PHY2208 Lecture 3

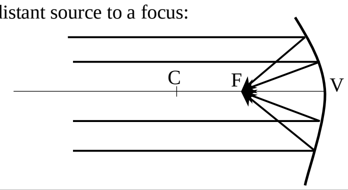
- Focal point and focal length
- Magnification by the spherical mirror
- Graphical ray tracing
- Telescope designs

(Y&F p. 1091-1093 and Section 35-4)

Object image relationship: $\frac{1}{s}+\frac{1}{s'}=\frac{2}{R}$

Clearly as $s \rightarrow \infty \quad s' \rightarrow R/2$

In this geometry, the mirror brings parallel ('collimated') rays from a distant source to a focus:



The point F (distance *R/2* from V) is the **focal point** of the mirror.

The distance *R/2* is the **focal length** of the mirror, symbol '*f*'.

Hence

$$\frac{1}{s}+\frac{1}{s'}=\frac{1}{f}$$

This is called the **'Gaussian mirror equation'**, and also applies to lenses – see later.

Graphical ray tracing

Consider an extended object of height *y*. We can use a graphical technique to determine *y'* (the image height).

To do this we locate the image of the tip of the object by finding the intersection of **any two rays** emanating from it which are reflected from the mirror. Four rays are especially Easy to draw:

1) The ray which passes through C will be reflected back through C.

2) The ray that strikes V is reflected symmetrically about the optic axis.

3) Any ray entering the mirror parallel to the optic axis is reflected so as to pass though F.

4) Any ray entering the mirror via F is reflected so as to emerge travelling parallel to the optic axis.

NB we may need to extrapolate ray paths to a point **beyond** the mirror to find an intersection point. This is a **virtual image** (recall the plane mirror example).

$$m=\frac{y'}{y}=-\frac{s'}{s}$$

Image magnification formula for a spherical mirror

NB –ve sign because image is **inverted**. Also **real** and **minified**.

Telescope designs

Telecopes can either be **refracting** (the objective is a lens) or **reflecting** (the objective is a mirror)

This simple refracting astronomical telescope has $M = -\frac{f_o}{f_e}$

The f-ratio and the plate scale

The **f-ratio** (which is a unitless quantity) is defined as the ratio of the effective focal length of the telescope (*F*) divided by its diameter (*D*):

$$f/\# = \frac{F}{D}$$

The plate scale of a telescope is the number of degrees, arcminutes, or arcseconds per unit distance in the focal plane of a telescope. It is usually quote in arcseconds per mm:

$$\text{platescale} = \frac{206265}{f/\# \times D}$$

where *D* is in mm. (One radian = 206265 arcseconds)

The Newtonian Design

The magnification of this telescope is once again $M = -\frac{f_p}{f_s}$

The parabolic mirror avoids **chromatic aberration** (see Lecture 5), and **spherical aberration** (Lecture 2).

The Cassegrain Design

The principle advantage of the Cassegrain design is the beam-spreading qualities of the secondary mirror, which means that the effective focal length is several times that of the primary mirror (good plate scale, good image quality of a large field-of-view) This allows for **compact**, **easily-engineered** (and cheap!) large telescopes. Most of the world's largest telescopes employ the Cassegrain design.