6.6: The Mean Sun

The bright yellow (or white) ball of fire that *appears* in the sky and which you could see with your eyes if ever you were foolish enough to look directly at it is the *Apparent Sun*. It is moving eastward along the ecliptic, and its right ascension is increasing all the time. Consequently consecutive upper transits across the meridian take about four minutes longer than consecutive transits of a star or of the First Point of Aries. The hour angle of the Apparent Sun might have been called the local apparent solar time, except that we like to start our days at midnight rather than at midday. Therefore the *Local Apparent Solar Time* is the *hour angle of the Apparent Sun plus twelve hours*. It is "local", because the hour angle of the apparent Sun depends continuously on the longitude of the observer. It is the time indicated by a sundial. In order to convert it to a standard zone time, we must know, among other things, our longitude.

The Apparent Sun has some drawbacks as an accurate timekeeper, particularly because *its right ascension does not increase at a uniform rate throughout the year*. The motion of the Apparent Sun, is, of course, just a reflection of Earth's annual orbital motion around the Sun. The Earth moves rather faster at perihelion (on or near January 4) than at aphelion (on or near July 4); consequently the Apparent Sun moves faster along the ecliptic in January than in July. Even if this were not so, however, and the Sun were to move at a uniform rate along the ecliptic, its right ascension would not increase at a uniform rate. This is because right ascension is measured along the celestial equator rather than along the ecliptic. If the Sun were moving uniformly along the ecliptic, its right ascension would be increasing faster at the solstices (where its motion is momentarily parallel to the equator) than at the equinoxes, (where is motion is inclined at $23^\circ.4$ to the ecliptic). So there are these two reasons why the right ascension of the apparent Sun does not increase uniformly throughout the year.

To get over these two difficulties we have to invent two imaginary suns. One of them accompanies the apparent (i.e. the real!) Sun in its journey around the ecliptic. The two start together at perihelion. This Dynamic Sun moves at a constant rate, so that the Apparent Sun (which moves faster in January when Earth is at perihelion) moves ahead of the imaginary sun. By the time Earth reaches aphelion in July, however, the Apparent Sun is slowing down, and the Dynamic Sun manages to catch up with the Apparent Sun. After that, the Dynamic Sun surges ahead, leaving the Apparent Sun behind. But the Apparent Sun starts to gain speed again, and catches up again with the Dynamic Sun at perihelion in January. The Apparent Sun and the Dynamic Sun coincide twice per year, at perihelion and at aphelion.

Now we imagine a second imaginary sun – a rather important one, known as the Mean Sun. The Mean Sun moves at a constant rate *along the equator*, its right ascension moving uniformly all through the year. It coincides with the Dynamic Sun at Υ. At this time, the right ascension of the Dynamic Sun is increasing rather slowly, because it is moving along the ecliptic, at an angle to the equator. Its right ascension increases most rapidly at the solstices, and by the time of the first solstice it has caught up with the Mean Sun. After that, it moves ahead of the Mean Sun for a while, but it soon slows down as its motion begins to make an ever steeper angle to the equator, and Dynamic Sun and the Mean Sun coincide again at the second equinox. Indeed these two suns coincide four times a year – at each of the equinoxes and solstices.

Local Mean Solar Time is the *hour angle of the Mean Sun plus twelve hours*, and the difference Local Apparent Solar Time minus Local Mean Solar Time is called the *Equation of Time*. The Equation of time is the sum of two periodic functions. One is the *Equation of the centre*, which is the difference in right ascensions of the Apparent Sun and the Dynamic Sun, and it has a period of one year. The second is the *reduction to the equator*, which has a period of half a year. The value of the Equation of time varies through the year, and it can amount to a little more than 16 minutes in early November. Local Mean Solar Time, while uniform (or as uniform as the rotation of the Earth) still depends on the longitude of the observer. For that reason, all the inhabitants of a zone on Earth roughly between longitudes $7^\circ.5$ East and West agree to use a standard the Local Mean Solar Time at Greenwich, also called Greenwich Mean Time, GMT, or Universal Time, UT. Similar zones about 15 degrees wide have been established around the world, within each of which the time differs by an integral; number of hours from Greenwich Mean Time.

We shall discuss in Chapter 7 small distinctions between various versions of Universal Time as well as Ephemeris Time and Terrestrial Dynamical Time.