Celestial equatorial coordinate system

Cite the equatorial coordinate system, the astronomical coordinate system most often used to indicate the positions of stars or other celestial objects in the celestial sphere. The celestial sphere is an imaginary sphere with the observer at its center. It represents the whole sky; all celestial objects other than the Earth are imagined to be located on its inner surface. If the axis of the Earth is extended, the points where it crosses the celestial sphere are called celestial poles; the north celestial pole is directly above the Earth's North Pole, and the south celestial pole directly above the Earth's South Pole. The large circle in the celestial sphere midway between the celestial poles is called the celestial equator; can be thought of as the earth's equator projected for the celestial sphere. It divides the celestial sphere into the north and south skies. An important reference point at the celestial equator is the vernal equinox, the point at which the sun crosses the celestial equator in March.To designate the position of a star, the astronomer considers a large imaginary circle passing through the celestial poles and through the star in question. This is the circle of the time of the star, analogous to a meridian of longitude on Earth. The astronomer then assifies the angle between the vernal equinox and the point where the circle of hours crosses the celestial equator. This angle is called the right rise of the star and is measured in hours, minutes, and seconds, rather than in more familiar degrees, minutes, and seconds. (There are 360 degrees or 24 hours in a full circle.) The right rise is always measured eastward from the vernal equinox. The observer then tells the angle between the celestial equator and the position of the star over the time of the star. This angle is called the decline of the star and is measured in degrees, minutes, and seconds north or south of the celestial equator, analogous to latitude on earth. Certain rise and declination together determine the location of a star in the celestial sphere. The right rises and declines of many stars are listed in several published reference tables for astronomers and navigators. Because the position of a star may change slightly (see proper movement and precession of the equinoxes), such tables should be reviewed at regular intervals. By definition, the vernal equinox is located on the right 0h and declination 0°. Another useful reference point is the sigma point, the point where the celestial meridian of the observer crosses the celestial equator. The right rise of the sigma point is equal to the observer's local lateral time. The angular distance from the sigma point to the hour circle of a star is called its time angle; is equal to the right rise of the star minus the local sidereal time. Because the vernal equinox is not always visible in the night sky (especially in spring), while the sigma point is always visible, the time is used in the location of a body in the sky. The Columbia Electronic Encyclopedia, 6th ed. See more Encyclopedia Articles on: Astronomy: General The Celestial Equatorial Coordinate System is based on the concept of the celestial sphere. The celestial sphere is an imaginary sphere of infinite ray around the Earth. Locations of objects in the sky are given by projecting their location on this infinite sphere. Although technically impossible to portray the prospect of looking down on the celestial sphere (being infinite in size), it is often convenient to portray a finite ray celestial sphere – as was done with the figure below. The celestial sphere is fixed relative to the universe. Your orientation doesn't change. However, as the earth rotates from west to east (counterclockwise from the perspective of looking at the north pole), an observer who is on earth will see the celestial sphere rotate from east to west (or clockwise when looking at the sky). Click and drag the star to change the location As terrestrial coordinates (i.e. longitude and latitude), two coordinates define a point in the celestial sphere. The rotation of the Earth defines a direction in the universe and it is convenient to base a coordinate outside that rotation/direction. The celestial equator is the coplanar line with the earth's equator (and 90° for the axis of rotation). The north celestial pole is directly above the north pole of the Earth and also to the south celestial pole. The coordinate indicating where an object is between these poles is declination. Declination is measured from the celestial equator. It extends from 0° at the celestial equator to +90° at the north celestial pole and from 0° at the celestial equator to -90° at the south celestial pole. Although declination does not use the designation N and S, latitude and declination are, however, closely related coordinates. The declination is represented by the red line in the figure on the right. The second coordinate in the celestial equatorial system is the right rise. It is analogous to (but not the same) longitude. Much has Greenwich is the arbitrary zero point for longitude, the right rise also has a zero reference point. This point is the Vernal Equinox Point. Why this point is a convenient choice is discussed in the next section of the module (Stations and the Ecliptic). Because the earth rotates, from the point of view of the earth, the celestial sphere rotates once every 24 hours (sidereas). The right ascent is consequently measured in hours (sidereal), 0h to 24h east of the Vernal Equinox Point. That is, east is the direction of increasing the right ascent. The middle circle with right ascent 0h is called the 0 hour circle. Because a circle is 360°, 1 hour of right ascent = 15° As the altitude and azimuth of a star are constantly changing, it is not possible to use the horizontal coordinate system in a of positions. A more convenient coordinate system for cataloging purposes is one based on the celestial equator and celestial poles and defined similarly to latitude and longitude on the earth's surface. In this system, known as equatorial coordinate system, the analogue of latitude is declination, . The declination of a star is its angular distance in measured degrees of the celestial equator along the meridian through the star. It is measured north and south of the celestial equator and ranges from 0° at the celestial equator to 90° at the celestial poles, being taken to be positive when north of the celestial equator and negative when south. In Figure 15, the declination of star X is given by the angle between Y and X. The analogue of longitude in the equatorial system is the angle of the hour, H (you can also see the symbol HA used). Defining the observer's meridian as the arc of the large circle passing from the north celestial pole through the zenith to the south celestial pole, the hour angle of a star is measured from the observer's west meridian (for observers in the northern and southern hemisphere) to the meridian through the star (0° to 360°). Because of the Earth's rotation, the hour angle increases evenly over time, from 0° to 360° in 24 hours. The hour angle of a particular object is therefore a measure of the time since it crossed the observer's meridian - hence the name. For this reason, it is often measured in hours, minutes, and seconds of time rather than in angular measure (as well as longitude). In Figure 15, the hour angle of star X is given by the Z-NCP-X angle. Note that all stars reach their maximum altitude above the horizon when they transit (or reach the upper culmination, in the case of circumpolar stars) of the observer's meridian. The declination of a star does not change over time. The angle of the hour does, and therefore is not an appropriate coordinate for a catalog. This problem is overcome in a manner analogous to how the Greenwich meridian was (arbitrarily) selected as the zero point for longitude measurement. The zero point chosen in the celestial sphere is the first aries point, and the angle between it and the intersection of the meridian through a celestial object and the celestial equator is called the right ascension (RA) of the object. The right ascent is sometimes denoted by the Greek letter and is measured from 0h to 24h along the celestial equator to the east from the first point of Aries, that is, in the opposite direction to which the angle of the hour is measured. Like the time angle definition, this convention applies to observers in the northern and southern hemispheres. In Figure 15, the right rise of star X is given by the -NCP-Y angle. figure 15: The equatorial coordinate system. As described earlier, most modern research telescopes do not use equatorial assemblies due to their higher cost and lower stability. This at the expense of the simplicity of telescope tracking - an equatorially mounted telescope only needs to move its right ascension axis to track the movement of the celestial sphere. Figure 16 shows an example of an equatorially mounted telescope. figure 16: An equatorially mounted telescope - the 3.9 m Anglo-Australian Telescope (AAT) in Australia. In the above discussions about coordinate systems and the celestial sphere we make the assumption that the stars are fixed on the celestial sphere and never move. For precise positional work on long-time scales, this assumption does not hold true - stars move in the celestial sphere. The Earth's axis of rotation is not fixed toward, but slowly precedes in space, such as a rotating top, due to the gravitational pulls of the Sun and Moon on the rotating, non-spherical Earth (see page 144 of Roy and Clarke for a detailed description). Because of this, the north celestial pole traces a small circle with a radius equal to the obliquity of the ecliptic, . This also causes the celestial equator to move, and as a result, the first Aries point is not really a fixed reference point; it gradually moves back along the ecliptic, for about 50 arcseconds a year, and is in fact currently in the neighboring constellation of Pisces. This movement is known as the precession of the equinoxes and means that even the right rise and declination are not coordinated and catalogs of stellar positions must specify the date (e.g. 1950.0 or 2000.0) to which they refer. More precisely, the coordinate frame used for catalog positions is defined by the position of the vernal equinox (the first aries point) on a specific date, so that astronomers talk about positions referred to (for example) the 2000.0 equinox. Although the pole takes about 26,000 years to make a revolution, the effect of precession is much greater than uncertainties in the positions of objects, so all positional measures must be corrected for precession. Precession rotates only the frame of reference, and has no effect on the relative positions of the stars. However, the stars are not stationary in space; they are all moving around the center of the Galaxy in different orbits, and the effect is that nearby stars have measurable movements relative to the Sun. The projections of these movements in the celestial sphere are known as the proper movements of the stars, usually given the symbol, and cause changes in the relative positions of the stars. For stars with significant proper movement, therefore, it is necessary to specify both the appropriate movement and the date of observation (known as the time), as well as the position of the catalog and the equinox to which it refers. If no time is given for a position, it is assumed that the epoch is the same as the equinox of the frame of reference. There are a number of other corrections, usually minor, that astronomers coordinates of an astronomical object before before precise positional work. These include atmospheric refraction, stellar aberration and nutation, which are all described in chapters 10 and 11 of Roy and Clarke. You should now be able to understand a page from a stellar catalog, an example of which is shown in Table 1. Table 1: An extract from a typical catalog of stars. Using the position of the first Aries point as the basis of the equatorial coordinate system is inappropriate for high-precision positional astronomy. This is due to the fact that the theories of the Earth's movement that define as the celestial equator and the ecliptic equator (and therefore the first point of Aries) move are imperfect. Even if these planes are defined without any reference to the movements of the Earth, there is no way to magically paint them on the celestial sphere at any time. Therefore, in practice, a set of fiduciary objects with assigned coordinates are used to define the coordinate system. The axes of the International Celestial Reference System (ICRS), the current standard celestial reference system, are defined by the adopted positions of a specific set of extragalactic objects (mainly quasars observed on the radio), which are assumed to have no measurable proper movements. The ICRS axes are consistent at 0.1 arcseconds with the 2000.0 equinox defined by the earth's dynamics. However, ICRS axes should be considered as fixed directions in space that have an existence independent of the dynamics of the Earth or the particular set of objects used to define them at any time.