Image Aberration

Perfect optic would produce a perfect image, but no optic (is there anything?) is perfect…

Defects →aberrations (像差)

✓Monochromatic aberrations —— 與波長無關
✓Chromatic aberrations
✓Other aberrations

Monochromatic aberration

Blurring of an image

Spherical aberration — affecting whole image → sharpness ↓
球面像差

Astigmatism — off-axis object in focus → asymmetry → elliptical images
散光

Coma 彗形像差— affecting edges and corners

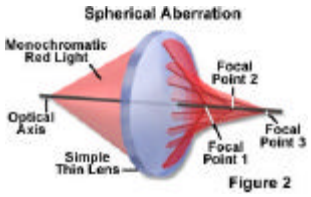
Degrading the shape of an image

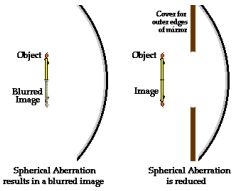
Distortion (geometric) — pincushion, barrel

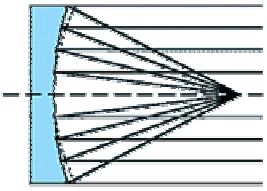
Field curvature — center in focus but edges are not, vice versa

Spherical aberration

— affecting whole image → sharpness ↓



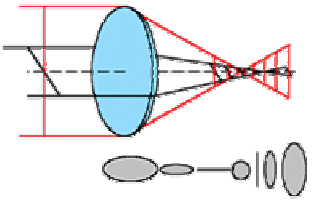


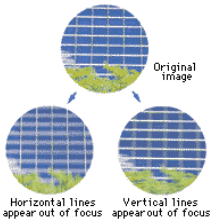


http://www.planet088.com/show_me1.asp?mpos=8

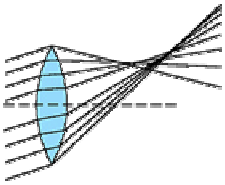
http://nikon.topica.ne.jp/bi_e/encyclo/ad.htm

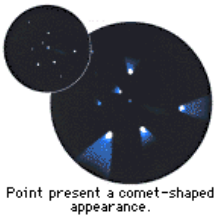
Astigmatism — off-axis object in focus → asymmetry → elliptical images

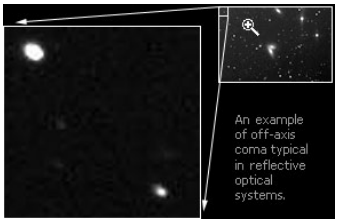




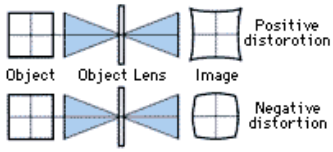
Coma — affecting edges and corners

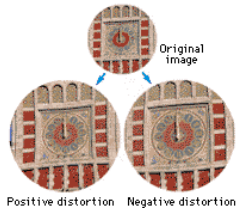






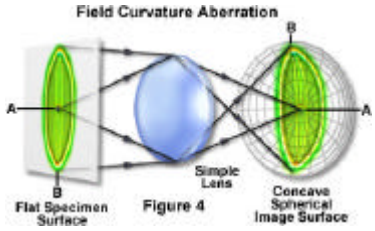
Distortion (geometric): pincushion, barrel



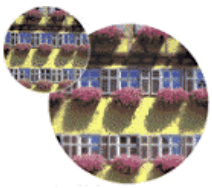


Field curvature

— center in focus but edges are not, vice versa



micro.magnet.fsu.edu/.../ opticalaberrations.html

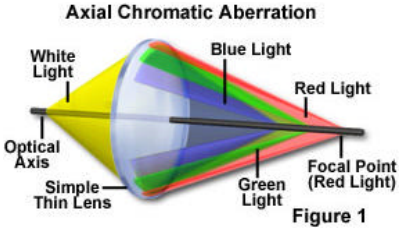


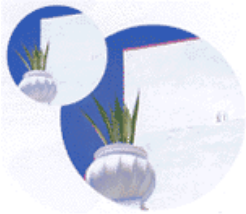
The periphery of the field appears out of focus.

Chromatic aberration

Color fringes in images → sharpness ↓

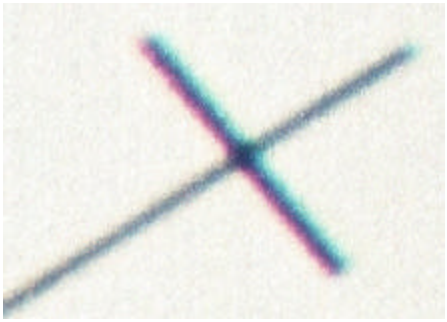
Apochromatic “APO” lenses（**消色差鏡片**）use special glasses to minimize chromatic aberration

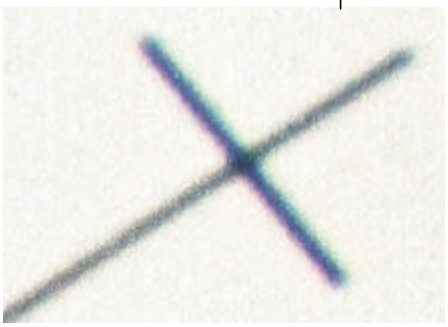




The image is blurred and appears coloured at the fringe.

With APO correction





http://www.vanwalree.com/optics/chromatic.html

Other aberrations

Flare (internal reflection within lens…image "washed out")

Vignetting (周邊減光) cutting off light in the corners of an image)

All the above (aberrations) can be corrected in theory, by careful optical design and/or the addition of correcting lenses. There is however a natural limit to the sharpness of an image ➔ diffraction（繞射）— spreading of light when it passes through an aperture — the smaller the aperture, the more the diffraction

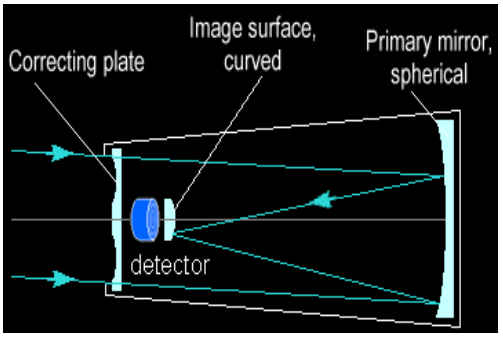
實務上，影像變形無法完全消除，一般望遠鏡有效視野限制在中央1度左右

Exception — Schmidt telescope, use of a spherical mirror, plus a central stop

Schmidt Telescope

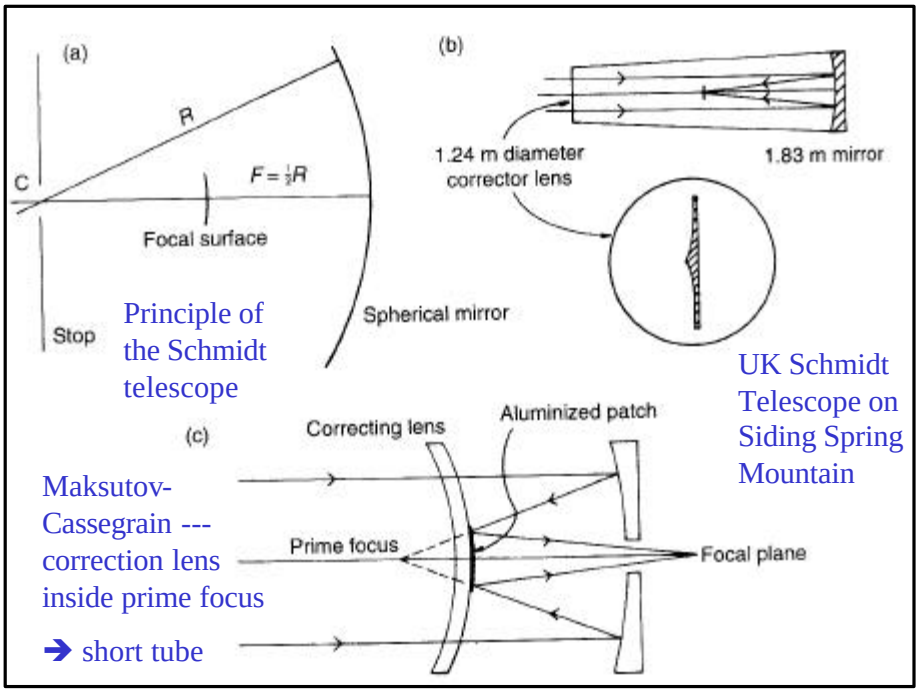
Instead of a paraboloid (hyperboloid) mirror, a Schmidt telescope uses a spherical mirror, but has a stop at the center of curvature.

修正鏡



球面主鏡

Stop 決定有效口徑，主鏡得大些



Principle of the Schmidt telescope

UK Schmidt Telescope on Siding Spring Mountain

Maksutov-Cassegrain --- correction lens inside prime focus

➔ short tube

All rays are "on-axis" → no off-axis aberrations

Focal length $F=R/2$ where R: radius of curvature

To correct for spherical aberration

→ a thin corrector lens

→ only little off-axis aberrations introduced

➔curved focal surface

∴ (1) bend the photographic plates or CCD chip!

(2) add a field-flattening lens

A Schmidt telescope offers a very wide field-of-view (FOV) at small focal ratios.

The 48-inch (1.2 m) Oschin Schmidt telescope at Mount Palomar Observatory, CA, USA
FOV = 6-7 degrees

- Schmidt telescopes are good for sky surveys to faint limits.
- Palomar Observatory Sky Survey (POSS) of the northern sky completed in 1956, with limiting magnitude~20-21 mag
- In the southern sky, with improved optics and better emulsions, the UK Schmidt (Australia, observing in the blue band, Kodak IIIa-J emulsion, J_{limit}=22.5 mag) and European Southern Observatory Schmidt (Chile, in the red band, IIIa-F, R_{limit}=22 mag), completed recently the survey of the southern sky

- The Palomar Schmidt, with experience gained with the southern Schmidts, is doing the second generation northern survey to a limit as faint as the ESO/UK survey.
- Plates of these surveys are scanned by automatic plate-measuring machines, e.g., COSMOS in Edinburgh and APM in Cambridge ➔ **Digitized Sky Survey (DSS)**
  → huge amounts of data, e.g., catalogs of positions shapes, brightness, for stars, galaxies, etc.