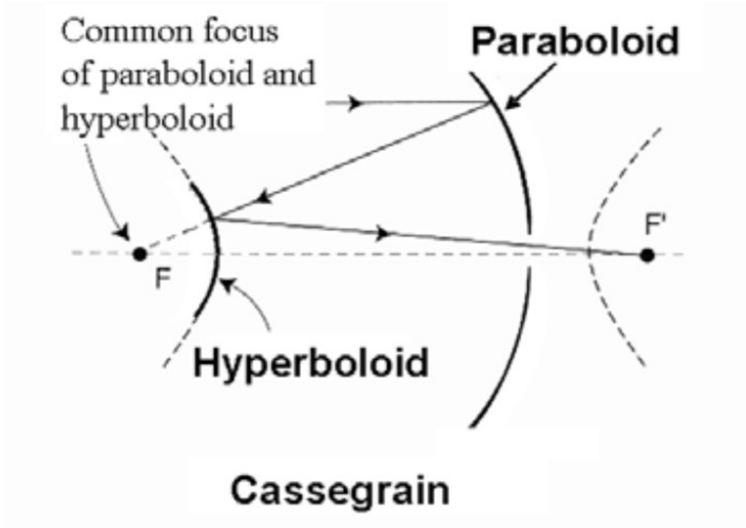
4.
You have a CCD camera with a large field of view attached to a typical small telescope and you see images with small “tails” toward the edges of the field, what could be wrong?

- images with small “tails” toward the edges of the field

  → coma aberration

  - off-axis effect
  - limit the image quality

- cause : secondary mirror



10. Using the information in Section 3.5 develop the RC design for the Keck 10m telescopes assuming a primary mirror diameter of 10m, a primary focal ratio of 1.75, a back focal length of 24% of the primary focal length, a final focal ratio of f /15, and a field of view determined by <0.5'' astigmatism. Calculate the radii of curvature and conic constants of the primary and secondary mirrors and find the distance between them.

Primary mirror diameter D_1 : 10m
Primary focal ratio F_1 : 1.75
Back focal length $bfl : 0.24f_1$
Final focal ratio F : 15
astigmatism <0.5'' →Field of view : ~20' (2θ)

$\left(AAS = \left(\frac{\theta^2}{2F}\right)[(m(2m+1)+\beta)/(2m(1+\beta))]\right)$

$$f_1 = D_1 \times F_1 = 17.5[\mathrm{m}]$$
$$bfl = 0.24 \times f_1 = 4.2[\mathrm{m}]$$
$$f = D_1 \times F = 150[\mathrm{m}]$$
$$m = \frac{f}{f_1} = \frac{150}{17.5} \approx 8.57$$
$$\beta = 0.24$$
$$k = \frac{1+\beta}{m+1} = 0.13$$

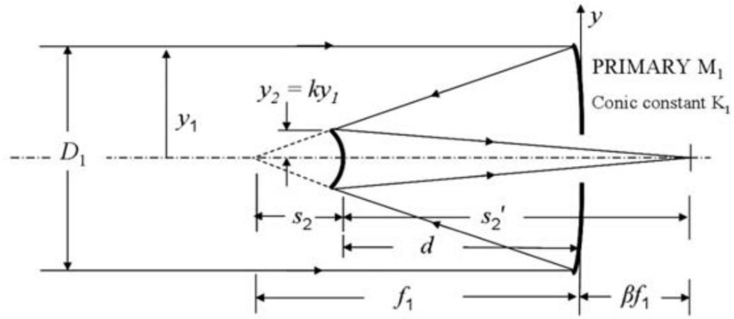
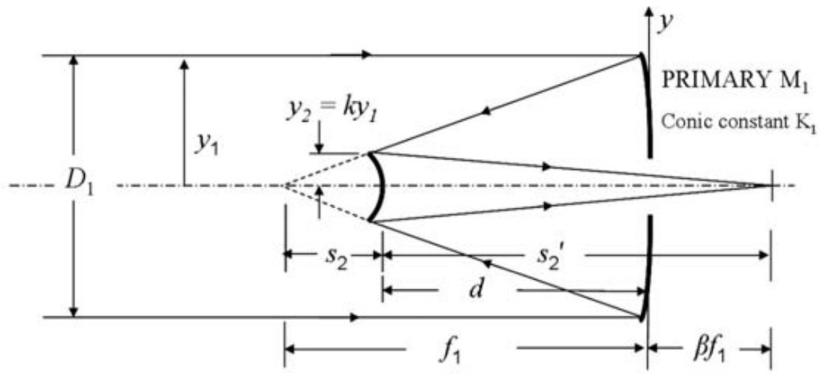


Figure 3.16. The main parameters involved in the design of a two-mirror telescope and their geometrical relationship to each other. Adapted from Schroeder (2000).

useful normalized parameters can be defined as follows:

$k = y_2/y_1$	where y_1 and y_2 are the heights of the rays at the edge of the primary and secondary, respectively;
$\rho = R_2/R_1$	where R_1 and R_2 are the vertex radii of the curvature of the primary and secondary mirror, respectively;
$m = -s_2'/s_2$	transverse magnification of secondary;
$f_1\beta = D_1\eta$	back focal distance: β and η are the back focal distance in units of the primary focal length f_1 and primary diameter D_1, respectively;
$F_1 = f_1/D_1$	primary focal ratio;
$F = f/D_1$	the system focal ratio, where f is the net focal length.



$$D_2 = D_1[|k| + 2\theta F_1(1-k)] = 1.39[\mathrm{m}]$$
$$s_2 = F_1 D_2 = 2.43[\mathrm{m}]$$
$$s'_2 = F D_2 = 20.8[\mathrm{m}]$$

$$R_1 = 2f_1 = 35[\mathrm{m}]$$
$$R_2 = 2f_2 = 2\frac{s_2 s'_2}{s_2 + s'_2} = 4.4[\mathrm{m}]$$
$$K_1 = -1 - \left[\frac{2(1+\beta)}{m^2(m-\beta)}\right] \approx -1.004$$
$$K_2 = -\left[\frac{m+1}{m-1}\right]^2 - \left[\frac{2m(m+1)}{m-\beta(m-1)^3}\right] \approx -1.644$$
$$d = f_1 - s_2 = 15[\mathrm{m}]$$

Table 3.3. Design parameters for a two-mirror aplanatic telescope.

Chosen parameter	*Derived parameter*	*Comments*
Primary diameter D_1	Collecting area	Light grasp ($\sim D^2$) Diffraction limit (λ/D)
Primary focal ratio F_1	Primary focal length $f_1 = F_1 D_1$ Primary vertex radius $R_1 = 2f_1$	Size of dome Alignment tolerance
Back focal length (bfl)	$\beta = \mathrm{bfl}/f_1$	Instrument volume Mirror support volume
Final focal ratio F	Magnification $m = F/F_1$ Effective focal length $f = mf_1$ Primary conic constant (K_1) Secondary conic constant (K_2) Aperture ratio k	Focus tolerance Plate scale From (m, β) From (m, β) From (m, β)
Field of view (2θ)	Secondary diameter D_2 Distance $s_2 = F_1 D_2$ Separation of mirrors $d = f_1 - s_2$ Image distance $s'_2 = FD_2$ Secondary focal length f_2 from $f_2 = s_2 s'_2/(s_2 + s'_2)$ Secondary vertex radius $R_2 = 2f_2$	For astigmatism (AAS) $< 0.5''$ Use image quality criterion to set field of view radius θ