AQA A-Level Physics

9.1 Telescopes

Flashcards

What is the axis of symmetry called?

What is the axis of symmetry called?

The principal axis

What is the principal focus?

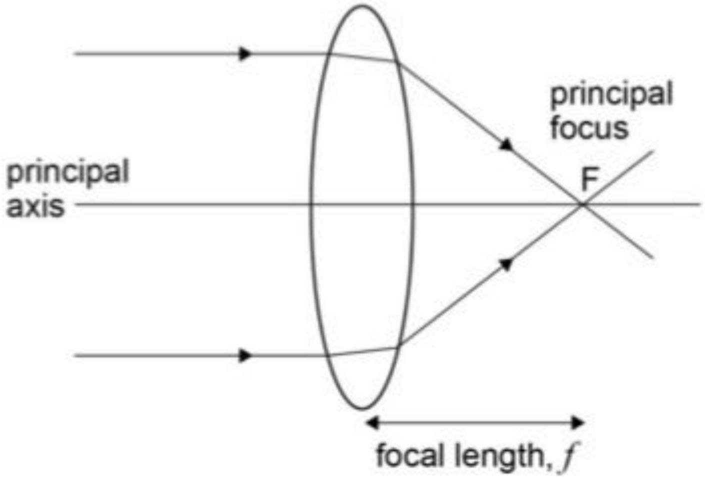
What is the principal focus?

A point on the axis which is the same distance from the optical centre as the focal length. This is where light rays travelling parallel to the principal axis prior to refraction converge.

Define focal length

Define focal length.

The distance between the centre of the lens and the principle focus



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What does ‘u’ represent in lens diagrams and equations?

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The distance between the object and the centre of the lens, u is always positive

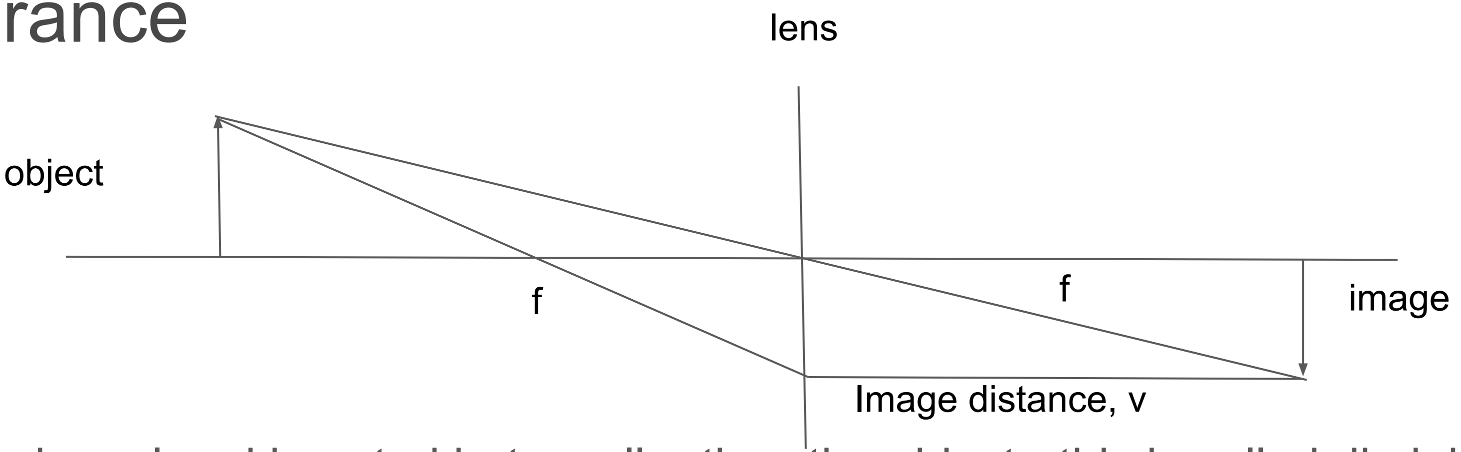
What does ‘v’ represent in lens diagrams and equations?

What does ‘v’ represent in lens diagrams and equations?

The distance between the image and the centre of the lens, v is positive for real images and negative for virtual images

Draw the ray diagram for an object that is a long way from the lens (beyond 2F) and describe the image's appearance

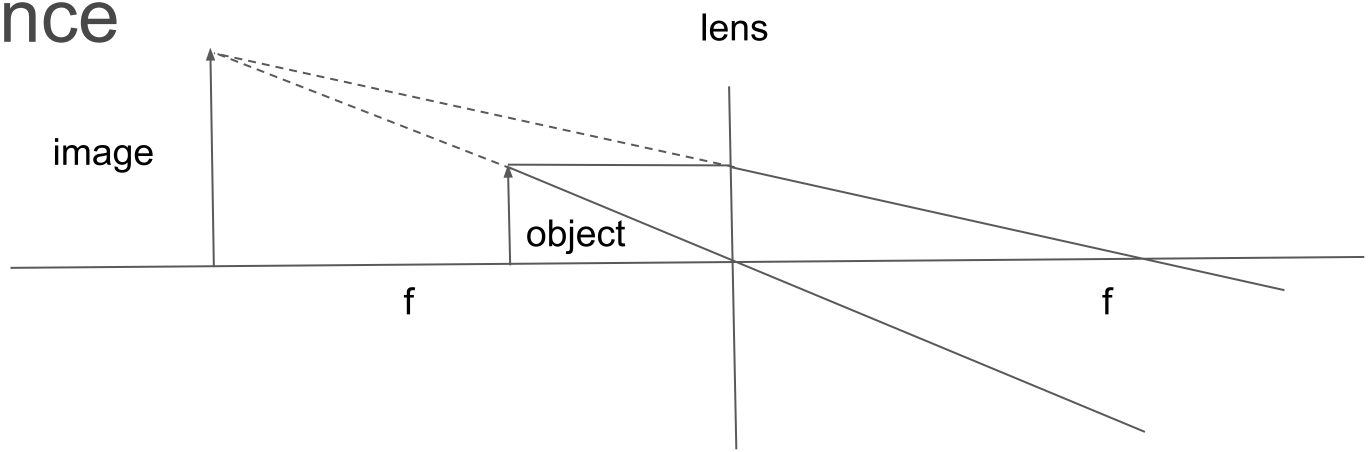
Draw the ray diagram for an object that is a long way from the lens (beyond 2F) and describe the image's appearance



The image is real and inverted but smaller than the object - this is called diminished

Draw the ray diagram for an object that is very close to the lens and describe the image’s appearance

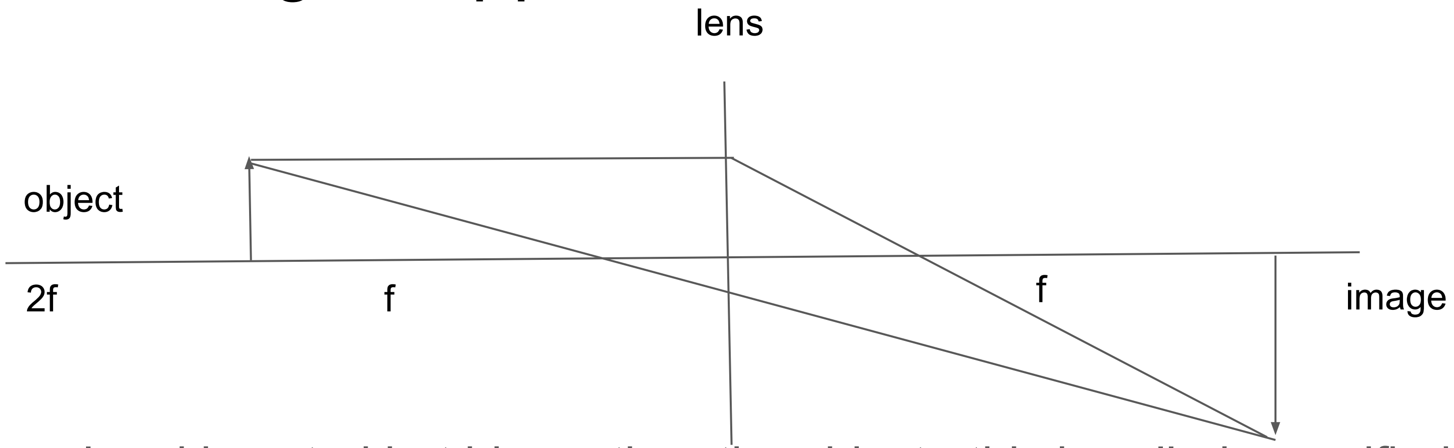
Draw the ray diagram for an object that is really close to the lens and describe the image's appearance



The image is virtual and upright but bigger than the object - this is called magnified

Draw the ray diagram for an object that is fairly close to the lens (Between f and 2f) to the lens and describe the image’s appearance

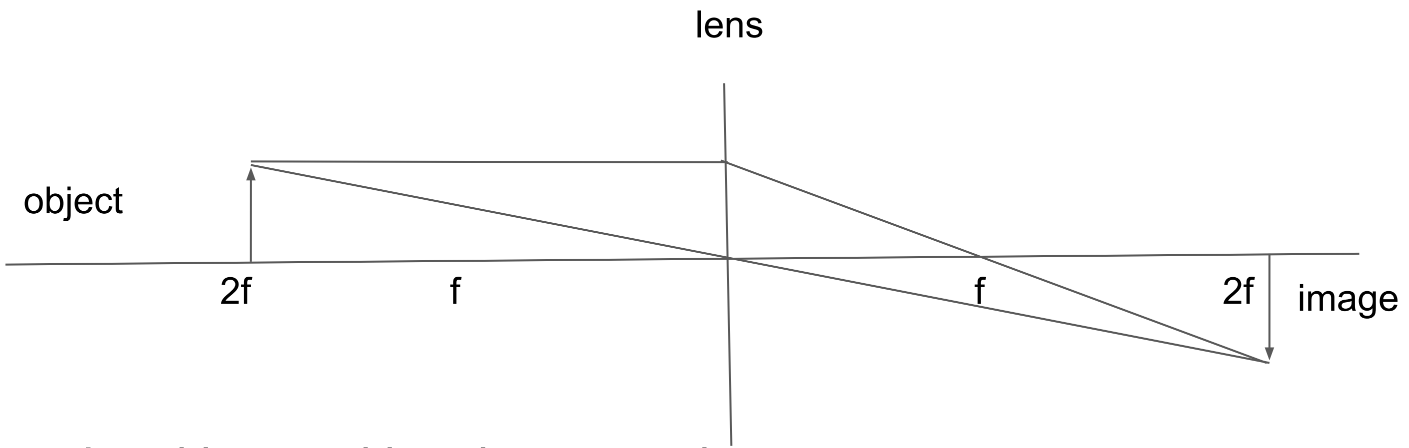
Draw the ray diagram for an object that is fairly close to the lens (Between f and 2f) to the lens and describe the image's appearance



The image is real and inverted but bigger than the object - this is called magnified

Draw the ray diagram for an object that is at 2f and describe the image's appearance

Draw the ray diagram for an object that is at 2f and describe the image's appearance



The image is real and inverted but the same size

What does normal adjustment in a telescope look like?

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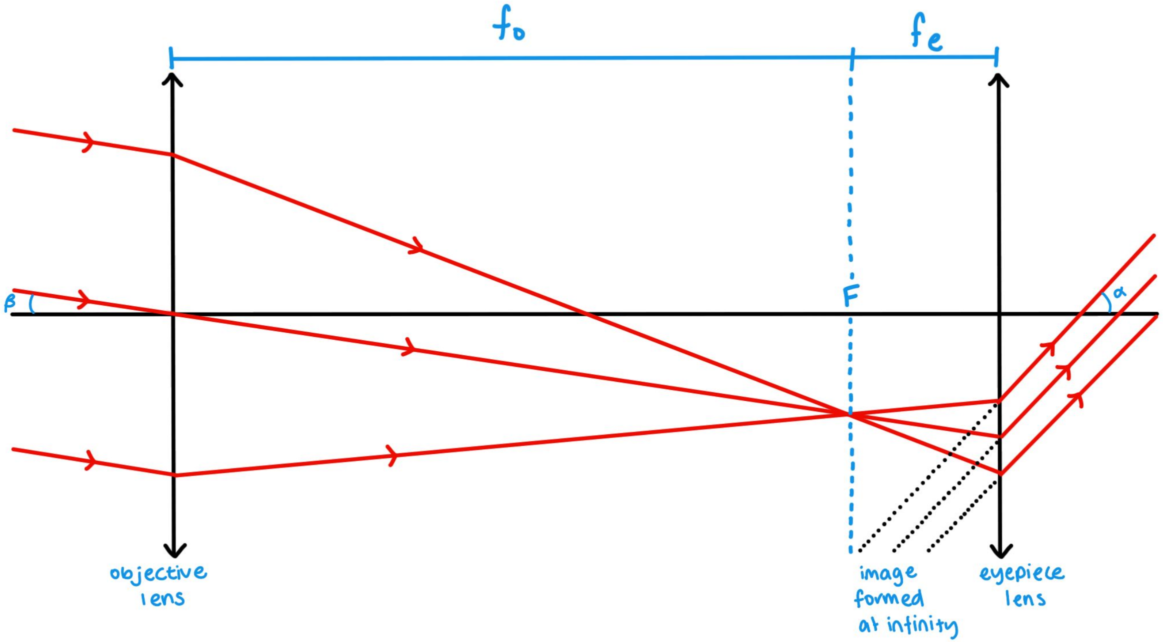
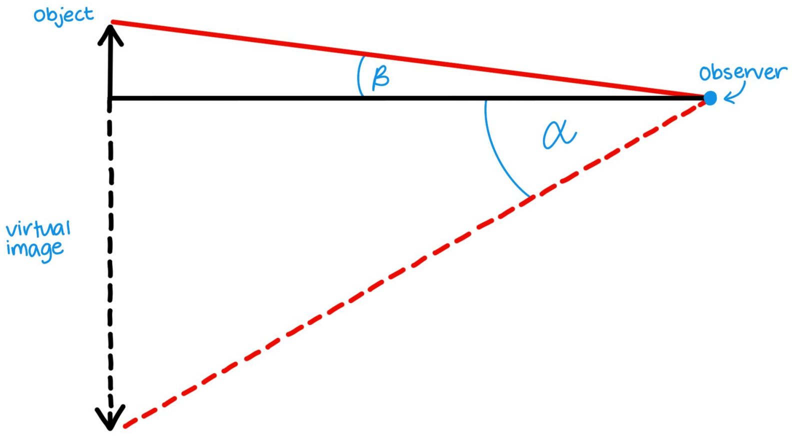


Give the formula for angular magnification in normal adjustment

Give the formula for angular magnification in normal adjustment

M = angle subtended by image at eye ÷ angle subtended by object at unaided eye

Can also be written as M = α / β



State the equation that relates M to the focal length for objective and eyepiece lenses

State the equation that relates M to the focal length for objective and eyepiece lenses

$M = f_o / f_e$

This can only be used if both angles from $M = \alpha / \beta$ are less than 10°

How does an astronomical refracting telescope work?

How does an astronomical refracting telescope work?

There are two converging lenses, the objective lens and the eyepiece lens. The role of the objective lens is to collect light and create a real image of a distant object. This image is then magnified by the eyepiece lens, which produces a virtual image (formed at infinity so as to reduce eye strain when looking between the object and the telescope image).

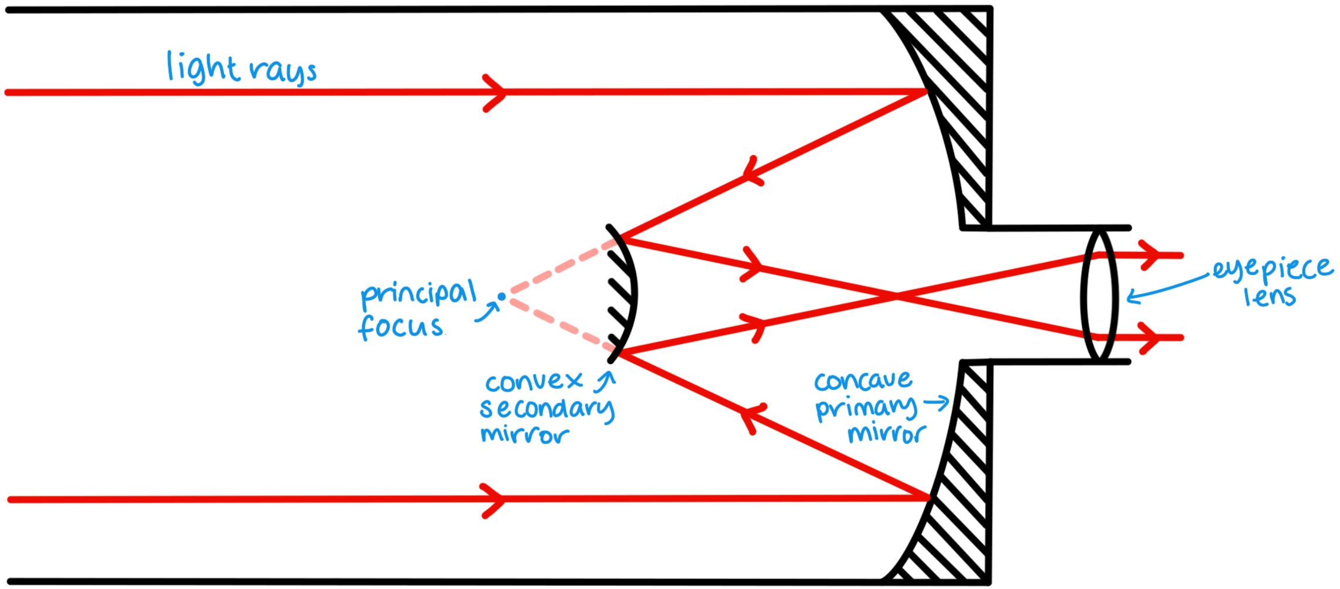
How does a cassegrain telescope work?

How does a cassegrain telescope work?

There is a concave primary mirror with a long focal length and a small convex secondary mirror in the centre. The light is collected by the primary mirror and focused onto the secondary mirror, which then reflects it onto an eyepiece lens.

What does the Cassegrain configuration look like?

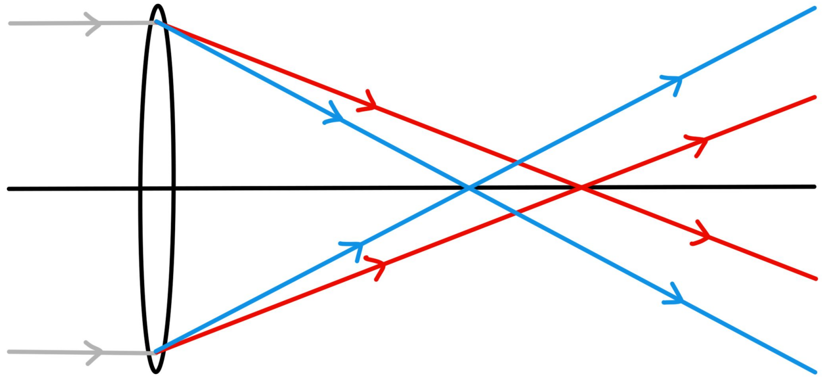
What does the Cassegrain configuration look like?



What is chromatic aberration?

What is chromatic aberration?

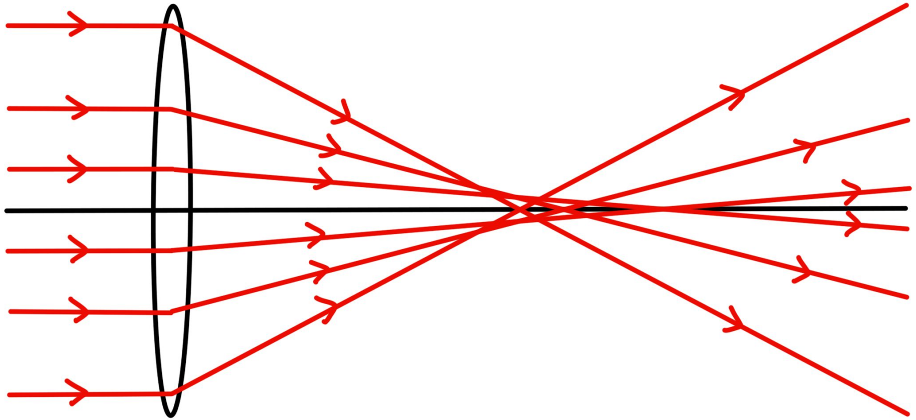
When a lens refracts different colours of light by different amounts as they have different wavelengths. This causes the image for each colour to form in a slightly different position, causing coloured fringes around the image



What is spherical aberration?

What is spherical aberration?

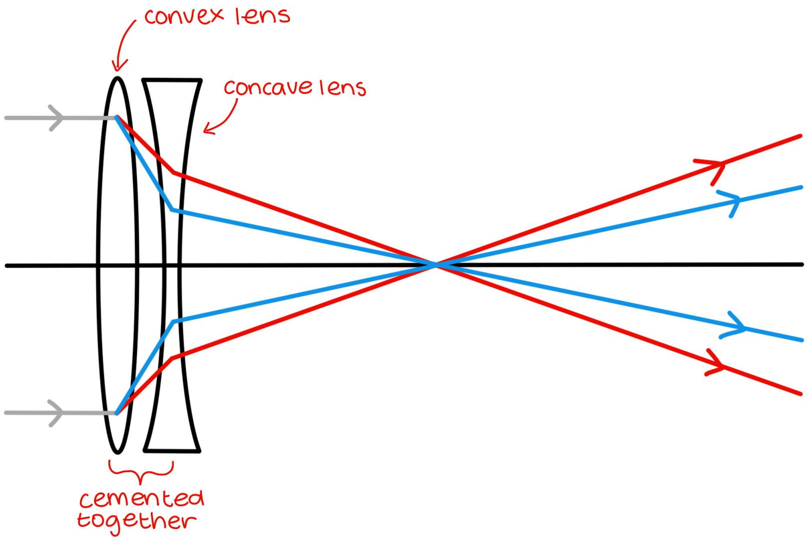
When light is focused in different places due to the curvature of a lens or mirror, causing image blurring. This can be resolved in reflecting telescopes by using a parabolic mirror.



Describe a solution to chromatic and spherical aberration in lenses.

Describe a solution to chromatic and spherical aberration in lenses.

Using an achromatic doublet brings all rays of light into focus in the same position by using a convex lens and a concave lens of different types of glass cemented together.



State 3 advantages of reflecting telescopes

State 3 advantages of reflecting telescopes

- There is very little chromatic aberration (only in the eyepiece lens, but this can be resolved by using an achromatic doublet)
- Simpler to increase the size of the objective since mirrors can be supported from behind and are lighter than lenses
- Using parabolic mirrors stops spherical aberration

What happens when you increase the size of the objective lens/mirror?

What happens when you increase the size of the objective lens/mirror?

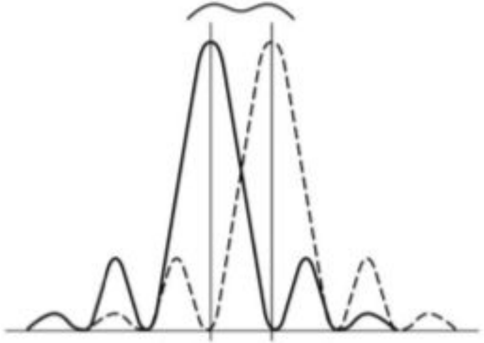
Increasing the diameter of the objective means you can observe fainter objects. This is because collecting power is proportional to $(\text{objective diameter})^2$.

Define the Rayleigh Criterion

Define the Rayleigh Criterion

‘Two objects will be just resolved if the centre of the diffraction pattern of one image coincides with the first minimum of the other’.

$$\theta \approx \frac{\lambda}{D}$$



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Explain the structure, positioning and uses of a single dish radio telescope

Explain the structure, positioning and uses of a single dish radio telescope.

Structure: Large parabolic dish that focuses radiation onto a receiver

Positioning: can be ground-based but must be in isolated locations

Uses: observing things such as galaxies, stars and black holes

Why do radio telescopes need to be larger than optical telescopes?

Why do radio telescopes need to be larger than optical telescopes?

Since radio waves have a much larger wavelength than visible light, in order to achieve the same resolving power as an optical telescope, the objective diameter must be much larger in accordance with $\theta \approx \lambda/D$.

Explain the structure, positioning and uses of an infrared telescope

Explain the structure, positioning and uses of an infrared telescope

Structure: Large concave mirror focusing light onto a detector. Must be cooled with cryogenic fluids to avoid interference.

Positioning: Must be in space as infrared light is blocked by the atmosphere

Uses: observing cooler regions in space (from a few tens to 100K)

Explain the structure, positioning and uses of an ultraviolet telescope

Explain the structure, positioning and uses of an ultraviolet telescope

Structure: Cassegrain configuration that focuses radiation onto solid state devices

Positioning: Must be in space as ultraviolet light is blocked by the ozone layer

Uses: observing the interstellar medium and star formation regions

Explain the structure, positioning and uses of an x-ray telescope

Explain the structure, positioning and uses of an x-ray telescope

Structure: combination of hyperbolic and parabolic mirrors to focus radiation onto a CCD

Positioning: Must be in space as x-rays are blocked by the atmosphere

Uses: observing high-energy events and areas such as active galaxies, black holes and neutron stars

Explain the structure, positioning and uses of a gamma telescope

Explain the structure, positioning and uses of a gamma telescope

Structure: no mirrors. Radiation passes through a detector made of layers of pixels.

Positioning: Must be in space as gamma rays are blocked by the atmosphere

Uses: observing gamma ray bursts, quasars, black holes and solar flares

What is a CCD and how does it work? *(not in AQA specification)*

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What is a CCD and how does it work?

CCDs (charge-coupled devices) are silicon chips divided into pixels, when a photon is incident on a pixel, electrons are released from the silicon atoms via the photoelectric effect, the electrons are confined to the pixel so it accumulates charge, the position and magnitude of which is used to create a digital image.

Compare the quantum efficiency of a CCD to the eye

Compare the quantum efficiency of a CCD to the eye

Quantum efficiency: the percentage of incident photons that liberate an electron in the photoelectric effect. This can be upwards of 80% for a CCD, compared to 4-5% for the human eye.

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Compare the resolution of a CCD to the eye

Compare the resolution of a CCD to the eye

CCDs have a spatial resolution of 10 micrometres, the minimum resolvable distance for the human eye is around 100 micrometres so CCDs are better for capturing fine detail.

Spatial resolution is how far apart 2 objects need to be to distinguish them.

Compare the convenience of a CCD to the eye

Compare the convenience of a CCD to the eye

The CCD is more convenient for accessing data remotely (like retrieving data from space telescopes such as Hubble). It is easier to analyse CCD data on computers, and CCDs have a wider spectral range, allowing them to perceive wavelengths that cannot be detected by the human eye. That being said, looking down a telescope is not an inconvenient task.