THE CELESTIAL SPHERE & THE STAR CHARTS

When we observe the sky during a given evening, it appears that the sky is rotating around a stationary Earth rather than the Earth rotating under a stationary sky. From night-to-night, we sense some changes in the sky (e.g., the Sun, Moon, and planets move relative to the background stars), but we still have the sensation that the Earth is at rest. To use and understand the Constellation Charts, it is most convenient to take this geocentric point of view: Imagine the Earth at rest and at the center of a very large radius “celestial sphere”. This celestial sphere rotates about what we know to be the Earth’s spin axis and on the inside surface of this sphere are the fixed stars in their familiar constellation patterns. The Sun, Moon, and planets (as well as any other solar system object) are also on this sphere’s inside surface, but are free to move about the stars (we say "inside surface" of the celestial sphere since this is the side of the celestial sphere that we actually look at from Earth). Technically, the stars move relative to each other as well, but because they are so far from the Earth, it takes hundreds of years to notice the changes. For all practical purposes then, we can assume the stars are fixed relative to each other on the inside surface of the celestial sphere.

Now to be able to tell a fellow observer where to look for a particular star, you need a coordinate system to mark the locations of the stars on the celestial sphere. To do so, it is assumed that the reader is familiar with the Earth's longitude-latitude system: latitude is the degrees north or south of the equator and longitude is the degrees east or west of the prime meridian through Greenwich, England. If one projects this coordinate system out onto the celestial sphere's inside surface, one essentially has the right ascension-declination system for the celestial sphere with but a few (albeit important) differences: 1) Declination (abbreviation = Dec) is the degrees north or south of the celestial equator, which is itself a projection of the Earth's equator onto the celestial sphere; 2) Right Ascension (abbreviation = RA) lines run from the north celestial pole (the point where the Earth's north pole projects onto the celestial sphere) to the south celestial pole and is measured in hours, minutes, and seconds (instead of degrees); 3) The zero of RA is at the Vernal Equinox (a point on the celestial equator discussed below) and RA increases to the east until after 24 hours of RA you are back to 0 RA; and 4) The RA-Dec system is stuck to the celestial sphere just like the stars, so that as the celestial sphere rotates, you (standing at a fixed point on the Earth's surface) should imagine the RA lines moving across the sky with the stars from east to west (Note: a given RA line does not stay permanently above a given longitude line, but rather rotates across the given longitude line once every 24 hours). You may want to consult your text to obtain more information of this RA-Dec system.

Let's clarify two points. First, imagine taking a duplicate of the celestial equator (which runs all the way around the celestial sphere) and pivoting it about two points located 12 hours of RA apart on the original celestial equator. Keep pivoting until the duplicate circle is tilted 23.5 degrees from the celestial equator (it is no coincidence that this angle is equal to the tilt of the Earth’s spin axis relative to its orbital plane). This new position is the path of the Sun (and the Moon and most of the Solar System's planets and asteroids) and is called the ecliptic. The second point is that as the Sun travels along this path, it is sometimes south of the celestial equator and sometimes north. The point at which the Sun crosses the celestial equator from the south to the north is called the

Vernal Equinox and the Sun crosses this point on the first day of spring in March. The constellation Pisces is also located about this point. The point where the Sun crosses from north to south is the Autumnal Equinox (located in Virgo) and the Sun will arrive there on the first day of fall in September. Finally, the point at which the Sun reaches its greatest extent north of the celestial equator is the Summer Solstice (in Gemini and on the first day of summer in June), and the southernmost point is the Winter Solstice (in Sagittarius and the first day of winter in December).

Now it isn't convenient to carry around a 3-D celestial sphere to help locate objects in the sky, so astronomers have followed the example of their geographer colleagues and created flat (2-D) maps to represent the sky. Like the geographers' maps, the celestial sphere maps will have some distortion, but their convenience more than overshadows this shortcoming. Now to visualize how the flat constellation maps (or charts) relate to the celestial sphere, imagine taking a very large knife and cutting off the top of the celestial sphere along the 60 degrees north Dec line. Also, cut off the bottom along the 60 degrees south Dec line. Finally, cut along the RA line that runs from the 60 degrees north Dec line through the Autumnal Equinox on the celestial equator and then down to the 60 degrees south Dec line. What you basically have is a wide belt centered about the celestial equator which is now unbuckled. By laying this belt down on a flat surface (with the inside stars facing up) you have made your SC-001 Constellation Chart. Also, if you take the original celestial sphere and use your knife to cut along the 30 degrees DEC line, the northern cap when turned over and flattened on a surface gives the SC-002 Constellation Chart.

The principal lines on both your constellation charts should now be evident. On the SC-001 chart, the celestial equator (Dec = 0 degrees) runs horizontally through the middle of the chart and the other Dec lines run parallel to it. Each of the major lines of Dec are 10 degrees apart and each of the little tick marks in Dec are one degree apart. RA lines run vertically. Note that the RA hours run "backward" starting with 0 hour at the center of the chart. This is because constellation charts are to be held up to the sky to match the stars (as opposed to laying them down on a table and then having to look up and down at the sky to make comparisons). Each of the major tick marks represent 1 hour of RA and each of the little tick marks represents 5 minutes of RA. The "sine" wave curve on the SC-001 chart is the ecliptic. If you curl the SC-001 chart up to form the belt region of the celestial sphere (the curled chart will have a cylinder shape with the stars on the inside), you will notice the ecliptic is not really curved; it is just the flattening process of creating the chart that gives the illusion that the ecliptic is a curved line across the sky.

On the SC-002 chart, the Dec lines are the concentric circles centered on the north pole in the middle of the chart. RA lines are the lines emanating radially from the pole. Note the direction that the RA values increase - clockwise.

With the description of the Constellations Charts and RA-Dec system given above, you should be able to give the coordinates of any object on the charts. Likewise, given the coordinates of some object, you should be able to go to that point and find the object referenced.

Your Constellation Charts provide other information as well. For example, look at the ecliptic line on the SC-001 chart. Note that there are dates along this line. These lines tell you where the Sun is on any given day. Check that this makes sense. For instance, we know that the constellation Orion is out at night in the winter. Notice that Orion is on the left side of your SC-001 chart, while the Sun (say around January 1) is on the right side (i.e., it is in the opposite direction from the Earth with respect to Orion). Thus, Orion is up in the sky when the Sun is down.

Determining which stars are up at any given time can also be done with the SC-001 chart to a certain extent. Notice that there is a second set of dates along the bottom of the chart. Read the description of these dates in the lower left corner of your chart. What this description is telling you is if you go outside on a certain day (say February 20) and wait until 8:00 PM (standard time not daylight savings time) all the stars you see along a vertical line running through the day of interest will be on your meridian in the real sky (for February 20, Betelgeuse will be one such star). The meridian is an imaginary line in the sky that runs from the southern point on your horizon to the point directly overhead (the zenith) and ends at the northern point on your horizon. Stars generally rise out of the east, cross the meridian halfway across the sky, and then set in the west. Thus, a vertical line through a date on the bottom of the SC-001 chart will give the stars that are halfway across the sky at 8:00 PM. Stars to the east or west of the meridian are found to the east or west of the appropriate vertical line on the chart. To first order (a rough estimate to reality) stars near the western horizon will be 6 hours of RA to the right (west) of the meridian line on your SC-001 chart) and stars near the eastern horizon will be 6 hours of RA to the left (east) of the meridian line. If you run off the chart, you merely need to come in from the other side of the chart. Consequently, at 8:00 PM on any given day, you can use your SC-001 chart to get a good idea of what stars are above the horizon and which are not. For times other than 8:00 PM, you merely move your median line from the 8:00 PM position by the appropriate amount. For example, if you are interested in a 10:00 PM time on February 20, start at the 8:00 PM spot and then move to the left 2 hours of RA. You should find that Procyon in now closer to the meridian.

Another interesting feature of the charts can be found on the SC-002 chart. You should notice a dashed line labeled "Orbit of Precession of the Pole". The line expresses the fact that the Earth spins in space like a top; the Earth's north geographic pole does not always point at Polaris, but over a 25,800 year period points in other directions as well. For example, Vega will be very close to being the "North Star" around 12000 AD. Because of this precession as well as the movement of the stars through space, the RA-Dec coordinates will change over time. Your charts are labeled "Epoch 2000" to reflect this fact. However, in our lifetime, we (the observer looking at the sky with only his/her eyes) will not notice any significant changes in the star positions.

Finally, note the legend on the constellation charts. There are symbols for a variety of deep sky objects (nebulae, clusters, galaxies, variables) and the size of the dots indicates the magnitude of the stars. Note that the magnitudes go up to a dimmest value of 6. Consequently, the constellation charts are meant to show you how the sky would look to the unaided eye under perfect conditions (no clouds, smoke, etc.).