ASTR 535 Lab notes

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Time, coordinate systems, observability tools

Time Systems

Systems of time: see Naval observatory reference for a full listing of different types of time.

Solar Time

- Time tied to position of Sun. Note the distinction between *mean* solar time and *apparent* solar time (the "equation of time" and the analemma).
- Most used solar time is Universal time. UT = local mean solar time at Greenwich = "Zulu". Tied to location of Sun, but average to "mean sun".
- Local time: accounts for longitude of observer. For practicality, legal time is split into time zones.
- In detail, official time is kept by atomic clocks (International Atomic Time, or TAI), and coordinated UT (UTC) is atomic time with leap seconds added to compensate for changes in earth's roation, where these are added to keep UTC wihin a second of solar time (UT1). See here for some details.

Sidereal time

- Times based on position of stars, i.e. Earth's sidereal rotation period 23h 56m 4s. Local sidereal time is GMST (Greenwich mean sidereal time) minus longitude. At the vernal equinox (time in sky when Sun crosses the celestial equator as its declination is increasing), sidereal time = UT. Difference between UT and GMST is one rotation (day) over the course of a year, so about 2 hours per month.
- Sideral is relevant for position of stars: stars come back to the same position every sidereal day.

Calendars

- Standard calendar is Gregorian, with leap years, etc.

- For astronomy, it is simpler to keep track of days rather then year/month/day. Most dates given by the `Juliandate` (number of days since UT noon, Monday, January 1, 4713 BC). Variations include modified Julian data (JD - 2400000.5 fewer digits and starts at midnight), heliocentric Julian date (JD adjusted to the frame of reference of the Sun, so can differ by up to 8.3 minutes).

- Note that repeating events are often described as an event *ephemeris:* $t_i(event) = t_0 + i(period)$.

- The term *ephemeris* is also used to describe how the position of an object changes over time, e.g. planetary ephemerides.

Coordinate systems

LPL website on astronomical coordinate systems

Celestial coordinate systems

(diagram)

- RA-DEC: tied to Earth rotation, longitude and latitude. Zero RA at vernal equinox

- ecliptic: tied to plane of Earth rotation around the Sun. Zero ecliptic longitude tied to vernal equinox.

- galactic: tied to plane of the Milky Way

At vernal equinox, RA = 12h crosses the meridian at midnight.

Note that for a celestial coordinate system tied to the Earth's rotation, coordinates of an object change over time because of the changing direction of the Earth's axis: precession and notation. Because of this, coordinates are always specified for some reference equinox: J2000/FK5, B1950, etc.; if using coordinates to point a telescope, you need to account for this (but generally, telescope software does this on its own). Note distinction between equinox and epoch, where the latter is relevant for objects that move (which everything does at some level).

Transformations between systems straightforward from spherical trigonometry.

Note the common usage of an Aitoff projection of the sky in celestial coordinates, with location of ecliptic and galactic plane.

Local coordinate systems

- Equatorial: HA-dec. $HA = LST - \alpha . LST = GMST - longitude$. Note normal convention for HA is to get larger to the west, i.e. opposite of RA. Objects at zenith have δ = latitude of observer.

- Horizon: alt-az or zd-az

Local coordinates are important for pointing telescopes. Note that there are various other effects that one has to consider for pointing a telescope at a source of known celestial position: proper motion, precession, nutation, "aberration of light", parallax, atmosphereic refraction.

Finding positions of celestial objects

Orientations of objects in the sky

Observability

Tools

Exercises

Next Section