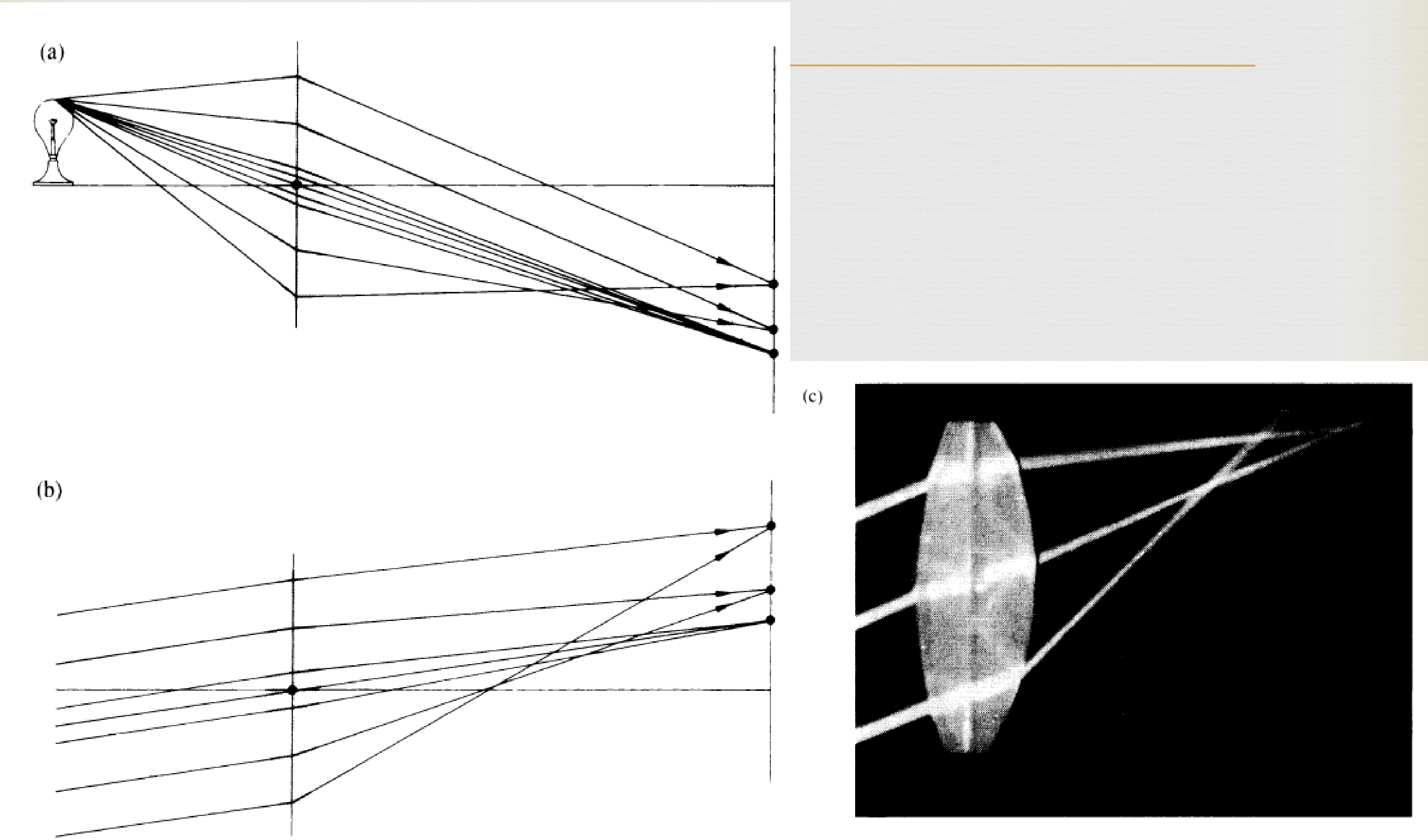
Hubble Telescope

Hubble Telescope

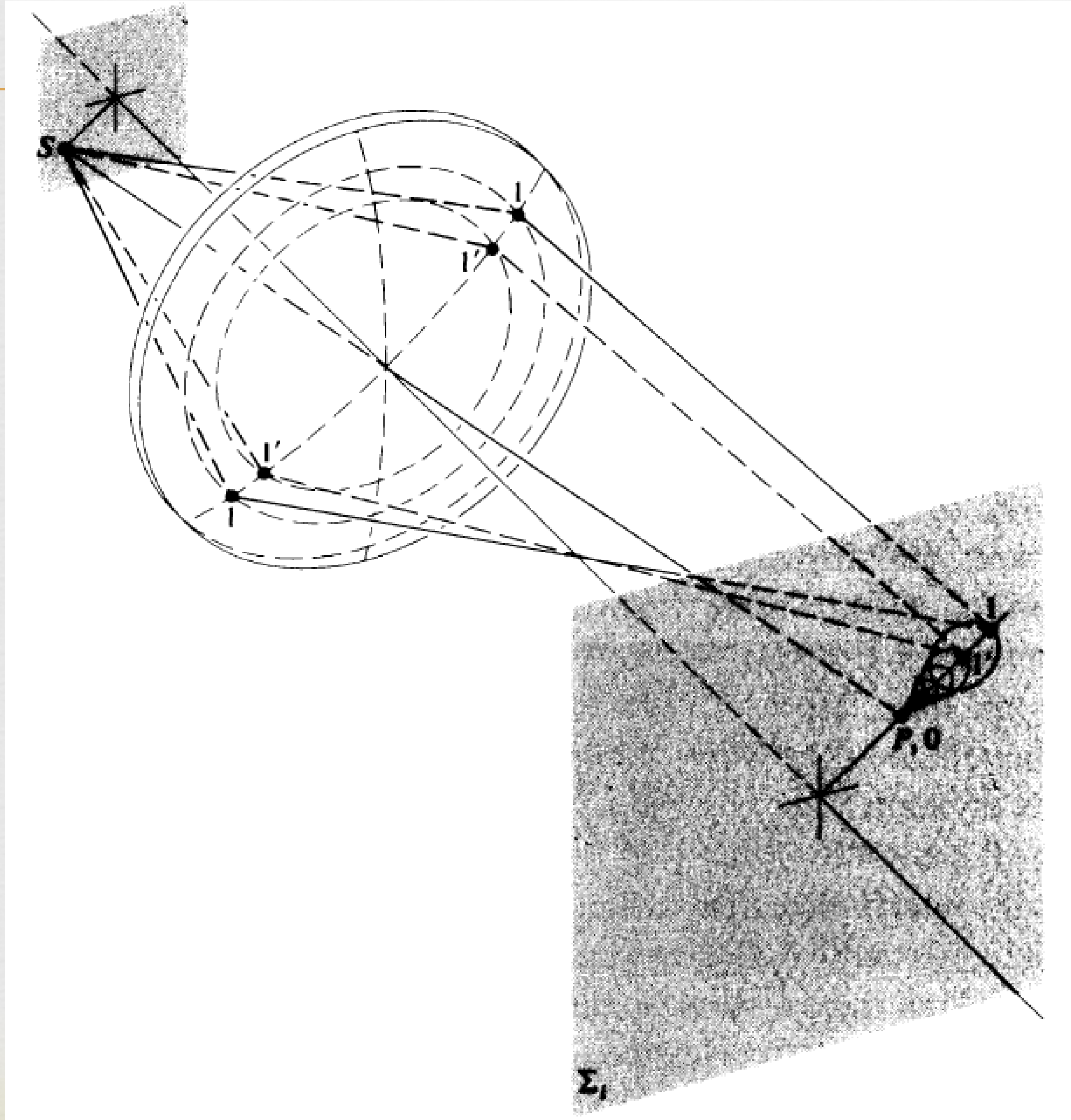


HST images of the M-100 galaxy with (before repair) and without (after repair) spherical aberration. (Photos courtesy of NASA.)

Coma



Coma



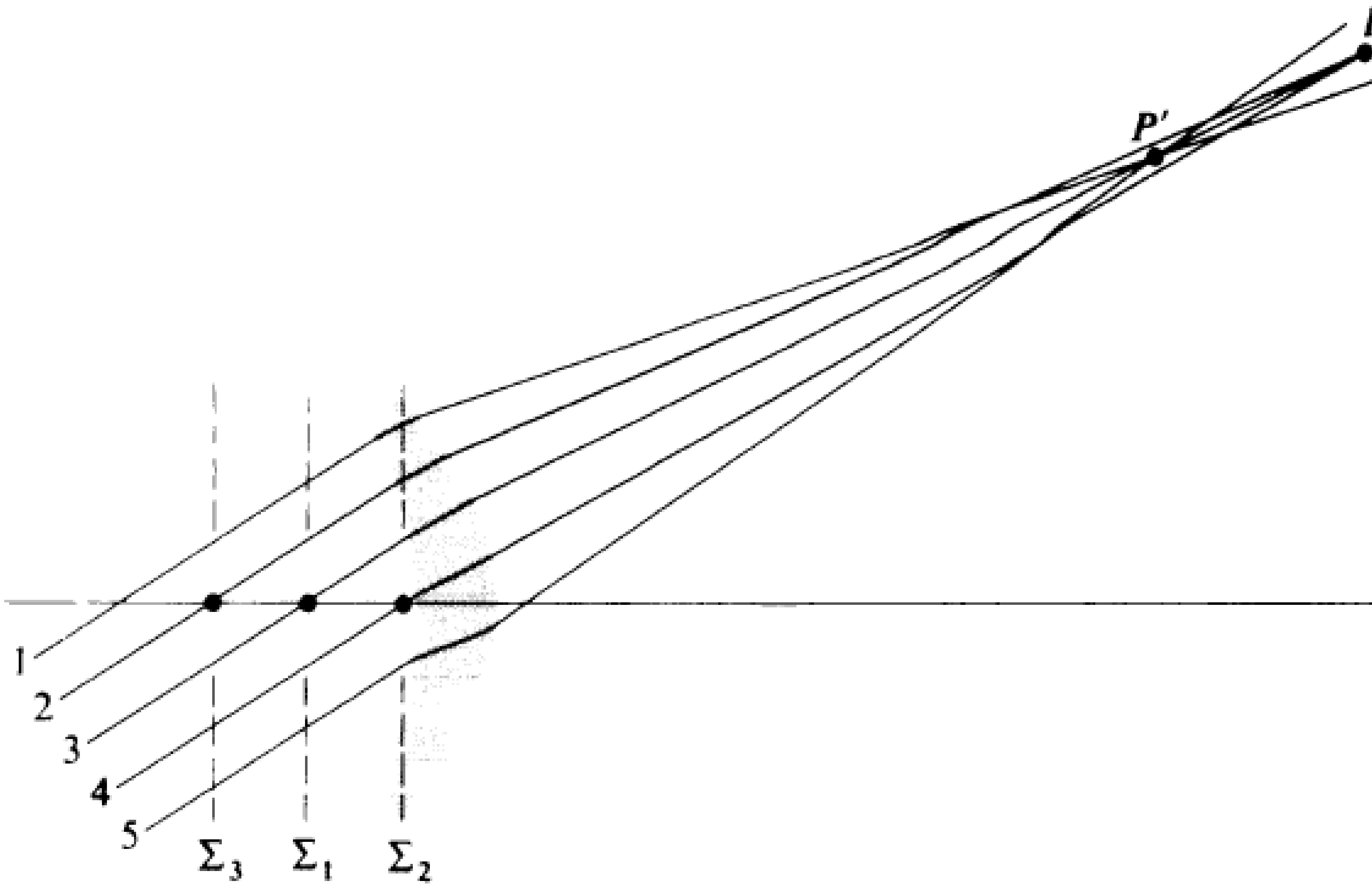
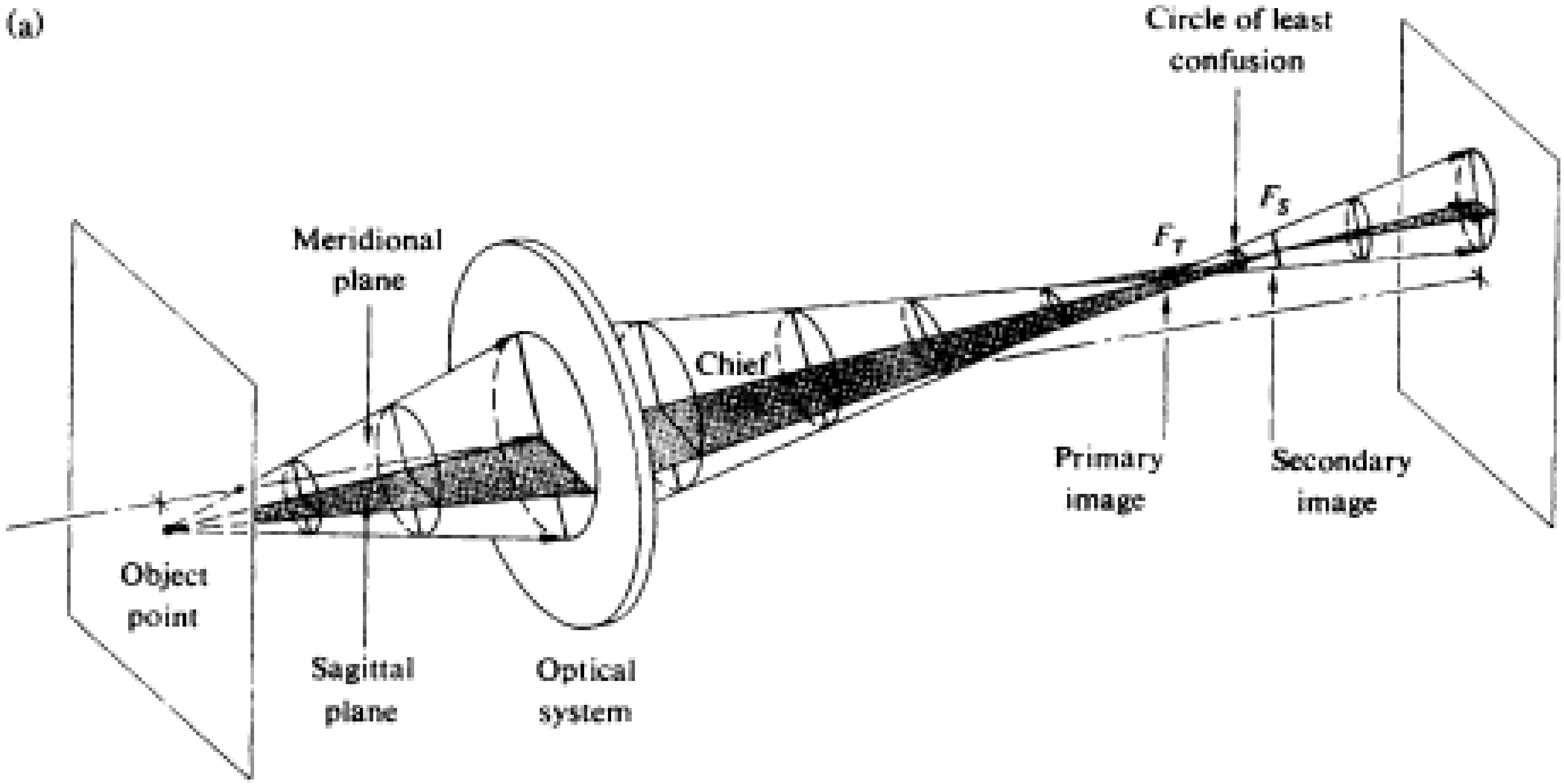
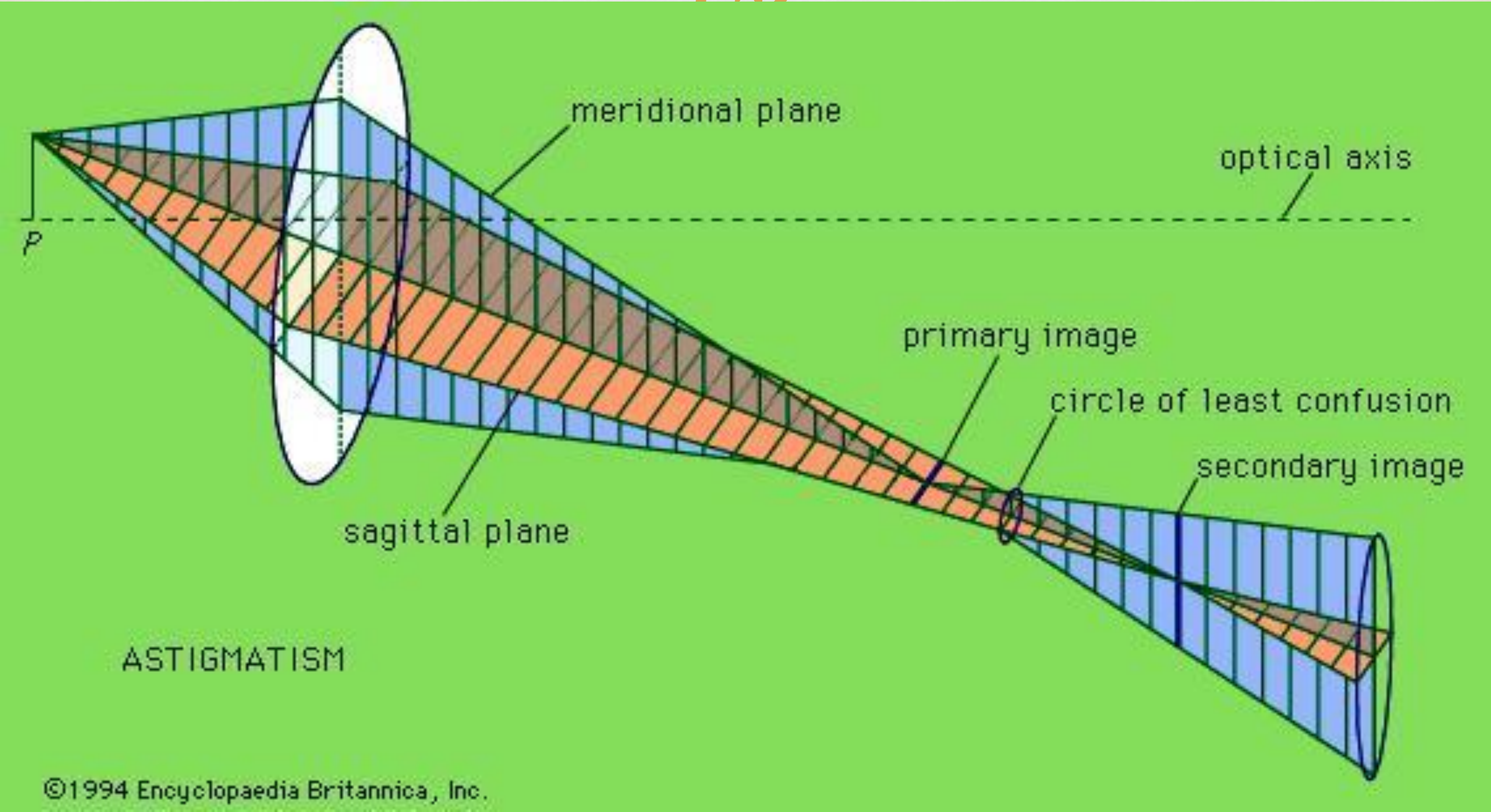


Figure 6.25 The effect of stop location on coma.

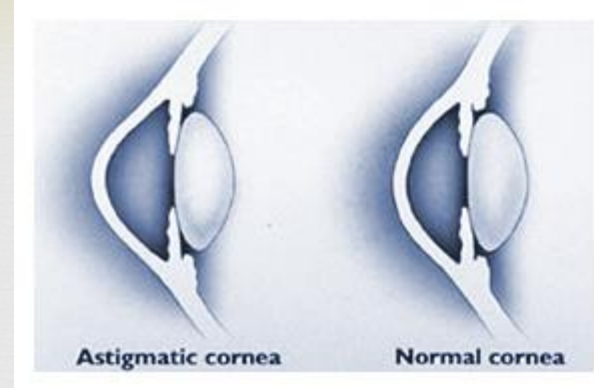
Astigmatism

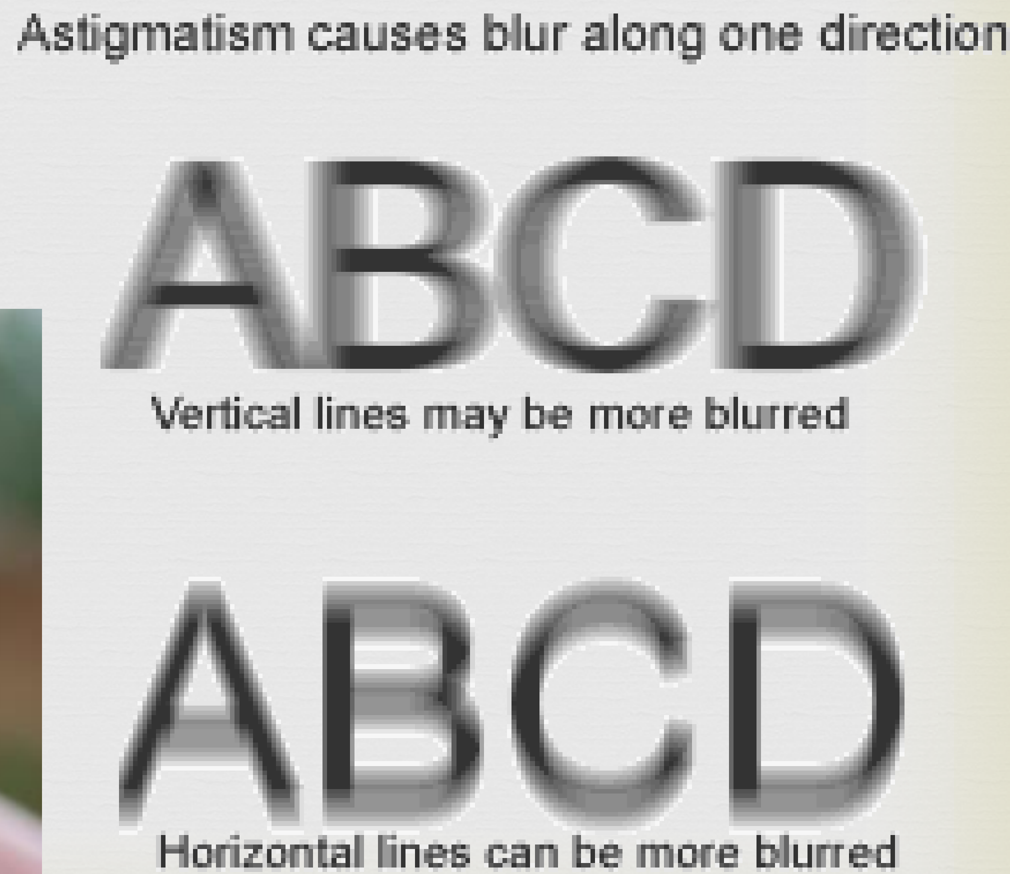


Astigmatism

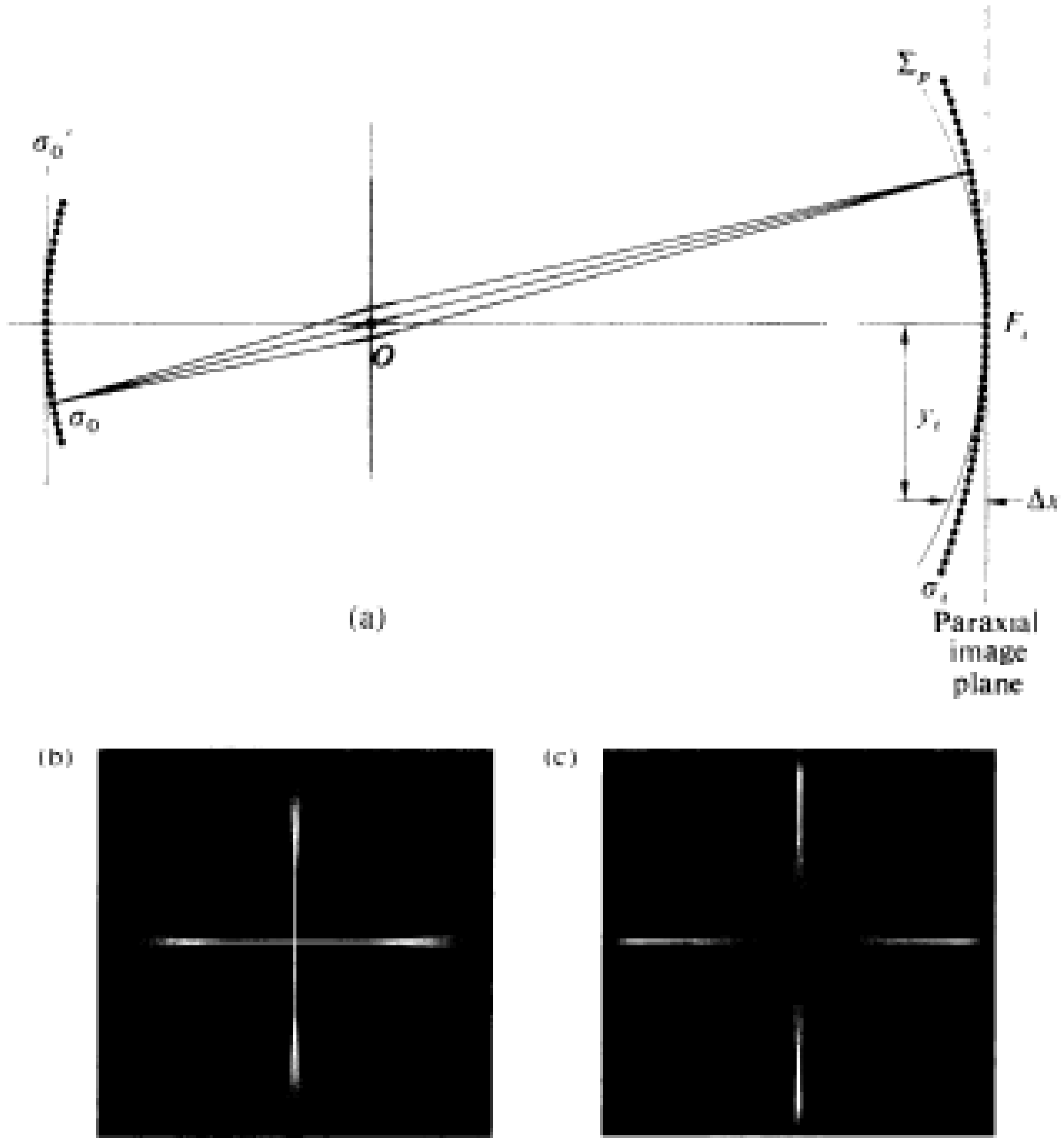


Astigmatism



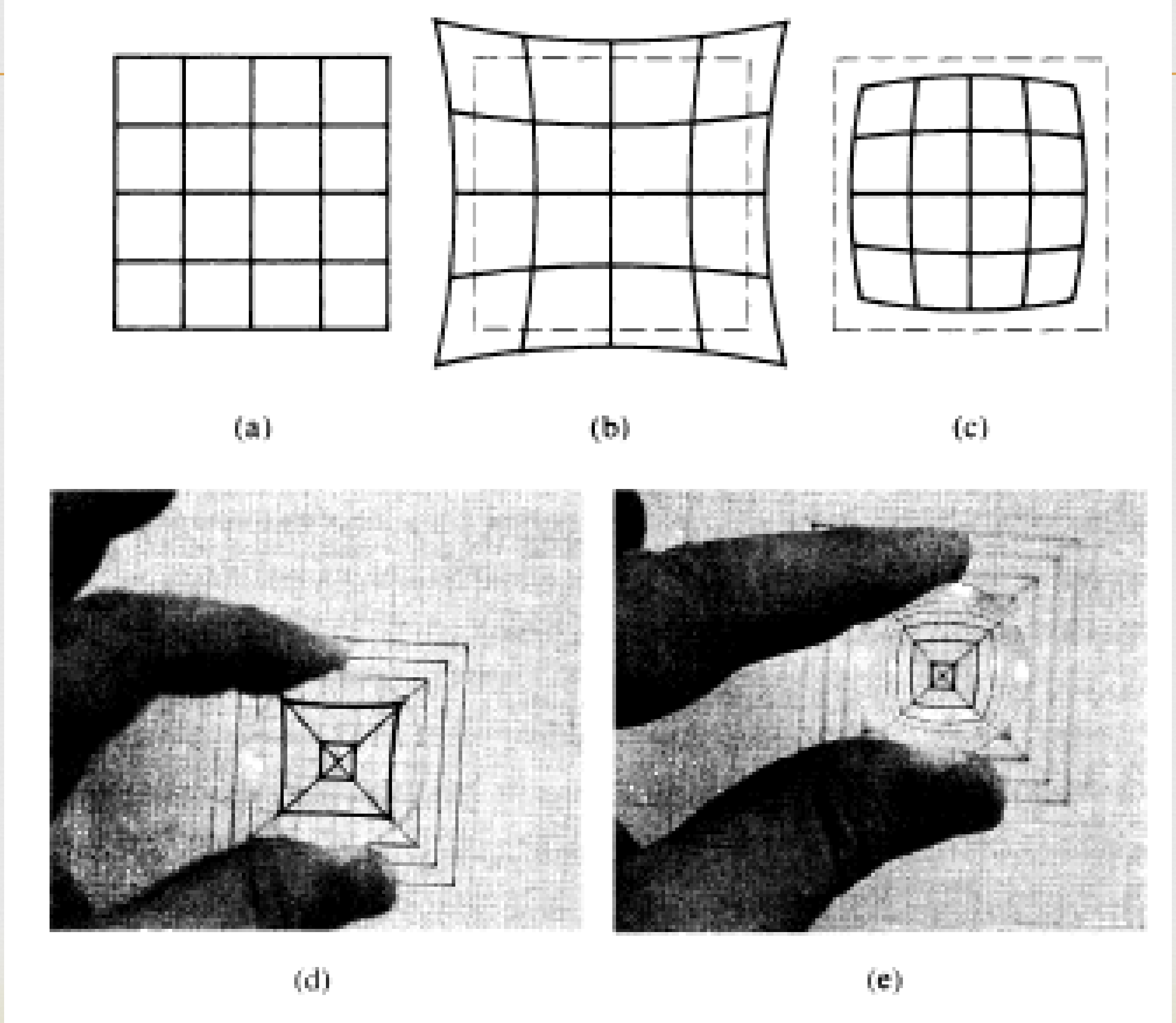


Field Curvature

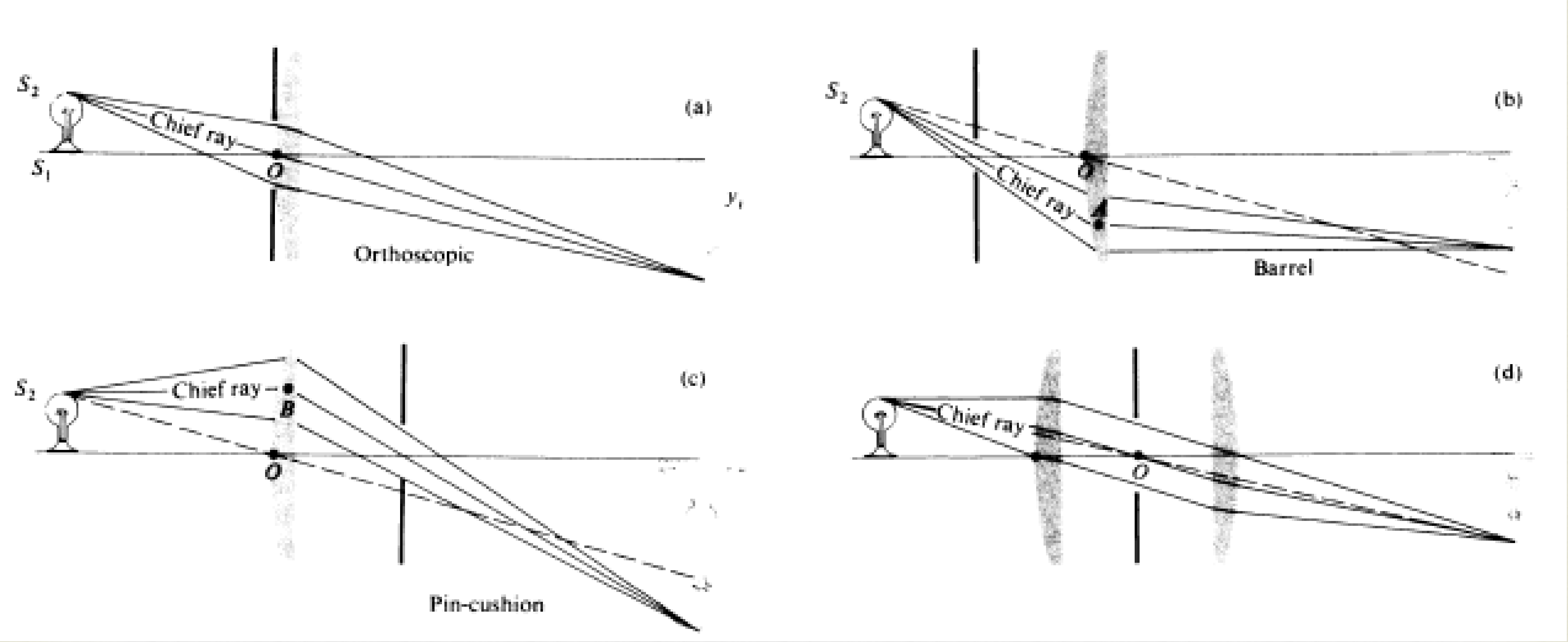


$$\Delta x = \frac{y_i^2}{2} \sum_{j=1}^{m} \frac{1}{n_j f_j}$$

Distortion



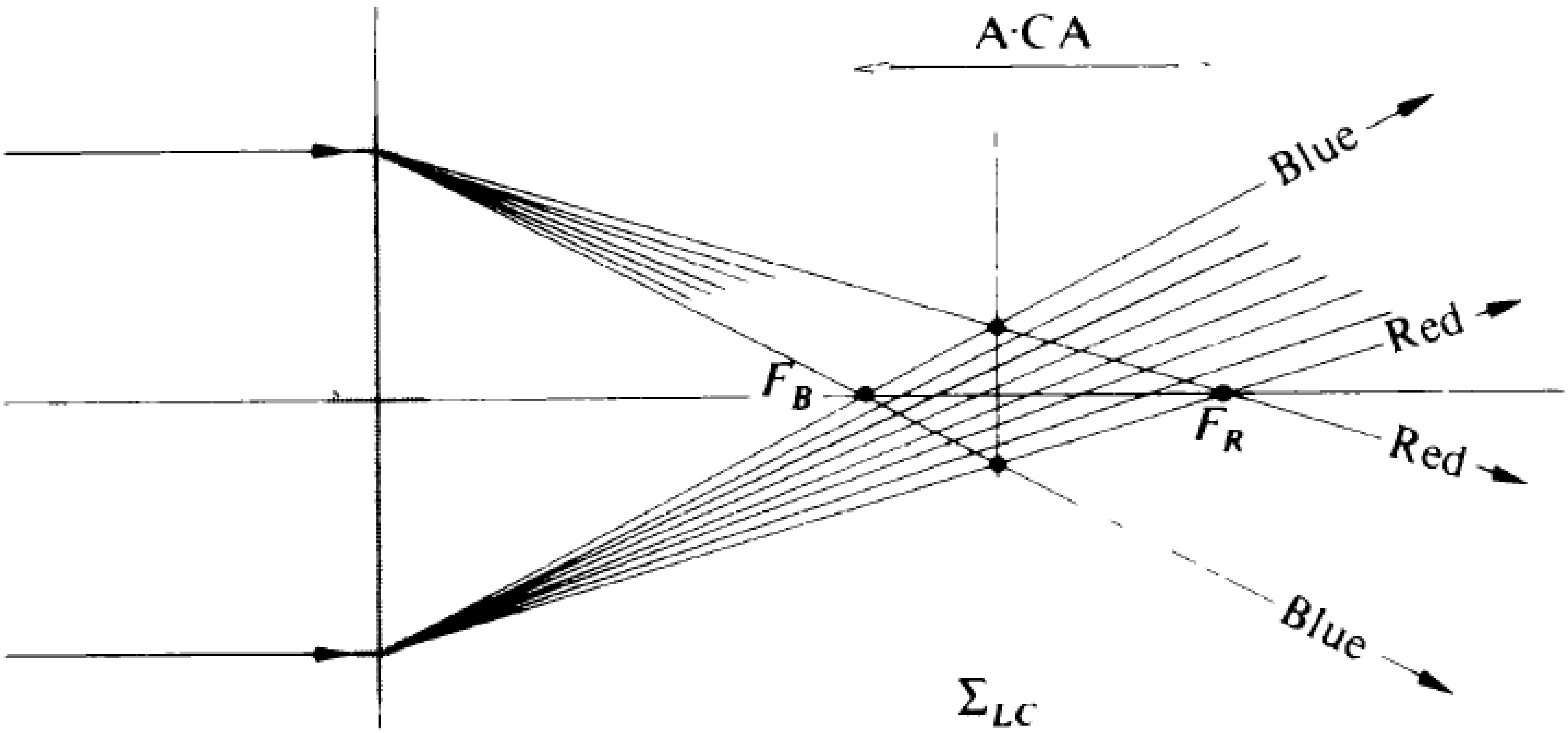
The Effect of Stop Location



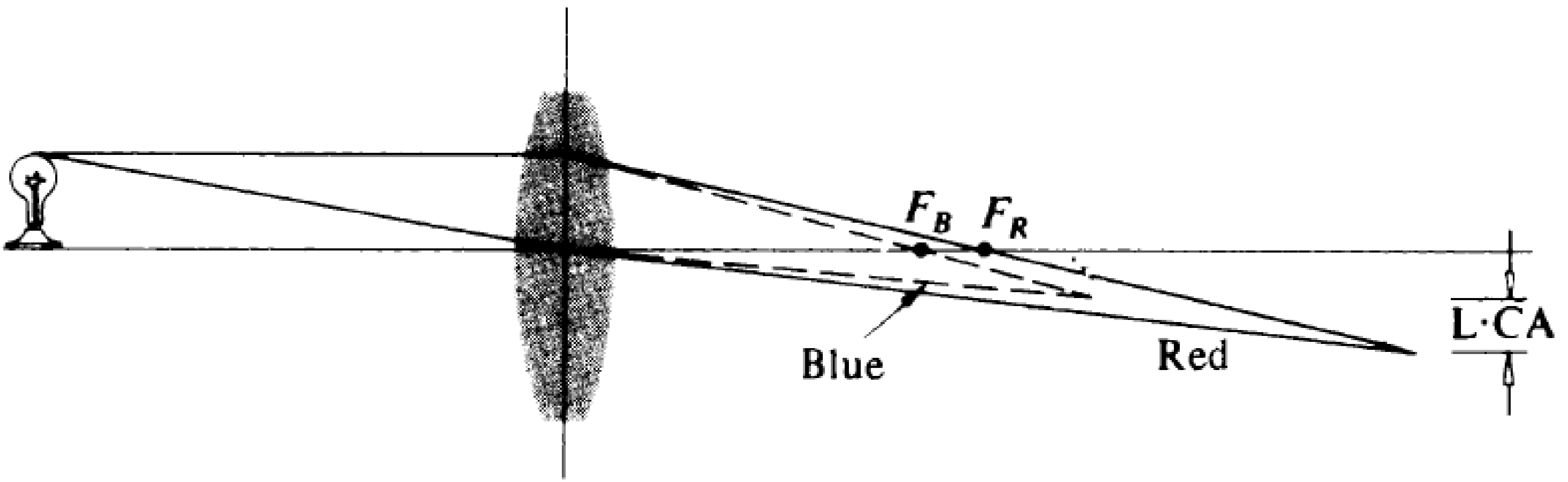
Chromatic Aberrations

$$\frac{1}{f} = (n_l - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \qquad [5.16]$$

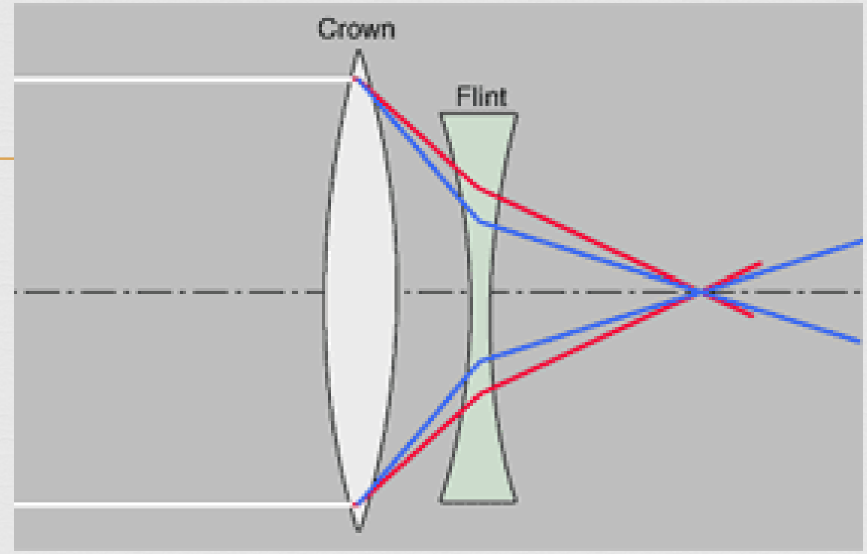
Axial Chromatic Aberration

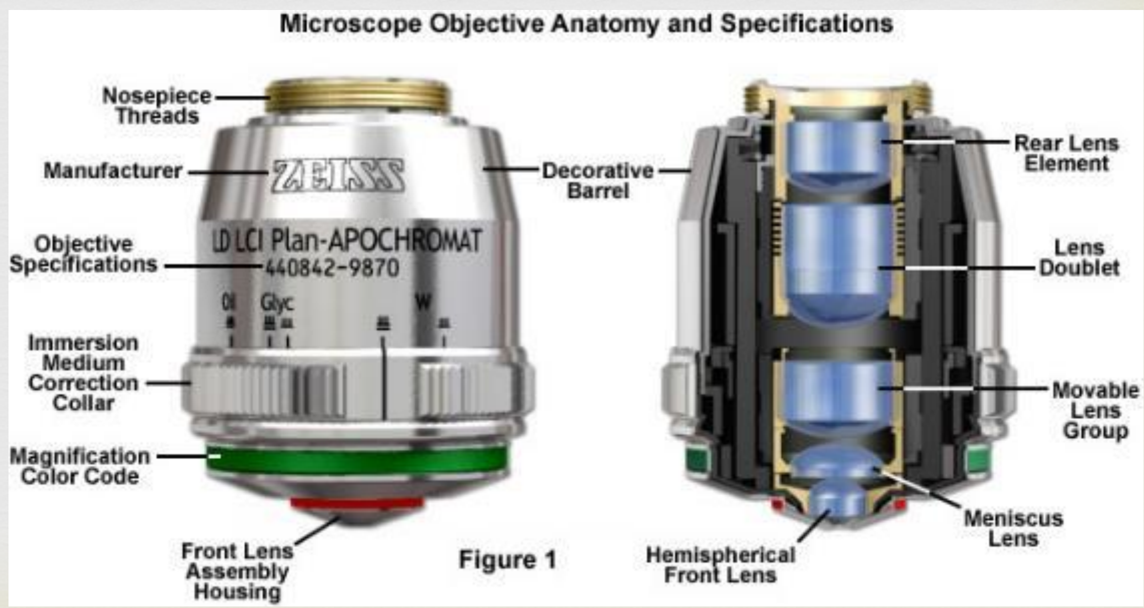


Laterial Chromatic Aberration



Achromatic Doublet





6.4 Grin Systems

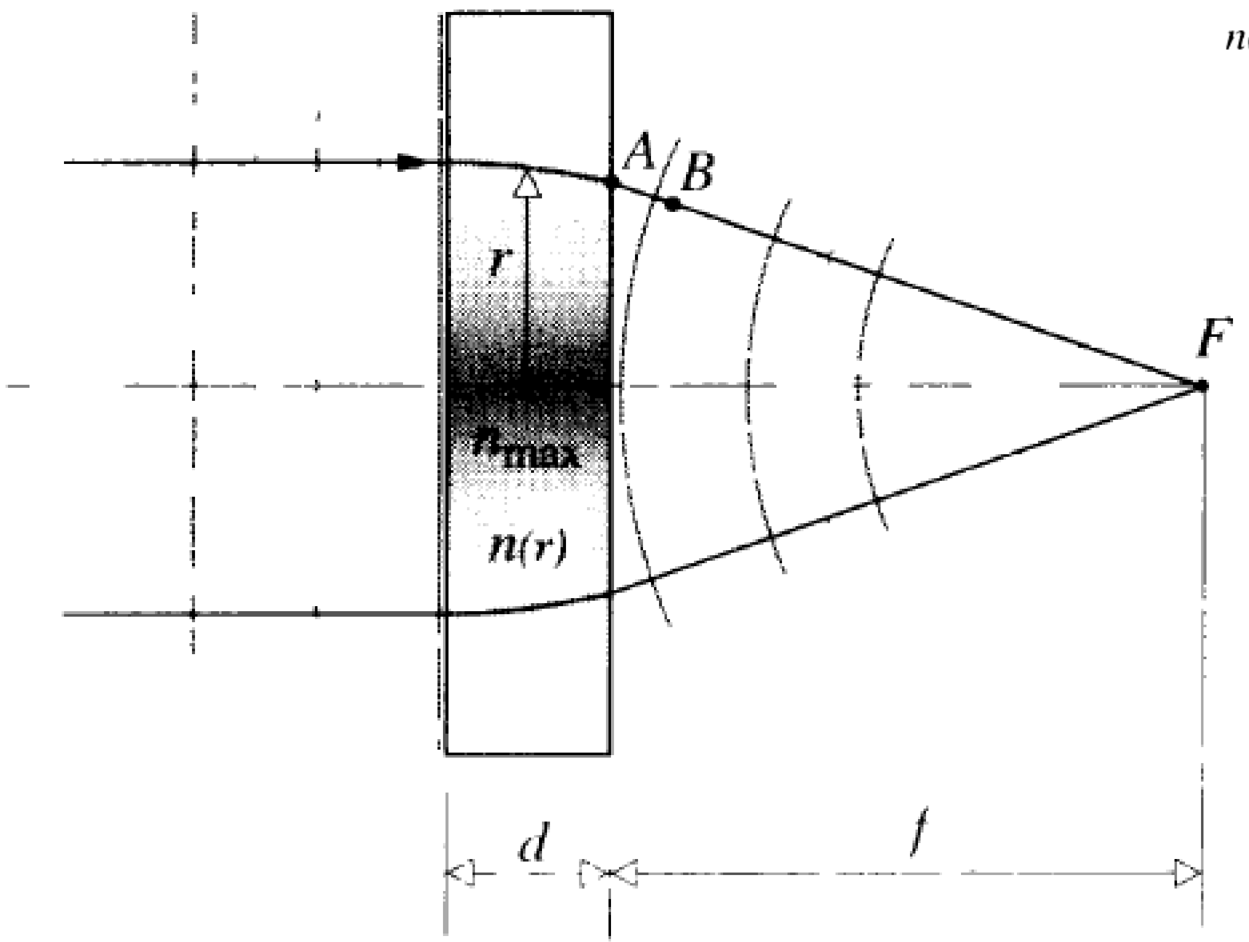
$$(OPL)_r + \overline{AB} = (OPL)_o$$

and

$$n(r)d + \overline{AB} = n_{\max}d$$

But $\overline{AF} \approx \sqrt{r^2 + f^2}$; moreover, $\overline{AB} = \overline{AF} - f$ and so

$$n(r) = n_{\max} - \frac{\sqrt{r^2 + f^2} - f}{d}$$



$$n(r) = n_{\max} - \frac{r^2}{2fd}$$

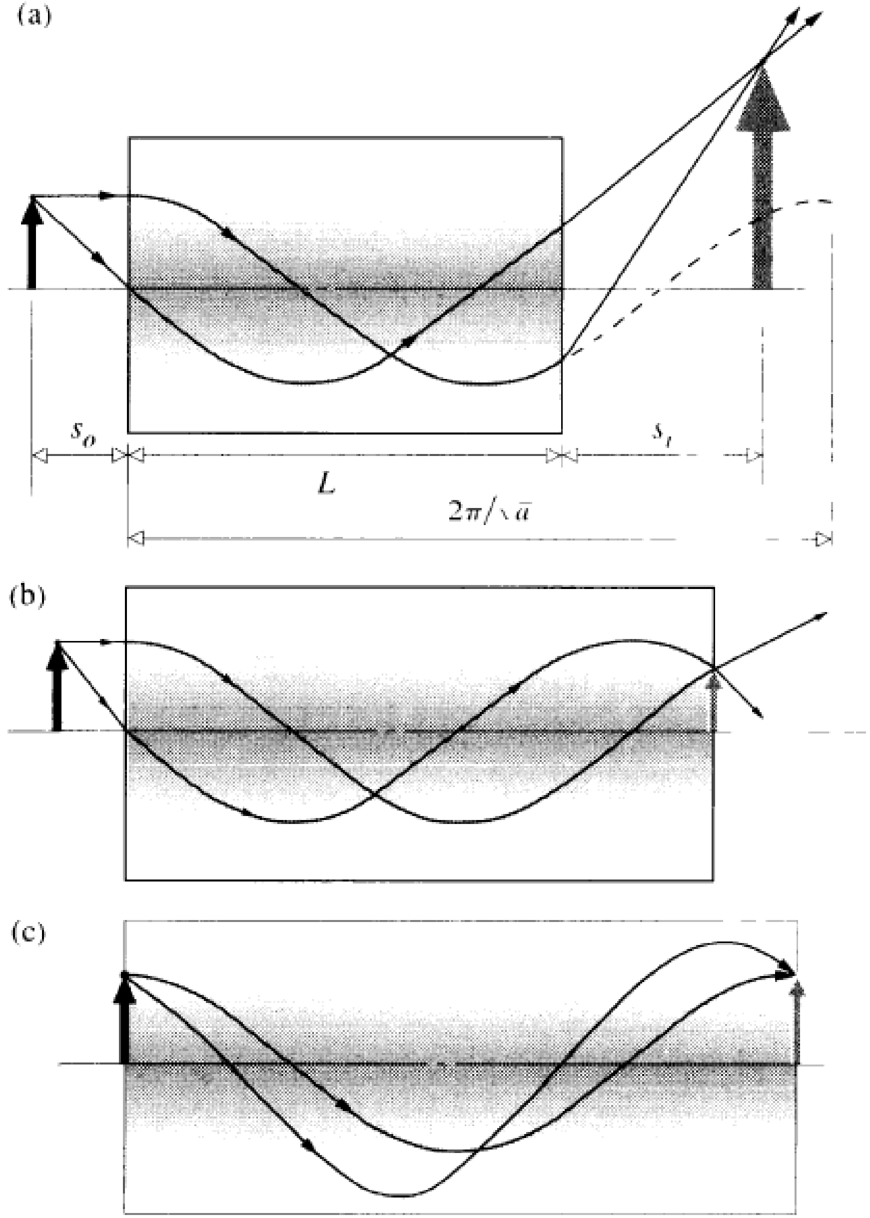


Figure 6.43 (*a*) A radial-GRIN rod producing a real, magnified, erect image. (*b*) Here the image is formed on the face of the rod. (*c*) This is a convenient setup for use in a copy machine.

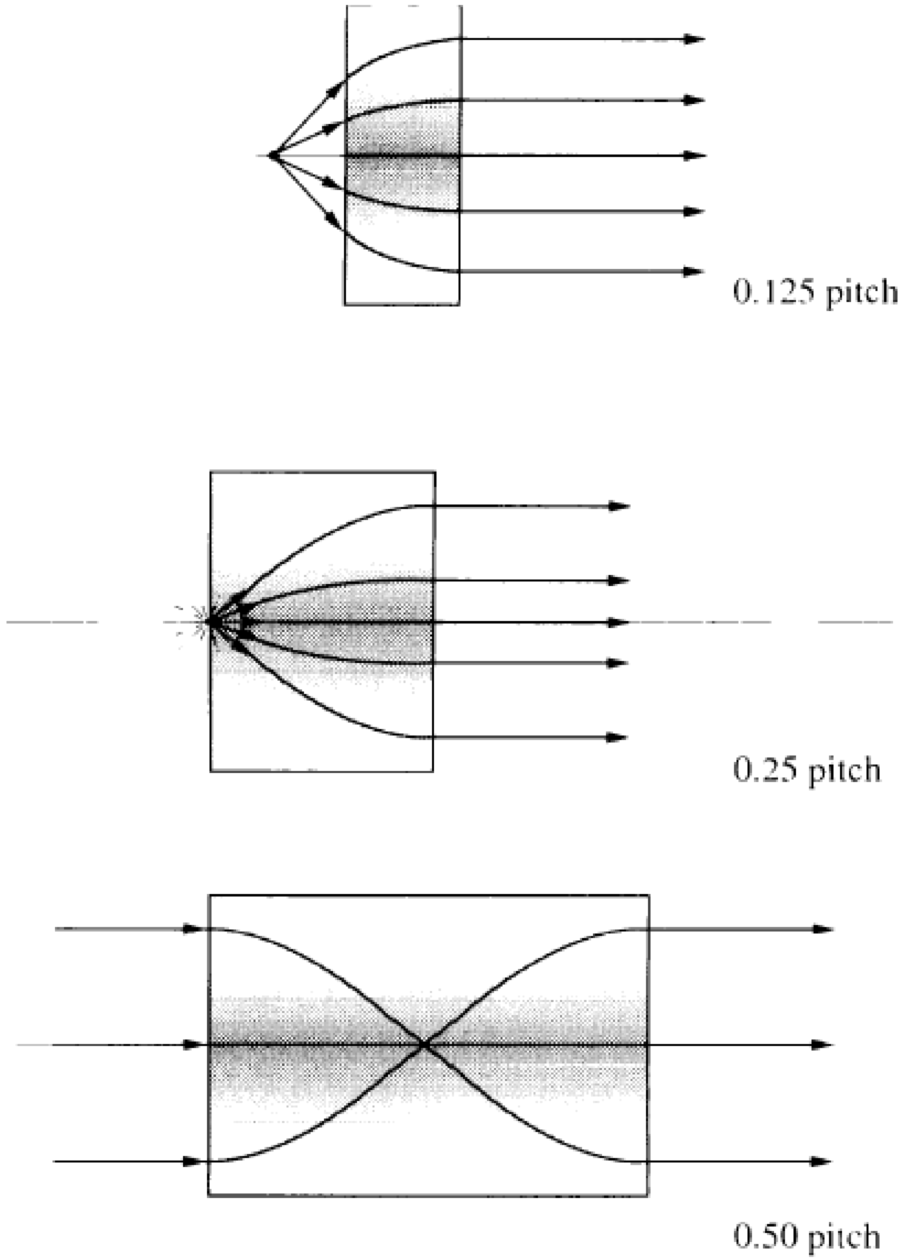


Figure 6.44 Radial GRIN lenses with several pitches used in a few typical ways.