Introduction to equipment

Robin Scagell
SPA Vice President

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Types of telescope

- refractor (divided into achromatic and apochromatic)
- reflector (divided into Newtonian and Ritchey–Chrétien Cassegrain)
- catadioptric (divided into Maksutov and SCT)

Types of mounting

- Altazimuth (divided into basic, driven, Dobsonian, side arm, GoTo)
- Equatorial (divided into German, fork, manual, driven, Go To, harmonic)

Refractors

Easy to use and robust – stay in alignment

Provide high contrast images with good field of view

Less prone to internal thermal effects than reflectors so can be used quickly.

Can have awkward observing positions, hence use of star diagonal

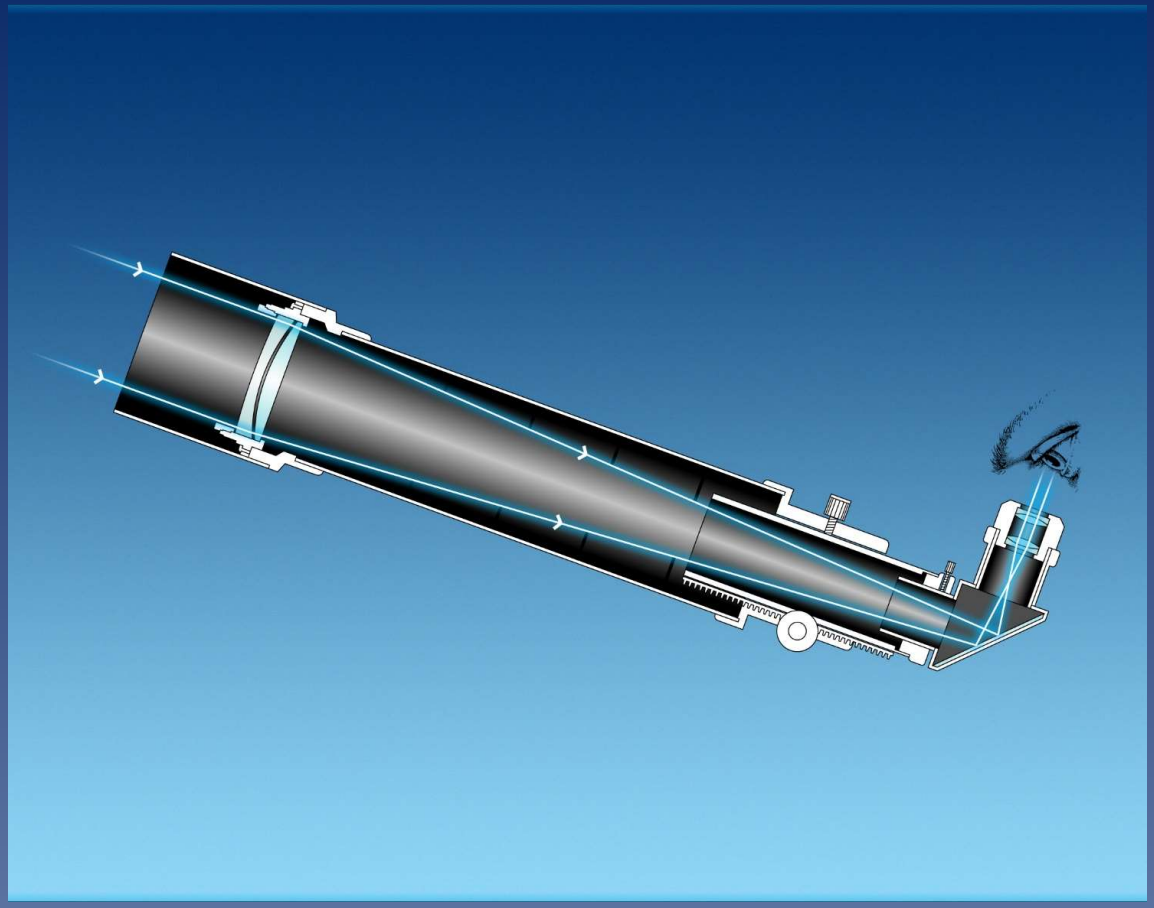
Expensive in large sizes

Achromatic refractors, despite their name, have false colour (chromatic aberration), noticeable when viewing high-contrast objects

Apochromatic, ED (extra low dispersion) or fluorite refractors are virtually free from chromatic aberration, but cost more.

For 120 mm (optical tube assembly, OTA, only)

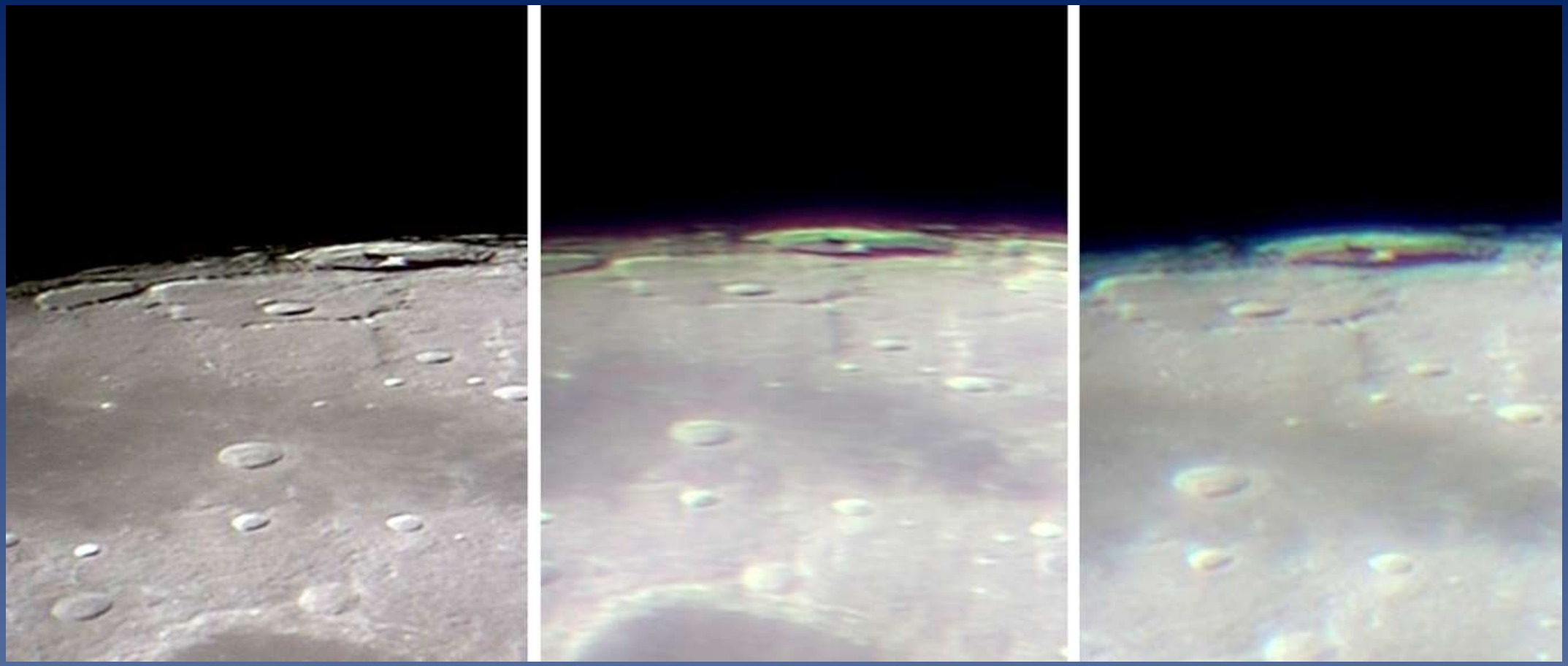
Achromatic £339, ED £1409, Apo £2669.



Refractors

‘Ordinary’ achromatic refractor suitable for visual use (Sky-Watcher Evostar 102 on EQ3-2 mount.) RRP £399.

Apochromatic refractor
Image credit: Mary McIntyre



Sky-Watcher 80 mm ED refractor

Unbranded 80 mm refractor

Bresser Skylux 70 mm refractor

Reflectors

Newtonians
Ritchey–Chrétiens

Free from chromatic aberration

Can be made any size, and large apertures are not excessively expensive

Good viewing position at side of tube

Rarely experience dewing up

Newtonian off-axis images may show coma

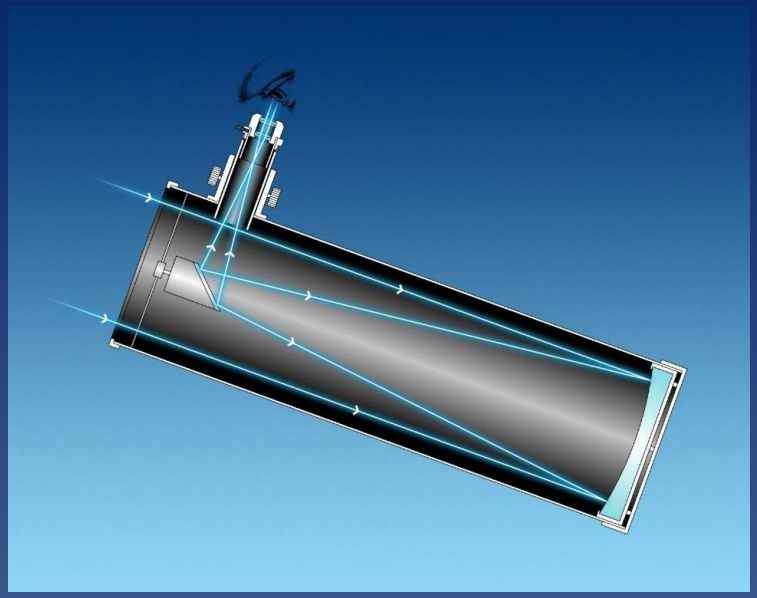
Mirror coatings deteriorate with age

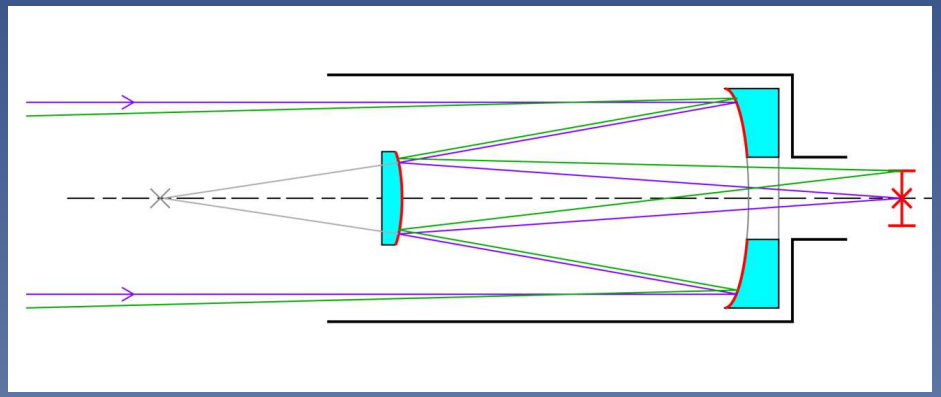
Light path more sensitive to misalignment (collimation) and tube currents

Reduced microcontrast due to central obstruction and diffraction effects

150 mm f/8 Newtonian on EQ3/2 mount £299

150 mm f/9 R-C tube only £459





Catadioptrics

Combine mirror and ‘lens’ to produce a compact tube with a long focal length: Schmidt–Cassegrains (SCT) typically f/10, Maksutovs typically f/14

Particularly suitable for planetary observing.

More expensive than a Newtonian of the same aperture

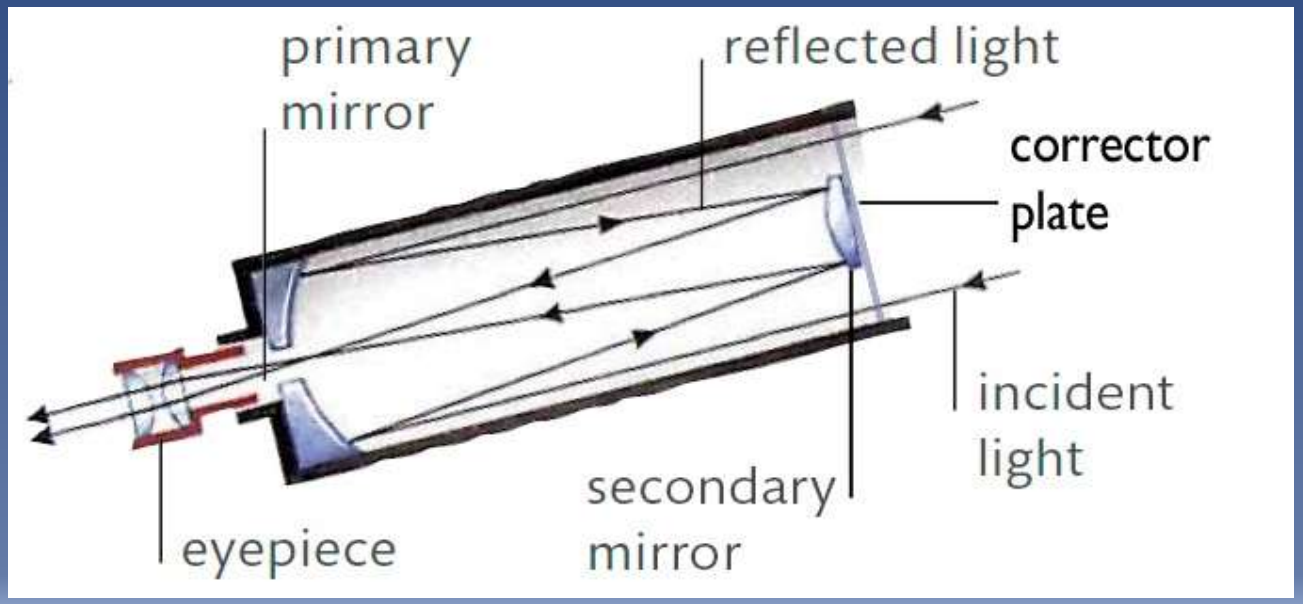
Prone to dewing up

Prone to thermal currents

Focused by moving main mirror which may cause focusing problems at high power.

127 mm f/12 Mak on GoTo £549

130 mm f/10 SCT on GoTo £999



Altazimuth mountings

Side-to-side and up-and-down

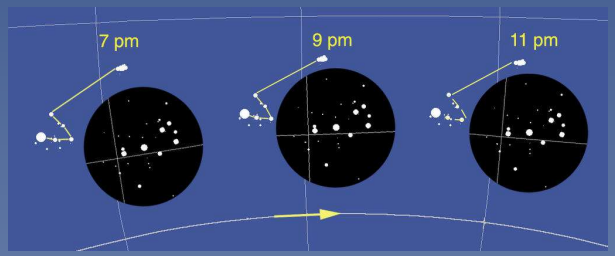
Potentially simple to use and stable, with no counterweights needed

Quick to set up

With computerised control can be made to track objects, although alignment needed.

Limited manual control

Even with driven computerised versions imaging exposures are limited to ~15 sec because of field rotation, although stacking is possible.



Sky-Watcher 102 mm refractor on AZ3 £258

Celestron NexStar130 on side-arm GoTo mount £509

Celestron CPC 800 £2599

Sky-Watcher 200P Dobsonian £369

Celestron StarSense Explorer LT70 £173

Sky-Watcher 130 (AZ-GTI) Wi-Fi GoTo £425

Equatorial mountings

Allow extended tracking of objects – particularly useful for long-exposure imaging

Complicated to set up and use for beginners

Require alignment on the sky (Pole Star) for every use

Most require a counterweight, which adds to the weight and convenience and may reduce stability

Types: German equatorial mount (GEM)

Centre-balanced

Fork

Vixen-type dovetail

Sky-Watcher Explorer 130M on driven EQ2 £259 (GEM)

Sky-Watcher Explorer 150PL EQ3 Pro GoTo £699 (GEM)

iOptron CEM26 centre-balanced (£1230, mount only)

Rainbow Astro RST-135 harmonic mount (£4095, mount only)

Celestron fork mount with wedge

Celestron CGX 925 EdgeHD On GEM (£5200 complete)

The visual view

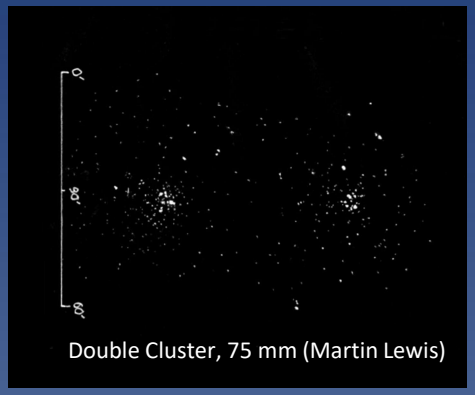
With small telescopes (70-80 mm) there is a lot of detail to be seen on the Moon and planets but you need to be patient – planetary views are lower contrast. Up to 75 or 100 x.

Larger telescopes give a brighter view and allow you to magnify more but seeing can the limiting factor.

Star clusters are high contrast so they look good with small telescopes. The larger the scope, the better resolved and brighter they are. Low powers often better than high ones.

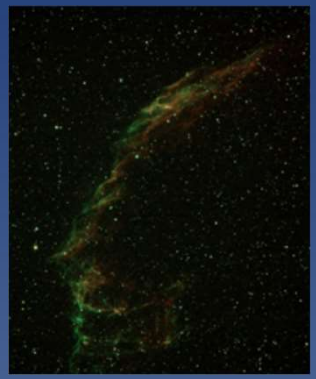
Deep-sky objects (galaxies, nebulae) are very pale through any size of scope. You only see obvious colour in planetary nebulae.

To see spiral arms in galaxies you need dark skies and large apertures, eg 300+ mm aperture.

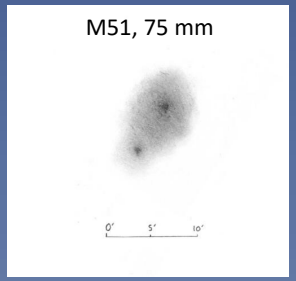


Double Cluster, 75 mm (Martin Lewis)

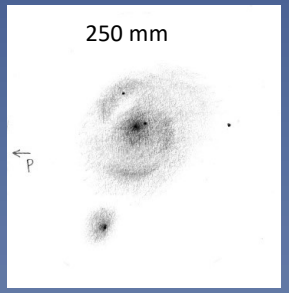
Veil Nebula, 130 mm + OIII filter (Robin Scagell)



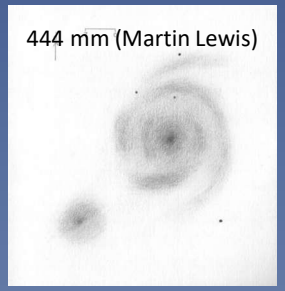
M51, 75 mm



250 mm



444 mm (Martin Lewis)



80 mm smart telescope

Smart telescopes

Automatic telescopes that set themselves up and plate-solve to align on the sky. Then take repeated short exposures or rotate the field. Controlled via smart phone or tablet. Unsuitable for planetary imaging

ZWO SeestarS50
50 mm refractor £539

Photos: Cath Adams, Jan Drozd

Unistellar eVscope Equinox
114 mm reflector £1760

Vaonis Vespera II 50 mm
£1400

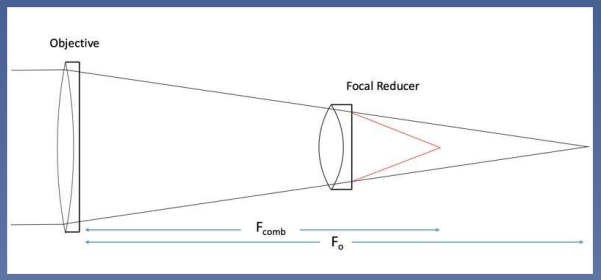
Focal length and aperture

Focal length is the distance between a lens and the image of a distant object.

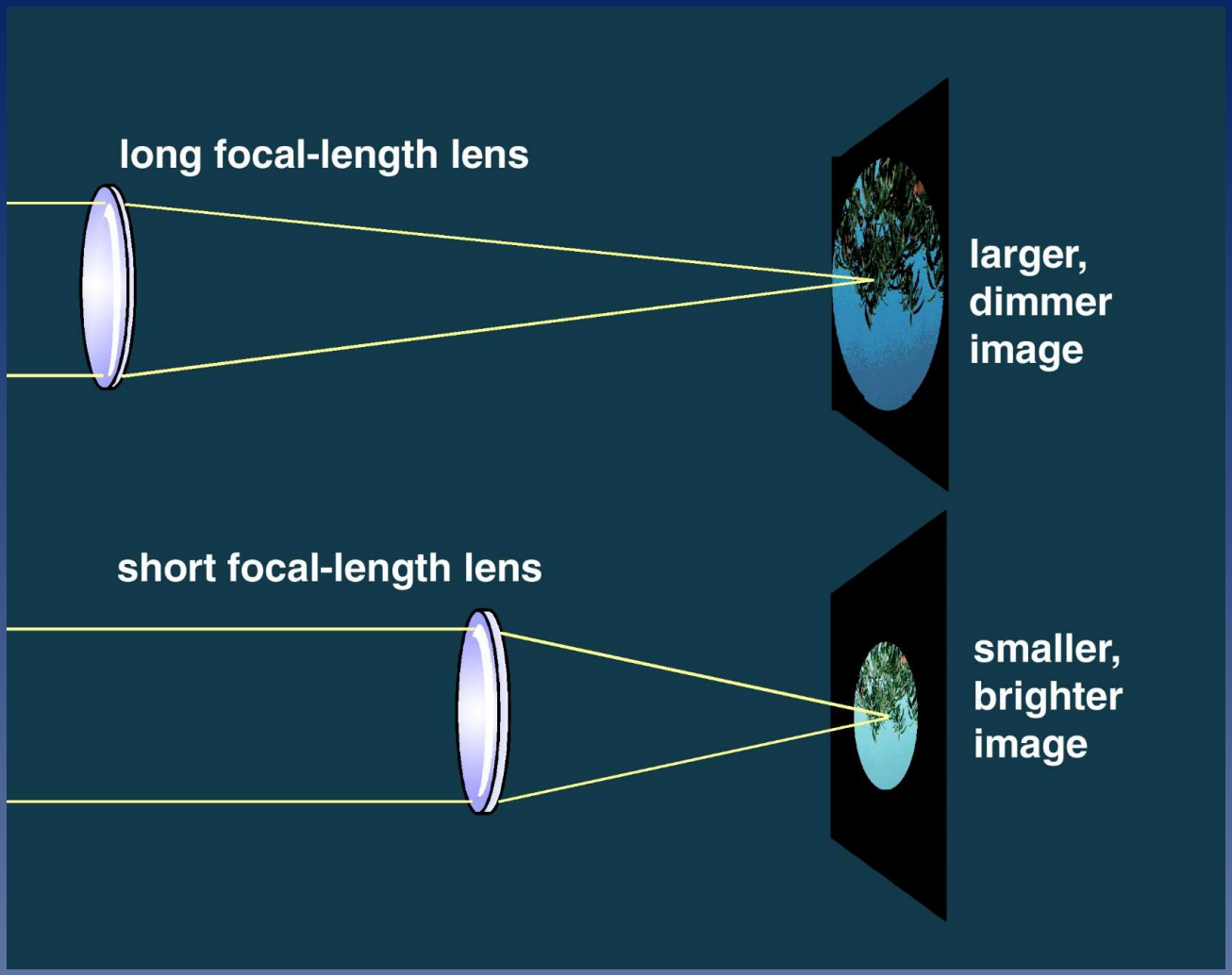
Two lenses of the same diameter (aperture) different focal length will give different images.

The larger the aperture the better the resolution of the telescope. Short focal lengths (shorter than f/5, say), however, are more difficult to manufacture to high quality.

Focal length may be altered using a focal reducer or a Barlow lens.



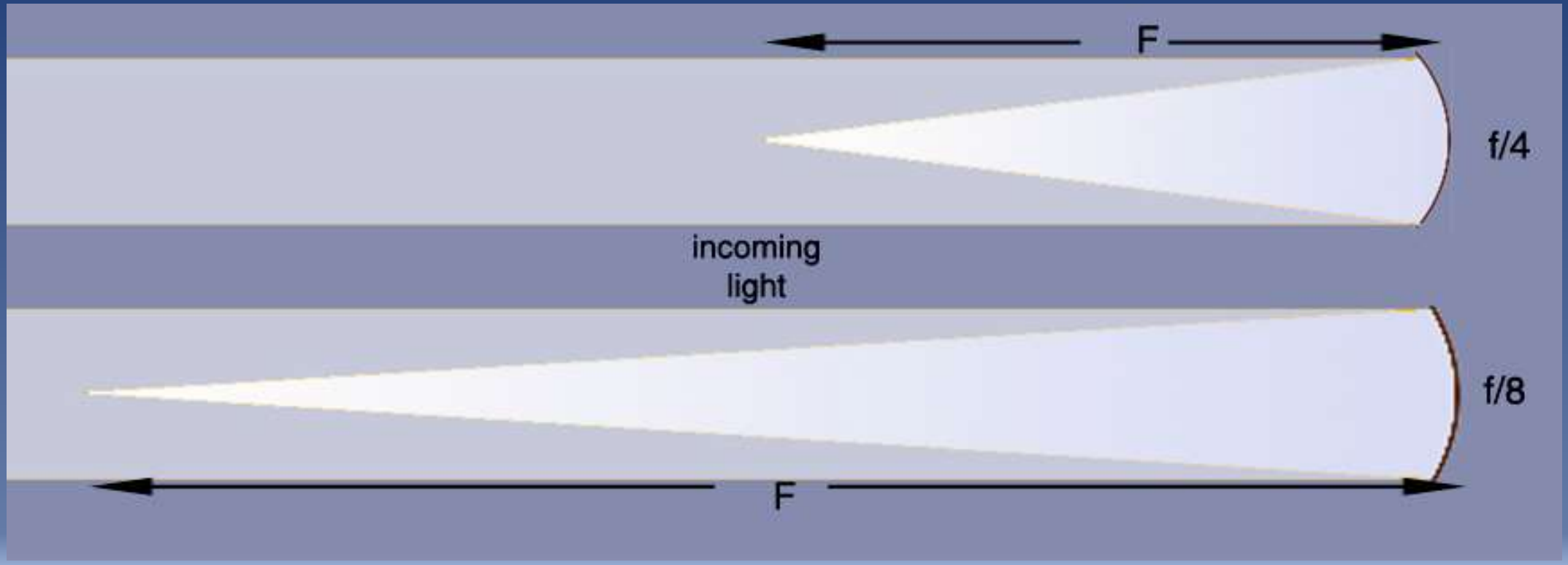
Credit: Agenaastro.com



The same applies to mirrors, as used in reflectors.

For both lenses and mirrors, the focal ratio, or f-number, is the ratio of the focal length to the aperture.

(Note that in photographic lenses, you can change the f-number of the lens by reducing its aperture using a diaphragm. The focal length stays the same, but the ratio changes)



Camera lens vs telescope

Camera lenses are designed for a specific camera mount and include a diaphragm to ‘stop down’ the lens (changing the f-number) to control depth of field and image quality, plus image stabilisation. Focusing by a ring.

Pentax 200 mm f/2.8 ED lens, £999

Telescopes can be adapted to suit any camera model, but have no diaphragm etc so have a fixed f-number and usually have a dovetail to fit a telescope mount. Can also be used with an eyepiece but you will probably need a star diagonal (additional) to reach focus.

Askar FMA180 f/4.5 180 mm telescope £415.

Limitations of telescopes for imaging

Chromatic aberration (CA) with achromatic refractors

Reflectors may need collimating (aligning optics with central axis of the instrument) – particularly noticeable with RC scopes

SCTs have mirror flop – very troublesome for planetary work

Coma – distorted images away from optical axis

Curved focal plane – requires field flattener

Need adapter to suit your camera

(NB – distinguish between Pentax M42, with 1 mm thread pitch, and T mount M42, with 0.75 mm thread pitch)

Limited focusing range on refractors and reflectors (but not usually SCTs) means that you usually need extension tubes to reach the focusing point. Some budget telescopes, such as the basic SW 130 reflector, can't easily be used with a camera

The location of sensor focal plane behind lens mount of a DSLR is ~ 55 mm. But the back focus of a telescope (the location of the focal point from the focuser) may not allow you to reach this with your camera

Field flatteners and focal reducers may cause problems with back focus – check with the supplier before buying.

Types of camera

Phone cameras: Now increasingly sensitive but have limitation of requiring you to photograph through the eyepiece of the telescope. None or limited range of optical zoom.

Compact/bridge cameras: More versatile, and have optical zoom. Often limited exposure and focus options.

DSLR: Versatile, can be used on telescope with adapter, and in some cases with astro filters using filter clip. No cooling, usually heavier than astro-cameras. Available in APS sensor and full-frame.

Mirrorless: same as DSLR but use digital rather than optical viewfinder – has benefits. DSLR and mirrorless can be used tethered to laptop.

Astro-camera: Available in one-shot colour (OSC) or mono. Most CMOS, not CCD. Wide range available for planetary and deep-sky imaging, allowing great versatility for use with narrowband filters.

iPhone 11: £439

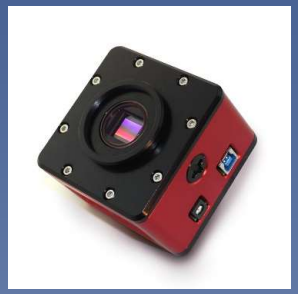
Lumix TZ-80: £289

Canon SX70: £579

Canon 250D: £829

Sony a7 III: £1699

ZWO ASI120MC-S planetary camera: £169



Atik ACIS 2.4 Colour CMOS deep-sky camera: £1395