

# Appendix A:

## The Equatorial System

### •Introduction

Most of us have had the experience of trying to locate a small, obscure town on a road map. The straight forward method is to systematically search the whole state for the name of the town. Sometimes one is lucky, but at other times the process is slow. Fortunately there is a better way. Most maps have a list of towns with each one accompanied by a pair of symbols; usually a letter and a number. These are used to greatly reduce the amount of area that we must search by indicating the approximate location on the map. Such pairs of symbols are known as coordinates and allow one to specify the position of towns. In astronomy we are interested in specifying the positions of objects in the sky as viewed by an observer on the earth. For the moment we will not worry about the distance to the object, but concern ourselves only with the direction to the object. We can express the direction to an object in the sky by giving the values of two angular coordinates.

It helps to picture the night sky as an immense glass sphere with the earth (and the observer) at its center and the stars affixed to the sphere. This sphere is known as the **celestial sphere**. There are numerous ways to specify the two angles necessary to give the direction to a celestial object. Astronomers use the **Equatorial System**.

### •The Equatorial System

You are undoubtedly aware of the rising and setting of the stars. However, you may not be aware that the stars appear to be rotating about a fixed point in the sky directly above the north point of the horizon. The fixed point in the northern sky about which this apparent stellar motion takes place serves as a convenient reference point in the sky. This point is the **north celestial pole (NCP)**, and its position in the sky is marked approximately by the bright star Polaris, also known as the North Star. If one were located in the southern hemisphere, a similar effect would be observed. The corresponding point in the sky south of the earth's equator is the **south celestial pole (SCP)**. The only

difference is that the stars appear to rotate counter-clockwise about the north celestial pole but clockwise about the south celestial pole.

Although we will not prove it here, it is an interesting fact that the altitude of the NCP equals the latitude of the observer's location. This is a useful principle in navigation.

In summary, the NCP is a point on the celestial sphere which lies on the observer's celestial meridian at an altitude equal to the observer's latitude. The NCP is below the horizon of observers south of the equator, just as the SCP is below the horizon of observers north of the equator.

The circle on the celestial sphere which is 90 degrees from both the NCP and the SCP is the **celestial equator**.

In order to set up a system of coordinates on the celestial sphere, it is necessary to specify both a reference point and a reference circle. For the equatorial system, the celestial equator serves as the reference circle. The celestial equator lies on the celestial sphere and in the same plane as the equator on the earth's surface. The **vernal equinox** is selected as the reference point. This is the point on the celestial equator where the sun is located on the first day of spring. To a terrestrial observer, the sun's apparent path through the sky (called the **ecliptic path**) crosses the celestial equator from the south to north on this date. The point of crossing is the vernal equinox.

The circles on the celestial sphere which pass through both celestial poles and cross the celestial equator at right angles are called **hour circles**. The hour circle which passes through the vernal equinox is labelled  $O^h$ . Every successive 15 degree interval measured along the celestial equator constitutes  $1^h$ .

The **right ascension (RA)** of a star is the angular distance measured in hours, minutes, and seconds from the hour circle of the vernal equinox eastward along the celestial equator to the point of intersection of the star's hour circle with the equator. Example: Since an hour equals 60 minutes, an object with  $RA = 15^h 10^m$  would be  $1/6^{\text{th}}$  of the way from the  $15^h$  hour circle to the  $16^h$  hour circle.

The **declination (Dec)** of a star is its angular distance from the celestial equator measured

along its hour circle. The declination is positive for an object north of the celestial equator and negative for an object south of the celestial equator. Note that the declination is  $0^\circ$  everywhere along the celestial equator.

The main advantage of the equatorial system is that it is independent of the observer's location, since it is not dependent on the locally defined horizon circle but rather on the universally defined celestial equator. If one expresses the position of an object in the sky in terms of RA and Dec, this suffices to locate the object for another observer anywhere else on earth.

Most astronomical telescopes have equatorial mountings. Once the telescope's polar axis has been properly oriented, one can point the telescope to any object in the sky, provided its RA and Dec are known, by setting these coordinates into the telescope's RA and Dec circles.

#### •More help

If you're still not sure what's going on with this coordinate system, ask your lab instructor to give you a copy of the "Road Maps in the Sky" lab from the 311 lab manual. You can also use the celestial globes located in the lab room to practice with.