PHY105 Answers 4

1. At a particular time, a certain star has an altitude of 45° 29' and an azimuth of 180° when observed from Sheffield (latitude 53° 23' N). Calculate the azimuths at which the star rises and sets. [5]
[Hint: find the star's distance from the North Celestial Pole, its *co-declination*. This is constant at all times. Also note that the star's motion is symmetrical, so once you have calculated one azimuth by spherical trigonometry you should be able to derive the other without further trig.]

Since altitude of NCP is latitude of observer, we know that the angle between the NCP and the zenith is 90° − this, or 36° 37'. Therefore the distance of the star from the NCP at azimuth 180° (i.e. when it is directly opposite the NCP, on the observer's meridian) is the star's distance from the zenith, 44° 31', plus 36° 37', or 81° 08'. [1]

Draw celestial sphere:
spherical triangle with star X setting has PX = 81° 08', PZ = 36° 37', and ZX = 90°. [1½]

Use cosine rule to calculate angle Z: cos PX = cos PZ cos ZX + sin PZ sin ZX cos Z = sin PZ cos Z as ZX = 90°. Hence Z = 75° 01'. [1]

As this is measured westwards from north, whereas azimuth is measured eastward from north, the azimuth of the star when it sets is actually 284° 59'. [½]

By symmetry, the rising azimuth is 360° − the setting azimuth, or 75° 01'. [1]

2. The star γ Draconis (Eltanin) was studied intensively in the 18th century because it happens to pass very nearly overhead in London (latitude 51° 29' N). Calculate the *minimum* altitude reached by γ Dra as seen from London. [2]

Draw celestial sphere, and deduce that star must have codeclination 38° 31'. [1]

It maintains this distance from the pole, so at its lowest point its altitude is the pole's altitude, 51° 29', minus this distance, i.e. 12° 58'. [1]

3. Walking home on September 29, I happened to notice that the nearly full Moon was very close to a bright "star". On looking this up, I discovered that the "star" was the planet Jupiter. The altitude and azimuth of Jupiter at the time (8 pm) were 16° 00' and 152° 04' respectively, and the altitude and azimuth of the Moon were 17° 45' and 153° 54'. How far apart, in degrees, were the Moon and Jupiter? [3]

This is the same calculation they've been doing with latitude and longitude. On celestial sphere, the spherical triangle has ZM = 82° 15', ZJ = 84° 00', and angle Z = 1° 50'. [1½]

Cosine formula gives cos MJ = cos ZM cos ZJ + sin ZM sin ZJ cos Z, [1]

so MJ = 2° 31'. [½]

4. An amateur astronomer wishing to buy a "starter" telescope to make visual observations of the Moon and planets would probably be advised by a reputable dealer to buy an achromatic refractor, for example the 80 mm $f/10$ telescope we have considered in previous problems. On the other hand, research telescopes are all, without exception, reflectors. Explain why the small refractor is a better choice than a reflector for the beginner, and why (in contrast) it is better to use reflectors when a large telescope is desired. [5]

Visual observations of the Moon and planets don't require a particularly large telescope. Indeed, for the Moon in particular, the larger field of view given by a small telescope is desirable; it also makes it easier to find objects. [1]

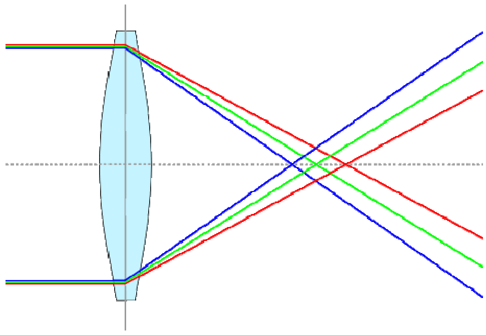
Given that you are going to buy a small telescope, a refractor is much easier to set up and requires less maintenance than a reflector. [1]

Research telescopes, in contrast, are large, and are used photographically. Therefore you want a reflector, because:

- *large mirrors are easier to make than large lenses (they can be segmented, and don't need to be perfectly transparent)* [1]
- *they are also much easier to support (because the light doesn't have to go through, they can be supported across the entire back face instead of just at the edges)* [1]
- *and of course they do not suffer from chromatic aberration.* [1]

5. Explain the following terms as they apply to astronomical telescopes, illustrating your answers with appropriate diagrams:

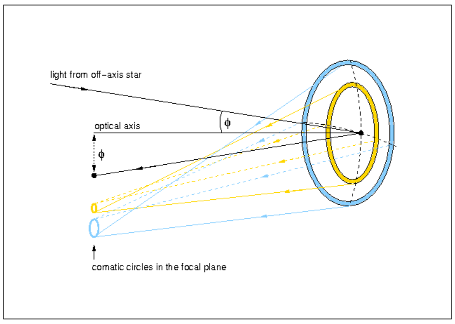
- chromatic aberration; [2]
  variation of focal length with wavelength, and hence presence of coloured haloes around images [1]



[1]

- coma; [2]

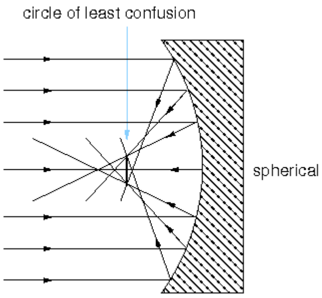
  elongated blur directed away from axis of lens/mirror, caused by failure to bring off-axis rays to a well-defined focus [1]



[1]

- spherical aberration; [2]

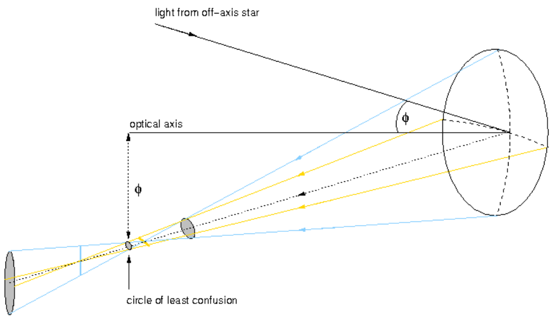
  blurred image caused by using spherical rather than parabolic figure for mirror [1]



[1]

- astigmatism; [2]

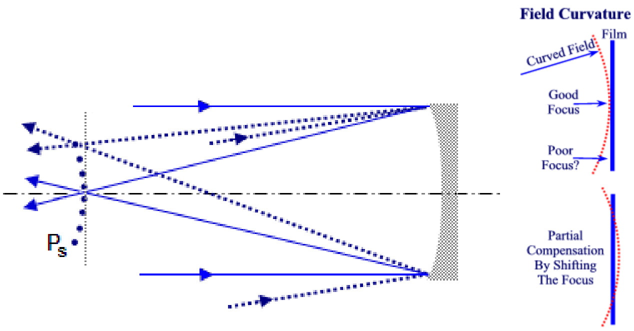
  elliptical image shape for off-axis sources, caused by fact that off-axis rays get focused to a line rather than a point [1]



[1]

- curvature of field. [2]

  as name suggests, telescope design in which focal "plane" is a curved surface, resulting in poor focus for objects at the edge of the field of view [1]



[1]