14.16 Resolving power of a telescope

The purpose of a telescope is to see distant objects distinctly. The details that the device can provide *depends on the angle* subtended at the objective by two distant, close point-objects and *not on* their *linear separation.*

The **resolving power** *of a telescope is defined as the reciprocal of the smallest angle subtended at its objective by two distant close point-objects that can be* **just** *recognised as separate ones by the telescope.*

Expression for resolving power—Let AB be the objective of the telescope (Fig. 14.26) of diameter D and O_1, O_2 (not shown) be two distant close point-objects (say, two stars) from which parallel rays show an angular separation $d\theta$ at the objective. The objective (with supporting ring) acts as a *circular aperture* and *forms* Fraunhofer diffraction pattern as images of O_1 and O_2. Let P_1 and P_2 be the positions of the central maxima of the images. The patterns may be too close to distinguish them as separate. But by Rayleigh's criterion, the patterns would be *just resolved* if the central maximum of one falls on the first minimum of the other.

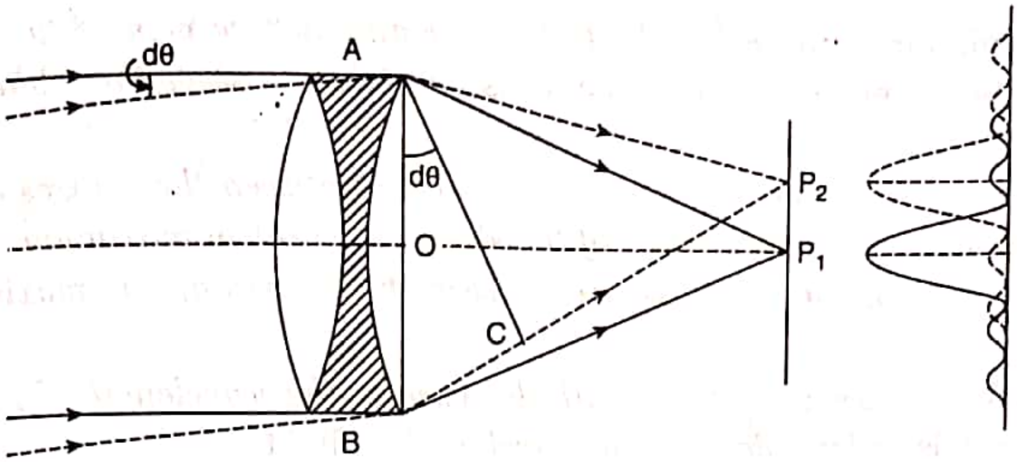

Fig. 14.26
Resolving power of a telescope

Now, the secondary wavelets travelling along AP_2 and BP_2 meet at P_2 and have a path-difference :

$$\Delta = BP_2 - AP_2 = BC$$
$$= AB \sin d\theta = AB \cdot d\theta = D \cdot d\theta$$
$$(\because \text{ angle } \theta \text{ is small})$$

If this $\Delta = \lambda$, then P_2 corresponds to the *first minimum* of the first image. So, for obtaining the ***just resolution***, we should have

$$D \cdot d\theta = \lambda \Rightarrow d\theta = \lambda / D \tag{14.16.1}$$

The condition holds for a *rectangular aperture*. For a ***circular aperature***, Airy modifies the condition to

$$\boxed{d\theta = \frac{1.22\lambda}{D}} \tag{14.16.2}$$

where $d\theta$ = the minimum resolvable angle between the two distant point-objects. So $d\theta$ = the ***limit of resolution***.

$$\therefore \textit{Resolving power} = \frac{1}{d\theta} = \frac{D}{1.22\lambda} \tag{14.16.3}$$

The expression for the ***resolving power*** of a telescope shows that

1. A telescope with a *larger diameter of the objective* has a *higher resolving power* and conversely.

2. The *smaller the wavelength* of the light, *higher* will be *the resolving power*.

• That P_2 corresponds to the first minimum may also be understood physically. Divide the whole wavefront AB into *two* halves, AO and OB. The path-difference between the secondary waves from the corresponding points in the above two halves is $\lambda/2$. So, all the secondary waves from the two halves will interfere *destructively*. P_2 thus corresponds to the *first minimum* of the *first image*.

Magnifying power *vs.* resolving power—The *magnifying power* of a telescope should be carefully distinguished from its *resolving power*. The following features are worth-noting.

1. The magnifying power is its *ability to show an enlarged view of the object* to the eye; the resolving power, on the other hand, is its *ability to show the amount of details* or grains in the object.

2. The magnifying power *increases with distance between the centres of diffraction pattern* of two points but gives *no idea of the size of the central maximum*; the resolving power provides ideas of *both the distance between the centres of two maxima and their width.*

3. The resolving power *increases with decrease of the wavelength* of light. But the magnifying power is *independent of the wavelength* of light.

4. The magnifying power of a telescope is given by F/f, i.e., the ratio of the focal length of the objective to that of the eyepiece. *Two telescopes of the same dia for the objective* will give *different magnifying powers* (as focal length can be different), but the *same resolving power for a given wavelength* since the resolving power is given by the ratio D/λ.