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 ↓

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

Coma — affecting edges and corners

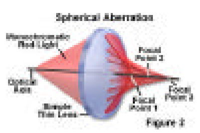
Degrading the shape of an image

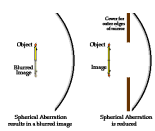
Distortion (geometric) — pincushion, barrel

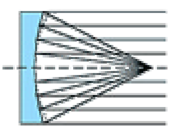
Field curvature — center in focus but edges are not, vice versa

Spherical aberration

— affecting whole image → sharpness ↓





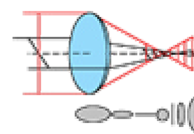


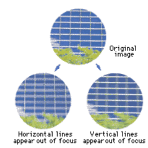
http://www.planet088.com/show_me1.asp?mpos=8

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

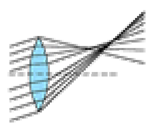
Astigmatism — off-axis object in focus

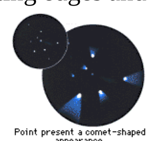
→ asymmetry → elliptical images

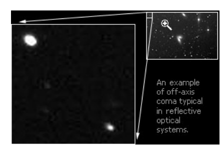




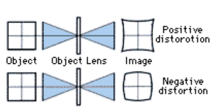
Coma — affecting edges and corners

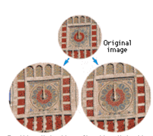






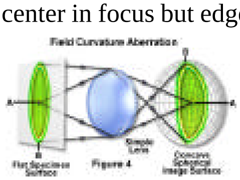
Distortion (geometric): pincushion, barrel

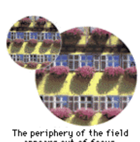




Field curvature

— center in focus but edges are not, vice versa



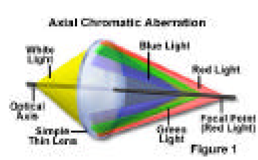


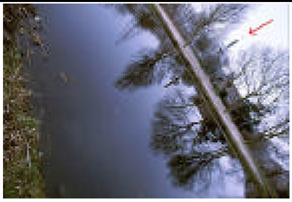
micro.magnet.fsu.edu/.../ opticalaberrations.html

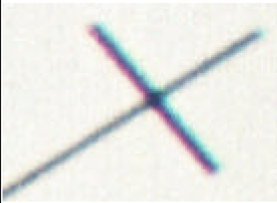
Chromatic aberration

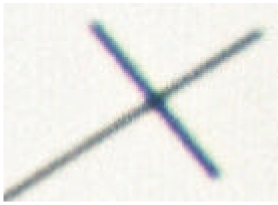
Color fringes in images → sharpness ↓

Apochromatic "APO" lenses use special glasses to minimize chromatic aberration





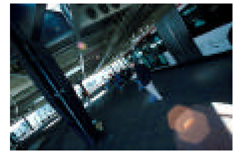




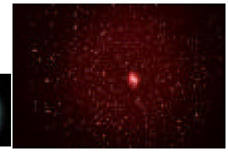
http://www.vanwalree.com/optics/chromatic.html

Other aberrations

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



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



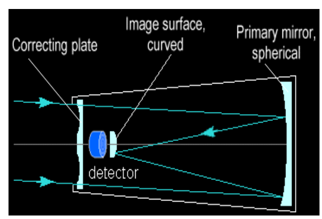
All the above (aberrations) can be corrected in theory, by careful optical design and/or the addition of correcting lenses. There is however a natural limit to the sharpness of an image ➔ diffraction（繞射）— spreading of light when it passes through an aperture — the smaller the aperture, the more the diffraction

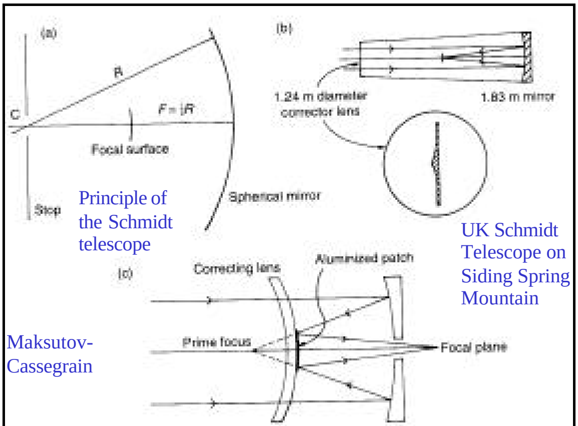
實務上，影像變形無法完全消除，一般望遠鏡有效視野限制在中央1度左右

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.





Principle of the Schmidt telescope

UK Schmidt Telescope on Siding Spring Mountain

Maksutov-Cassegrain

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
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

Ch 2, 6

- 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.