Chapter 1

The sky and the celestial sphere

The Sun, and sometimes the Moon are, by and large, the only astronomical objects visible in the day sky. Traditionally, astronomy has been a nocturnal activity. The nigh sky is filled with stars (Figure 1.1). The night sky has captured the human imagination for over many thousand years. The starss, it was noticed, maintain a nearly fixed pattern on the sky. The relative positions of the stars on the sky do not change. . The entire pattern of stars on the sky revolves around the earth, completing one cycle in 24 hours. This diurnal rotation of the fixed pattern of stars on the sky is now known to be a consequence of Earth's rotation. It is now also known that the stars are at very large distances from us, and consequently their motions do not cause any discernable changes in their positions on sky (atleast to the naked eye).

Ancient astronomers identified different patterns in the distribution of stars. While some of the patterns are quite easy to identify, it may requires a considerable amount of imagination to identify others. These fixed patterns on the sky are referred to as *constellations*. The patterns identified as constellations differ from culture to culture, and these are often closely related to mythology.

The definition of the constellations have changed over time. The constellations have at present been redefined so that every star in the sky is now in exactly one constellation. In 1929, the International Astronomical Union (IAU) adopted the constellation boundaries that define the 88 official constellations that are in use at present. Figure 1.2 shows the Orion costelation

The constellations are not real. The various stars that make up a constellation are typically not physically associated with one another, the stars

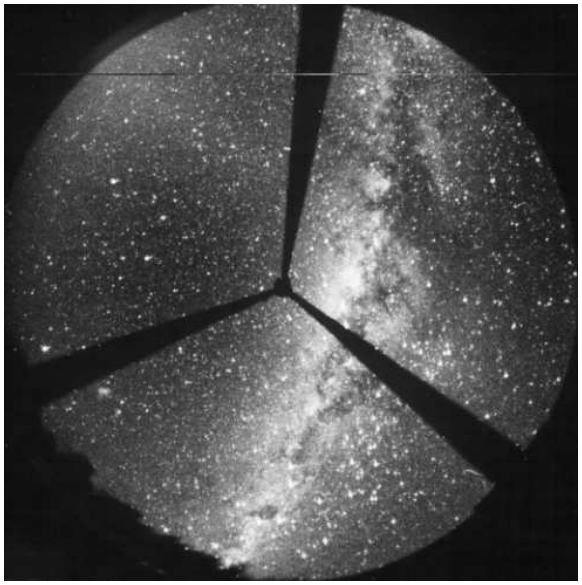

Figure 1.1: A picture of the night sky showing the Milky Way.

being at different distances from us. The appear associated only in projection on the sky.

While the stars maintain fixed positions in the sky, there are other objects namely the Sun, Moon and planets which waner relative to the fixed stars. Their wandering is restricted to the vicinity of a circle on the sky known as the *ecliptic*. The wandering is restricted to a small band in the sky called the *zodiac*. Figure 1.4 shows the constellations in the zodiac.

Considering Earth's motion around th Sun, it completes one orbit in 365.25 days. In addition, the Earth rotates around an axis which is inclined at 23.5° to the plane of Earth's orbit around the Sun Figure 1.5. For an observer on Earth, the Sun is at an angle of 23.5° above the Equator in position A which corresponds to the Summer Solstice. The Sun cuts the Equator when the Earth is at position B, and it is 23.5° below the Equator in position C.

The Equator is perpendicular to Earth's rotation axis. For an observer on Earth, Sun appears to move along a circular path on the sky. This circle which makes 23.5° to teh Equator (Figure 1.6) , is called the ecliptic. The position of the Sun appears to move west to east along the ecliptic on the celestial sphere.

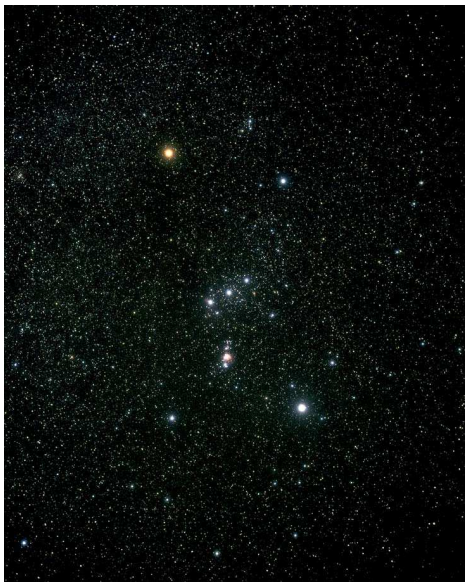

Figure 1.2: An image of the Orion Constellation.

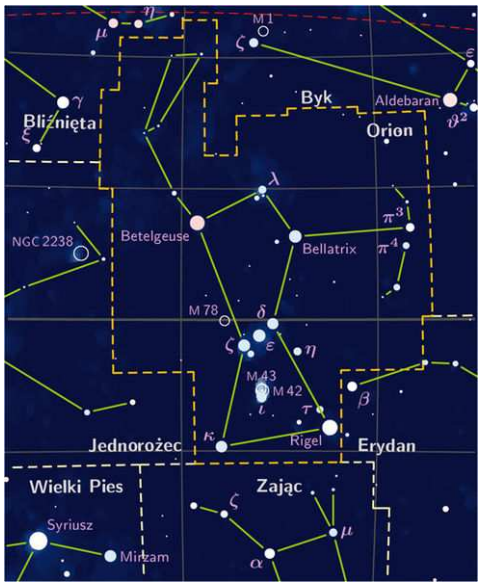

Figure 1.3: A map of the Orion Constellation.

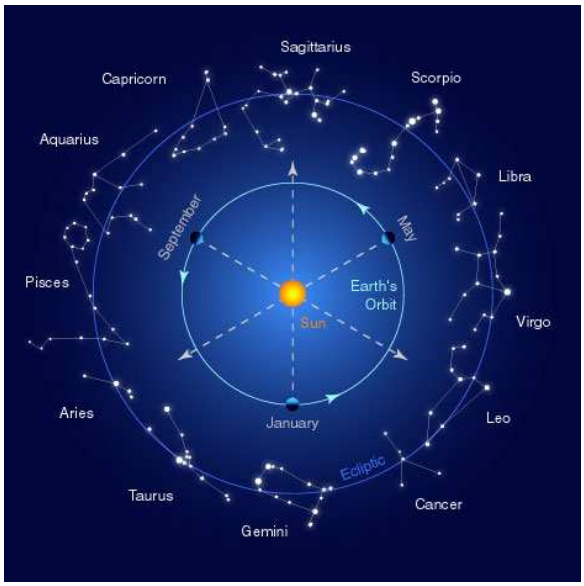

Figure 1.4: The constellations in the zodiac.

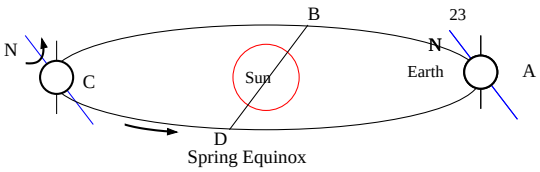

Figure 1.5: The Earth's orbit around the Sun

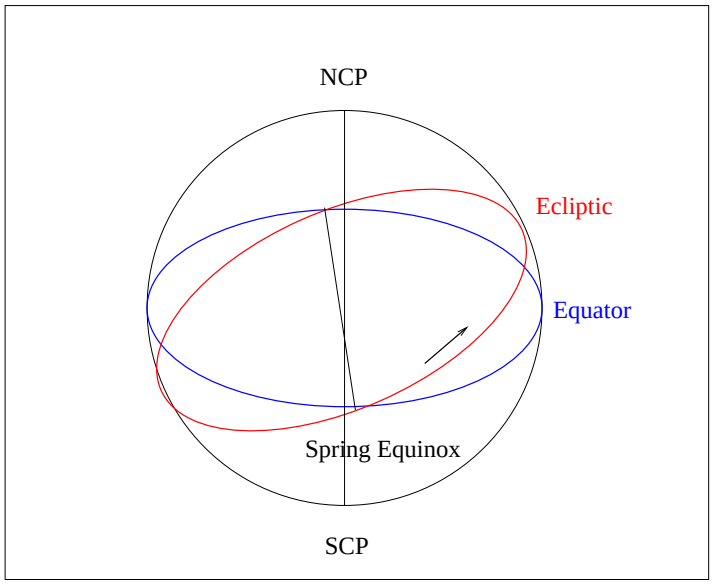

Figure 1.6: The Equator and the ecliptic.

The Moon's orbit around the Sun, and the motion of the planets around teh Sun are all nearly coplanar with Earth's orbit around the Sun. As a consequence the appear to wander in the vicinity of the ecliptic.

Eath's rotation axis points towardsa direction within 1° to a star known as the Pole Star or Polaris located in the Ursa Minor constellation. Viewed from Polaris, the Eath appears to rotate in teh counter-clockwise direction. The rotation is prograde *ie.* the rotation and revolution are in the same direction 1.7. As a consequence the sidereal day is shorter than the solar day.

The Earth's rotation axis is not fixed. It is known that this axis precess due to external tidal torques from the Sun, Moon and other objects on the Earth. The period of this precession is about $26,000$ years.

1.0.1 Angular coordinates

It is convenient to represent the sky as a fictitious sphere of very large (infinite) radius centered on the earth. All astronomical objects seen in the sky are then assumed to be located on this sphere. Two coordinates are adequate to specify the position of any object on the celestial sphere. The celestial

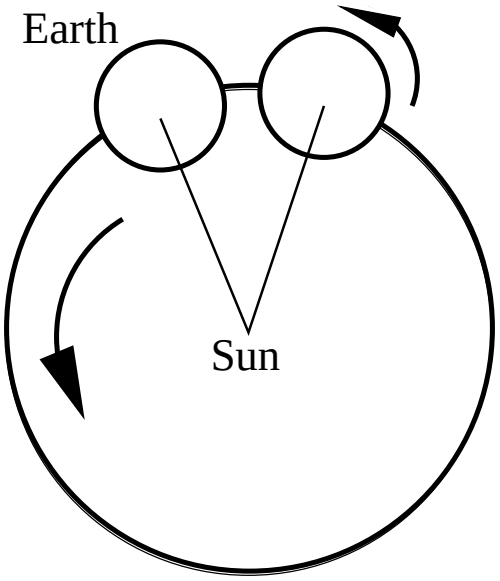

Figure 1.7: Prograde motion.

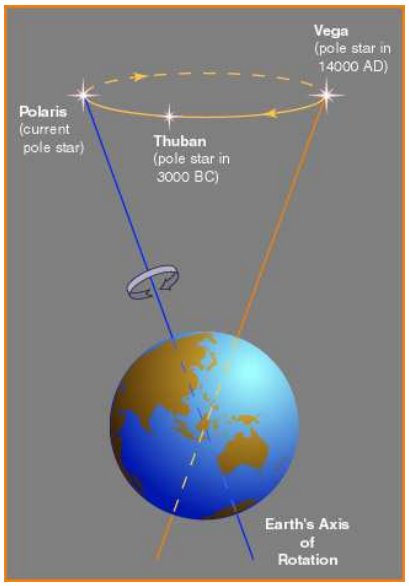

Figure 1.8: Precession of Earth's rotation axis.

equator is the great circle where the Earth's equatorial plane intersects the celestial sphere, and the north and south celestial poles (NCP and SCP) respectively refer to the two points where the Earth's rotation axis intersects the celestial sphere.

We briefly discuss the **equatorial system** of angular coordinates on the sky. The **right ascension** (RA) α and **declination** (DEC) δ define an angular coordinate system on the sky or the celestial sphere. The coordinate system is fixed to the celestial sphere as it appears to rotate from east to west due to the Earth's rotation.

The right ascension and declination are very similar to the latitude and longitude, while the latter are circles drawn on the Earth's surface the former are circles drawn on the celestial sphere. The declination δ, like the latitude, is measured in degree's from the equator and the NCP and SCP are at $\delta = 90^\circ$ and $\delta = -90^\circ$ respectively. The right ascension differs from the longitudes in that it is measured in hours, minutes and seconds (24 hrs = 360°) increasing from west to east. Further, the origin $\alpha = 0$ is not located at the Greenwich meridian, it is located at the meridian through the position where the ecliptic cuts the equator at the Vernal (Spring) Equinox. We use (α, δ) or (RA,DEC) to denote the position of an astronomical source on the celestial sphere Figure 1.9.

Figure Sources:
Figure 1.1: 1953, T. E. Houck and A. D. Code, Blue filter, 45 minute integration
Figure 1.2: $http://hubblesite.org/newscenter/archive/releases/2001/12/image/b/$,
Figure 1.3: $http://en.wikipedia.org/wiki/File:Orion_constelation_P3_map_PL.jpg$

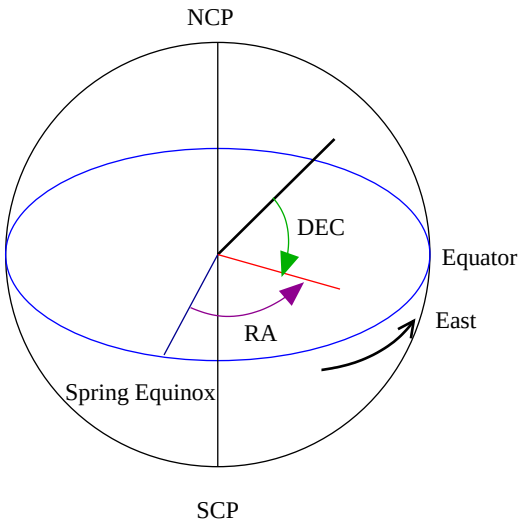

Figure 1.9: RA, DEC and the celestial sphere.