Time Systems

Explanation of Terms

Universal Time Coordinated (UTC): an average time from many atomic clocks adjusted with leap seconds so that it is in approximate correspondence with the rotation of the Earth. It is essentially the same as Greenwich Mean Time (GMT, sometimes called "Zulu" or Z). This is the essential defined time.

leap second: Time has its origin in the rotation of the Earth, but now a second is defined by atomic physics, independent of the Earth's rotation. Since the Earth's rotation is slowing, there is a gradual increasing miss-match between a day and 86,400 SI seconds. When the miss-match between the orientation of the Earth and the count of SI seconds approaches 0.6 seconds the International Earth Rotation and Reference Systems Service (IERS), may declare a leap second (a minute with 61 seconds) on a particular date. Leap seconds complicate the life of those managing time, but are required if daylight is to occur at a 'normal' time-of-day.

Zone Time (ZT): At a longitude of $n^h = n15^\circ$ where $n \in \mathbb{Z}$, offset UTC by n hours. Typically this is the civil time in a region 15° of longitude wide, centered on this longitude with adjustments made to accommodate civil boundaries. We are in the US Central Time Zone ($\mathrm{UTC} - 6^h$) which would be centered on longitude $90^\circ = 6^h$. Currently we are on Daylight Saving Time (CDT) as we set our clocks ahead in March, so we are currently subtracting a smaller number (5) from UTC. Centuries ago, time in each town was set by the Sun's location in the sky: noon was defined by the Sun crossing the meridian, i.e., noon was when the Sun moved from a.m.=*ante meridiem* to p.m.=*post meridiem* (Latin). Since sunrise times advance continuously from the east coast to the west coast, this meant that noon was at sightly different times at cities located a few miles apart. Zone time creates a region of the same time with discontinuities at zone boundaries making up for the actual continuous variation in 'noon'.

Mean Solar Time (MST): Because of the elliptical orbit of the Earth, the Sun's motion on the Celestial Sphere is not exactly uniform. Thus in order to make a time that advances uniformly throughout the year, MST uses a fictitious object (the Mean Sun, MS) as the thing defining noon. The Mean Sun moves uniformly on the Celestial Equator completing one circuit in one year. (The actual Sun moves at slightly varying rates on the Ecliptic. The Mean Sun has a RA that is within a few minutes of the RA of the actual Sun.) Mean Solar Time equals the Hour Angle of the Mean Sun plus 12^h. MST is a local time.

Sidereal Time ($^*T$): Using the cycle of the Sun's motion to define time makes sense for most of society, but astronomers care about the cycle of the stars' motion. So instead of using the Sun's sky location to define noon, we use the Vernal Equinox (RA=0) to define time. Sidereal Time is equal to the Hour Angle of the Vernal Equinox. This of course means that the Sidereal Time at different locations is different, but at the observatory we only care about how our sky is oriented. Note: 24^h of sidereal time takes about $23^h\ 56^m$ of 'normal' time.

Julian Date (JD): is a count of days (and fractions of days) from noon on a particular day (in 4713 BC) at Greenwich. (Note Julian Days begin/end at noon at Greenwich; since night observations at SJU often start at around midnight in Greenwich, our fractional JD is often ~ 0.5) The current JD is about $2\frac{1}{2}$ million, so astronomers often subtract some consistent offset from the actual JD to make the numbers more convenient. Note if starlight is emitted exactly periodically, it will not appear periodic from Earth because of the finite speed of light. (When the Earth, in its orbit, is nearer the star, the pulse will be observed earlier.) Thus times are often adjusted to what would have been seen by an observer on the Sun; this is the Heliocentric Julian Day (HJD).