4.3 ASTRONOMICAL SURVEYING

Celestial Sphere.

The millions of stars that we see in the sky on a clear cloudless night are all at varying distances from us. Since we are concerned with their relative distance rather than their actual distance from the observer. It is exceedingly convenient to picture the stars as distributed over the surface of an imaginary spherical sky having its center at the position of the observer. This imaginary sphere on which the star appears to lie or to be studded is known as the celestial sphere. The radius of the celestial sphere may be of any value - from a few thousand metres to a few thousand kilometers. Since the stars are very distant from us, the center of the earth may be taken as the center of the celestial sphere.

Zenith, Nadir and Celestial Horizon.

The Zenith (Z) is the point on the upper portion of the celestial sphere marked by plumb line above the observer. It is thus the point on the celestial sphere immediately above the observer's station.

The Nadir (Z') is the point on the lower portion of the celestial sphere marked by the plum line below the observer. It is thus the point on the celestial sphere vertically below the observer's station. Celestial Horizon. (True or Rational horizon or geocentric horizon): It is the great circle traced upon the celestial sphere by that plane which is perpendicular to the Zenith-Nadir line, and which passes through the center of the earth. (Great circle is a section of a sphere when the cutting plane passes through the center of the sphere).

Terrestrial Poles and Equator, Celestial Poles and Equator.

The terrestrial poles are the two points in which the earth's axis of rotation meets the earth's sphere. The terrestrial equator is the great circle of the earth, the plane of which is at right angles to the axis of rotation. The two poles are equidistant from it. If the earth's axis of rotation is produced indefinitely, it will meet the celestial sphere in two points called the north and south celestial poles (P and P'). The celestial equator is the great circle of the celestial sphere in which it is intersected by the plane of terrestrial equator.

1 CO-ALTITUDE OR ZENITH DISTANCE (Z) AND AZIMUTH (A).

It is the angular distance of heavenly body from the zenith. It is the complement or the altitude, i.e. $z = (90^o - \theta)$.

The azimuth of a heavenly body is the angle between the observer's meridian and the vertical circle passing through the body.

Determine the hour angle and declination of a star from the following data:

(i) Altitude of the star = 22 º 36'

(ii) Azimuth of the star = 42 º W

(iii) Latitude of the place of observation = 40 º N.

Solution.

Since the azimuth of the star is 42 º W, the star is in the western hemi-sphere.

In the astronomical DPZM, we have

PZ = co-latitude = 90 º - 40 º = 50 º

ZM = co-altitude = 90 º - 22 º 36' = 67º 24' ; angle A = 42 º

Knowing the two sides and the included angle, the third side can be calculated from the cosine formula

Thus, cos PM = cos PZ . cos ZM + sin PZ. Sin ZM. cos A

= cos 50 º . cos 67 º 24' + sin 50 º . sin 67 º 24'. cos 42 º

= 0.24702 + 0.52556 = 0.77258

PM = 39 º 25'

Declination of the star = d= 90 º - PM = 90 º - 39 º 25' = **50 º 35' N.**

Similarly, knowing all the three sides, the hour angle H can be calculated from Eq. 1.2

$$\cos H = \frac{\cos ZM - \cos PZ.\cos PM}{\sin PZ.\sin PM} = \frac{\cos 67°24' - \cos 50°.\cos 39°25'}{\sin 50°.\sin 39°25'}$$

$$= \quad = \frac{0.38430 - 0.49659}{0.48640} = -0.23086$$

cos (180 º - H) = 0.23086

180 º - H = 76 º 39'

H = 103 º 21'.