Acc.No 90096

Astronomy for Nonastronomical Computer Programmers

A.Pramesh Rao

(27 Dec 90)

The idea of this note is to give a feeling for common astronomical jargon, so that a non specialist with a reasonable scientific background can communicate with an astronomer. Starting with coordinate systems used by astronomers, i will try to take it upto some typical astronomical observations keeping in view the proposed hardware/software architecture for the GMRT on—line system.

Co ordinate systems

Right Ascension and Declination:-

Astronomers give the position of sources in terms of two angles called Right Ascension (RA) and declination (Dec). These can be thought of as the logitude and latitude of a point on the celestial sphere. If we define a right handed coordinate system with origin at the centre of the earth and the z axis towards the North pole, the declination is the same as the polar coordinate 0, while the RA is the same as the polar coordinate ~, except that IRA is measured in units of time (hours, minutes and seconds) rather than angle (conversion being 24 hours=260 degrees). While the zero of declination is well defined and corresponds to a source over the equator, PA .(as is true of logitude also) has no natural origin and has to be arbitrarily fixed. The origin of PA is fixed at the position of the sun when it crosses the equator travelling from south to north (the vernal or spring equinox). In this system, the coordinates of distant sources is roughly constant, the IRA and Dec of the sun changes periodically with time with a period of one year. The moon, planets and comets trace out complex paths in the IRA Dec plane.

Epoch of Observation:-

A problem arises because the rotation axis of the earth precesses like a top with a period of 26000 years because of which the position of an object in the PA Dec coordinated system defined with respect to the equatorial plane of the earth, changes measureably with time. Thus if we want to specify the position of a source, we must specify not only its PA and Dec, but the date (epoch) at which the observations were made so that we know the orientation of the IRA Dec coordinate system with respect to the sky. The epoch of the observation is usually given as subscript following the PA Dec of the source. Since the ~precession of the earths rotation axis is a smooth and well ~‘ understood function of time, we can transform the RA Dec of a source at one epoch to another epoch using “ Precession” programs. If each astronomer gave his measured positions in RA Dec at different epochs corresponding to the date on which he made his observations, everyone would spend most of their lifetimes running these “ Precession “ programs, since if we want to compare two positions, they have to be in the same coordinate system.

To avoid this, the general astronomical convention is to transform the observed coordinates to certain fixed epochs (epoch of 1950. till recently and the epoch of 2000. by the time things starts seriously at GMRT) and publish things in these epochs. This implies that if we want to observe a source, we have to precess its coordinates from the epoch in which it is given to the actual date of the observations. This whole problem could have been avoided if we had created a coordinate system fixed wrt the celestial sphere. Such systems do exist, like the ecliptic, galactic and supergalactic coordinate systems, but the RA Dec (also known as the equatorial coordinate system) continues to be the most commonly used since it is the most convenient for ground based observations. Siderial time and Hour Angle: The RA and Dec of a source on a given date is not enough for an observer to go out and look for a source. This is because the earth rotates about its axis, because of which the east west position of a source changes with time. We can define another coordinate system with origin at the centre of the earth, z axis parallel to the earth's axis of rotation, and x axis, joining the centre of the earth to the point on the equator corresponding to the longitude of the site where the observer is located. The polar coordinates of a source in this frame, 6 is the declination of the source and ~ is called the hour angle (usually measured in hours) are enough to actually locate a source in the sky. This frame of reference, called the observers frame of reference rotates as the earth rotates with respect to the celestial sphere and so the hour angle of a source increases with time. From the BA of the source and the local time one has to calculate the hour angle of the source before it can be observed. The system of time that we commomly use is called solar time actually civil time), in which one day or 24 hours is defined as the time interval between two transits of the sun. In this system, if we know the local time of the day we know the east west position of the sun. At 6 am the sun rises, and so is 90 degrees to the east, at 12 noon, it is at its highest point, at 2 pm it is 30 degrees to the west, and so forth. However, this does not work so simply for other sources. This is because the HA of the sun is not constant but increases by about a degree a day because the earth is moving around the sun. Because of this the earth has to rotate by 361 degrees to come back to the sun, while it has to rotate only 360 degrees to come back to any other distant source. We can define the siderial day as the time interval between two transits of any distant star and this time interval will be shorter that the solar day by 360/361.