

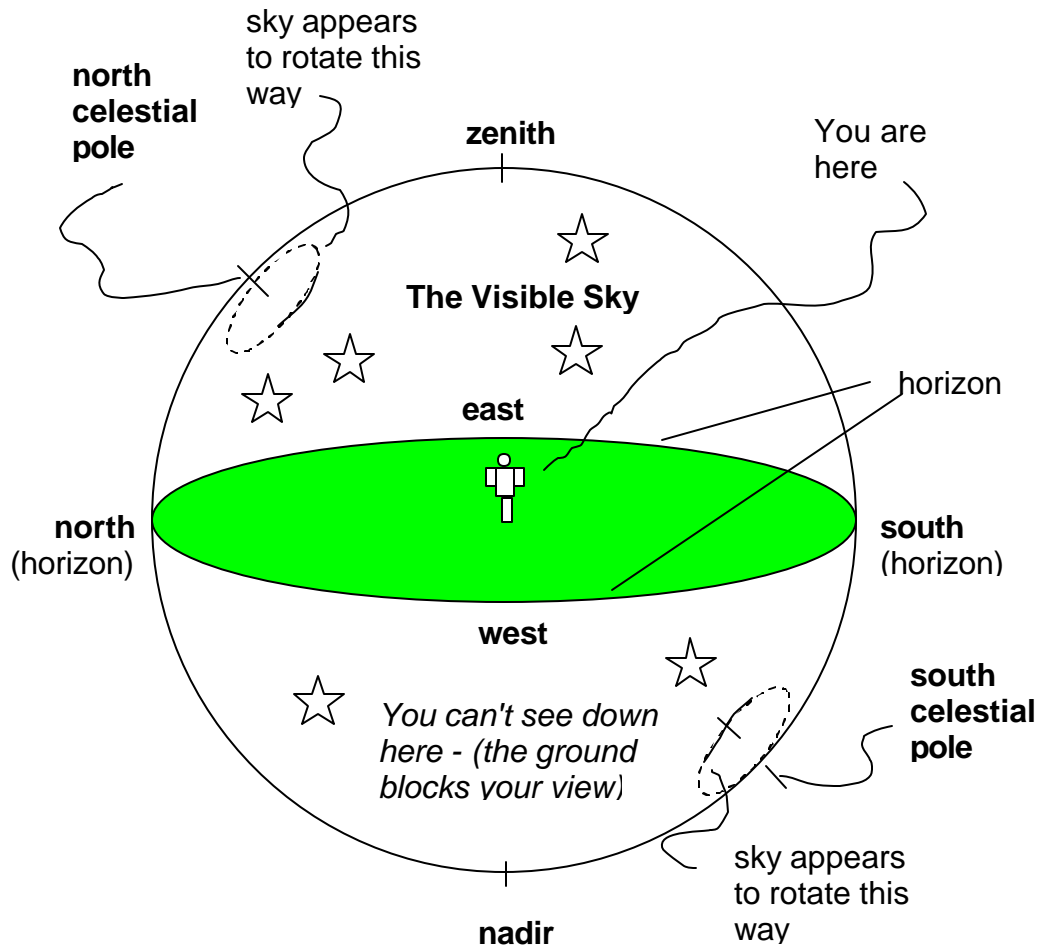
The Sky and Its Motions

To understand the cosmologies of ancient peoples it is important to know how they perceived the sky. In one sense this is quite easy - just get away from city lights (deserts and mountains are good) on a dark night and look up. Aside from the occasional plane or satellite, this is pretty much the way the heavens have always looked. The sky appears to be a dome spanning the landscape, and the stars, the planets, and the moon seem to be attached to this dome, like distant chandeliers hanging from a high ceiling. We call this dome the **celestial sphere**, and we never see more than half of it. The other half is not visible, our view blocked by the earth beneath our feet. The first impression is that everything is stationary; nothing is moving, not the earth, not the sky. However, in less than an hour the careful observer will note that stars near the eastern horizon are notably higher in the sky, while stars near the western horizon are lower and in some cases have disappeared altogether. The distinct impression is that the dome is rotating.

It needs to be stressed that the apparent motion observed over the course of a single evening is of the dome itself, not the objects (stars, planets, the moon) attached to it. In particular, the **stars** exhibit no perceptible motion **relative to each other** and the patterns they form (we call these patterns **constellations**) have remained essentially unchanged for thousands of years. However if observations are extended over a number of days, other motions will become apparent. The very next night, for example it will be obvious that the moon has moved to another location relative to the stars (and has changed shape). In a few days more it will be clear that the planets are also on the move. In fact the word **planet** means "**wandering star**". To naked eye observers this is the only thing which distinguishes a planet from a star - a planet is a star-like object that moves around the celestial sphere, while true stars remain fixed.

So already it is becoming complicated. The dome of the sky with the "fixed" stars is rotating around the earth while at the same time the moon and planets are slowly moving around the dome, through the constellations. And then there is the sun. Although the stars cannot be seen when the sun is in the sky, observations over an extended time period right after sunset and just before sunrise make it clear that the sun, too, is moving through the stars.

The drawings below depict the main features of the sky for an observer in California (or any mid northern latitude).

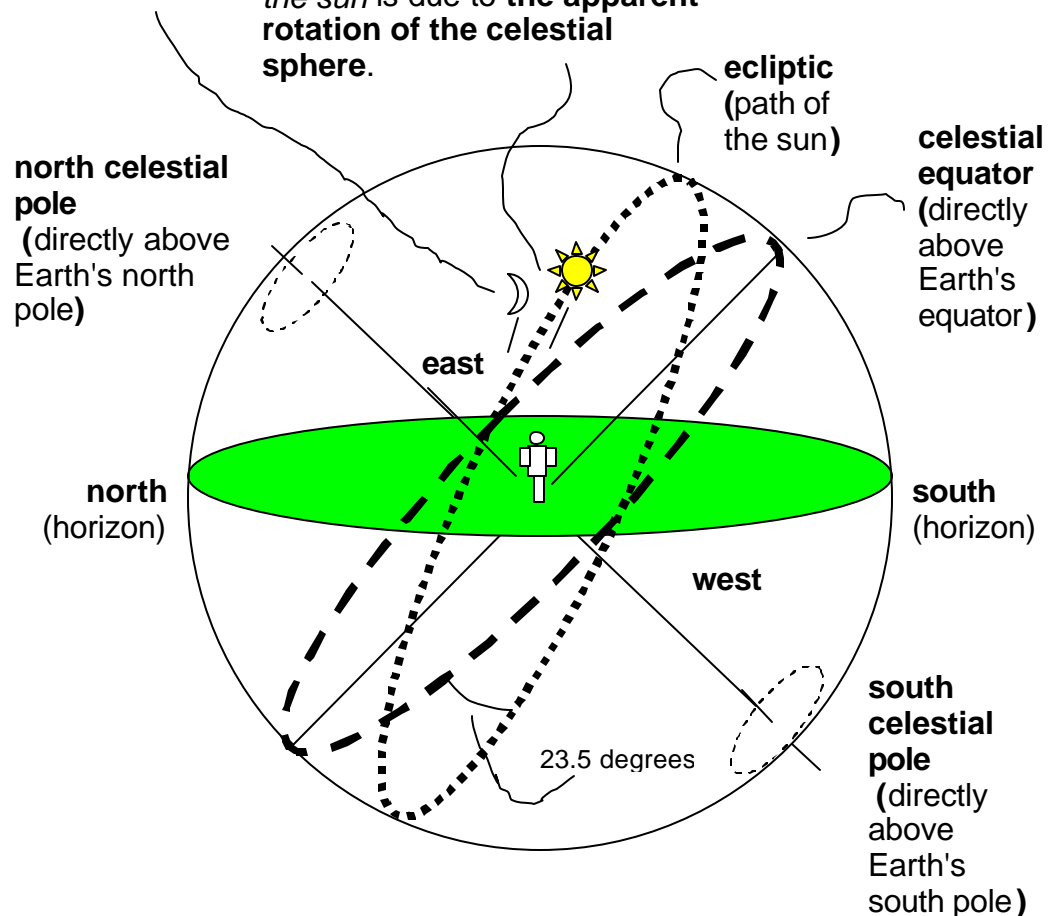


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- The celestial sphere appears to rotate from **east to west** and makes one complete rotation in 24 hours. This is known as the celestial sphere's **diurnal** motion. From northern latitudes the center of this rotation is a point in the northern sky, the **celestial north pole**. Note that the north celestial pole *is not at the horizon*. It is about half way up the sky (approximately 34 degrees above the horizon in southern California), and there is a relatively bright star very near the pole known as **Polaris** (also known as the **North Star**). As shown in the drawing above, there is also a **south celestial pole**, but it is not visible to observers in the northern hemisphere.

The moon follows a path close to the ecliptic and takes one **month** to travel completely around the celestial sphere

The sun takes **one year** to go completely around the ecliptic. The *diurnal rising and setting of the sun* is due to the **apparent rotation of the celestial sphere.**



- The sun makes one complete trip around the celestial sphere in one year, always following the same path, the **ecliptic**. The direction of travel is **west to east**, a direction opposite to the celestial sphere's diurnal rotation. The sun's motion along the ecliptic is so slow that it is hardly noticeable during course of a day. Therefore **the apparent rising and setting of the sun is not due to its motion along the ecliptic but rather the diurnal rotation of the celestial sphere.**
- The ecliptic is inclined approximately 23.5 degrees from the **celestial equator** (the line which divides the celestial sphere into two hemispheres and is directly overhead for an observer located on the terrestrial equator). As a consequence, during the course of a year, the sun has a maximum northern position (reached on June 21, the **Summer Solstice**), a maximum southern position (reached on December 21, the **Winter Solstice**) and crosses the equator twice (on March 21, the **Vernal Equinox**, and on September 21, the **Autumnal Equinox**).
- The moon also travels around the celestial sphere along a path very near the ecliptic (inclined by about 5 degrees). The moon takes 27.3 days to return to the same position on the celestial sphere (the **sidereal month**) and 29.5 days to return to the same

position relative to the sun (the ***synodic month***)

- The motions of the planets are more complicated. First of all there are two types of planets visible to the naked eye: (1) Mercury and Venus and (2) Mars, Jupiter and Saturn. Mercury and Venus are always found near the sun and are visible only right after sunset in the west or just before sunrise in the east. These planets seem to follow complex looping paths near the eastern or western horizons. On the other hand, the second group of planets (Mars, Jupiter and Saturn) generally follow the west -to-east travel of the sun and moon, but periodically they stop in their tracks and reverse direction for a couple of weeks before reversing again and continuing their normal journey. The "backward" travel is known as ***retrograde motion*** and planets moving in this direction (east-to-west) are said to be ***retrograding***. Since this phenomenon occurs over a period of weeks, it will be noticed only by observers who watch the sky systematically over an extended time span.