Using the SFA Star Charts and Understanding the Equatorial Coordinate System

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The SFA Star Charts are four separate charts. Chart 1 is for the north celestial region and chart 4 is for the south celestial region. These notes refer to the equatorial charts, which are charts 2 & 3 put together to form one long chart.

Every object in the sky has a coordinate. The coordinate system that uses right ascension and declination is known as the Equatorial Coordinate System.

For us living in the northern hemisphere (above the equator), the equatorial charts can be used when facing south, east or west. At the bottom of the chart, you’ll notice a series of twenty-four numbers followed by the letter “h”, representing “hours”. These hour marks are right ascension, which is the equivalent of celestial longitude. The same point on the 360 degree celestial sphere passes overhead every 24 hours, making each hour of right ascension equal to 1/24th of a circle, or 15 degrees. Each degree of sky, therefore, moves past a stationary point in four minutes. Each hour of right ascension moves past a stationary point in one hour. Every tick mark between the hour marks on the equatorial charts is equal to 5 minutes. The component values of right ascension (RA) are (h) hours, (m) minutes, and (s) seconds. The bright star, Antares, in the constellation Scorpius has a RA 16h 29m 30s.

At the left and right edges of the chart, you will find numbers marked in degrees (°) and being either positive (+) or negative(-). The 0° mark represents the bold line moving horizontally cross the center of the chart, which is the celestial equator. The celestial equator divides the sky into north (+) and south (-) in the same respect the equator divides the Earth into north and south. The numbers marked in degrees refer to declination. Declination is the equivalent to celestial latitude where the plane of the celestial equator is 0° and the north celestial pole is +90° from the celestial equator and the south celestial pole is -90° from the celestial equator. Each tick mark of declination on the equatorial charts is equal to 1 degree. Each degree can be further subdivided into 60 equal arc-minutes, and each arc-minute may be divided into 60 arc-seconds. Declination (DEC) is noted in (°) degrees, (‘) arc-minutes, and (") arc-seconds. The bright star, Antares, in the constellation Scorpius has a DEC -26° 25’ 55”.

Pick any star on your star chart and determine its RA and DEC. Use a ruler or piece of notebook paper to make a straight line from the RA marks at the bottom of the chart through the object (a star in this case) and write down the right ascension coordinate. Then do the same for the declination from the left or right edge of the chart. Don’t forget the (+) or (-) symbol for declination. Leaving the sign off is ambiguous and can be easily mistaken by others. These two pieces of information form the coordinates for that object. The coordinates for the bright star, Antares, in Scorpius would be written as follows:

α Scorpius (Antares) RA 16h 29m 30s DEC -26° 25’ 55”
Some stars have proper names and some have common names. Some stars have both. The proper name for a star is its **Bayer Designation**, which is a Greek letter combined with the name of the constellation in which it resides. Generally, the brightest star in a constellation receives the first letter in the Greek alphabet, alpha (α). The second brightest receives the second letter, (β) beta, and so on. The common name for a star is simply a name used to refer to the star. For instance, αLyrae is the brightest star in the constellation Lyrae and its common name is Vega.

The curved line moving horizontally across the equatorial charts is called the **ecliptic**. The ecliptic is the apparent path of the Sun through the sky over the course of one year. The dates along the ecliptic mark the dates the Sun is between the Earth and that point in the sky. For instance, locate November 20th along the ecliptic. On this date, the equatorial coordinates of the Sun are approximately RA 15h 38m DEC -20° 30’ . The dates along the ecliptic are only used for locating the position of the Sun.

The dates along the top of the equatorial charts will be used quite often as these dates allow us to find the stars that lie along the **meridian** for a given day. The meridian is an imaginary, stationary line that moves from the north celestial pole to the south celestial pole and through the **zenith** (whatever is directly above you) dividing the sky into east and west. If you stand so that you’re facing south or north, you’re facing the meridian (the middle of the sky).

The meridian is important because it is a reference for locating constellations in the sky. For instance, locate today’s date along the top of the chart. Note that you will have to approximate the location of the date if you cannot find the exact date printed. Generally, each tick mark
between the date marks is one day. Once you’ve established the date, imagine a line drawn from the date to the right ascension mark at the bottom of the chart. The stars on the chart that fall on this line represent the stars that are in the middle of the sky (on the meridian) for that date at 8 p.m. local time. This is why the phrase “Local Meridian for 8 PM” is located at the top of the chart.

The star charts are unaware of daylight savings time (DST). They assume that all “local time” is in reference to standard time (ST). If your location on Earth is under daylight savings time when using the charts, you must locate the right ascension for 8 p.m. then subtract one hour.

Example: On August 21st, the stars that lie along the meridian at 8 p.m. are those at RA = 18h according to the chart. If you’re under daylight savings time, however, the stars that lie along the meridian are really those at RA = 17h at 8 p.m. local time.

It’s also important to know how much of the sky you should be able to see at any given time during the night and which constellations are visible. Consider that at any given time, half of the Earth is in darkness and the other half is in sunlight. There are 24 hours of right ascension and half of 24 is 12. So, you can theoretically see about 12 hours of right ascension at any given time during the night. Since the meridian divides east and west, you can see 6 hours of right ascension to the left (east) of the meridian and 6 hours of right ascension to the right (west) of the meridian. Of course, this assumes that you do not have buildings, trees, mountains, etc. blocking your horizon.

Another frame-of-reference previously mentioned is the zenith. The zenith is the point in the sky that is directly overhead. If you know what should be overhead before you go outside to stargaze, finding constellations will be much easier. You can locate the zenith on the star chart by intersecting the current RA at the meridian with a declination equivalent to your latitude on Earth.

Example: The City of College Station is at approximately +30.5° (north) latitude on the Earth. Let’s assume that today’s date is August 30th. During the month of August, College Station is under daylight savings time; so, we must remember to take that into account. First, locate the position of stars along the meridian for this date. I will estimate this to be around RA 18h 30m. Then, one hour of right ascension is subtracted due to daylight savings time, which means the stars at RA 17h 30m are really those at the meridian for this date at 8 p.m.

Now, locate along the right (or left) edge of the star chart, DEC +30.5°, since that is my latitude on Earth. Now, imagine where a line drawn vertically from the right ascension for this date would intersect a line drawn horizontally from the declination for this latitude. Your zenith for August 30th at 8 p.m. is the intersection of these lines. At 8 p.m. on August 30th, the constellation Hercules would be nearest the zenith.

Unfortunately, it is still daylight at 8 p.m. on August 30th in College Station. So, how would you know what would be at your meridian or zenith if it were later...say, 10 p.m.? Since east is to the
left of the meridian on the equatorial charts and stars rise in the east, add one hour of right ascension for every hour after 8 p.m.. Therefore, at 10 p.m. on August 30th the stars that lie along the meridian would be those stars with a RA 19h 30m. Now, count six hours of right ascension to the left and six hours to the right of the meridian. The constellations falling within this twelve hour span of right ascension will be visible in the sky at 10 p.m.

**Estimate Rise Times Using the Equatorial Charts**

A good way to estimate when an object will rise above the horizon is to use what we’ve already learned and add a couple of simple steps. If you were asked what time the Great Nebula in Orion (M42 RA 5h 35m) will rise on August 21st in College Station, you would use the following steps:

1. Locate the RA that would be at the meridian for the given date on the chart.
2. Correct for Daylight Savings Time if necessary.
3. Locate the eastern horizon limit (add six hours to the RA from step 2).
4. Count the number of hours of right ascension from the RA from step 3 to the object.
5. Add the number of hours from step 4 to 8 p.m.
6. Add one hour to the value from step 5 (this allows time for object to rise above the horizon).

Solution: The right ascension of stars along the meridian at 8 p.m. on August 21st accounting for daylight savings time is RA 17h. The eastern horizon limit is at RA 23h. There are 6h 30m of right ascension between the eastern horizon limit and M42.

8 p.m. + 6.5 hours + 1 hour = 3:30 a.m.

Therefore, the Great Nebula in Orion will be above the horizon at 3:30 a.m. on the following day.

**Using Chart 1 (Northern Region)**

The information you’ve learned using the equatorial charts also applies to the northern region chart, except this chart is only used when facing north. Locate the date along the outer perimeter of the chart. Account for daylight savings time if necessary. Hold the chart such that the current right ascension at the meridian is pointed to the zenith (straight up). This will be the position of the constellations in the northern region.

Since the north celestial pole is directly above the Earth’s north pole, the celestial pole rises above the horizon an equal number of degrees as your latitude on Earth. Of course, if you have buildings, trees, mountains, etc. in your path, you may not be able to see the celestial pole. Polaris is a binary star system that lies very close to the celestial pole. Because it is so close to the celestial pole, we refer to Polaris as our North Star.
From our perspective in northern latitudes, some stars near the north celestial pole never fall below the horizon (set). These stars are known as circumpolar stars. Can you determine which stars are circumpolar without going outside?

**Stellar Magnitudes**

On both charts 1 & 4 in the lower right-hand corner are a series of black dots representing stars with numbers next to them.

This is the magnitude scale for all of the charts. The larger the dot, the brighter the star is in the sky. The brighter the star, the lower the number such that a 1st magnitude star is brighter than a 5th magnitude star. A 1st magnitude star is 2.512 times brighter than a 2nd magnitude star. Likewise, a 1st magnitude star is 100 times brighter than a 6th magnitude star. Under excellent seeing conditions, the unaided human eye can detect stars as faint as 6th magnitude. There are three primary types of magnitude: **apparent, visual, absolute**.

**Apparent** magnitude ($m$) is a measure of brightness as observed from Earth. It can be a physical measurement or a subjective measurement.

**Visual** magnitude ($m_v$) is measured through the visible part of the spectrum (the part of the spectrum we can see with our eyes) usually centered around 550 nanometers (5500 angstroms). Typically, star charts and atlases and planetarium computer applications are based on visual magnitudes.

**Absolute** magnitude ($M$) is the apparent magnitude an object would have if it were 10 parsecs from Earth. One parsec is equal to about 3.26 light years. This allows astronomers to compare the relative brightness of stars and other objects. For instance, the Sun has an apparent magnitude of -26 because it is so close to us. However, its absolute magnitude is about 4.
Converting Sexagesimal Coordinates to Decimal Values

RA to Decimal = hours + (minutes / 60) + (seconds / 3600)
DEC to Decimal = sign * (|degrees| + (arc-minutes / 60) + (arc-seconds / 3600))

You’ll find that there are several methods used to write equatorial coordinates. Right ascension almost always precedes declination. Therefore, leaving off the RA and DEC is a way of abbreviating coordinates. Below are a few examples of how equatorial coordinates can be written.

RA 00h 00m 00.000s DEC ±00° 00' 00.000" RA 00 00 00.000 DEC ±00 00 00.000
00h 00m 00.000s ±00° 00' 00.000"
00 00 00.000 ±00 00 00.000
00:00:00.000 ±00:00:00.000 00 00.000 ±00 00.000 00.000000 ±00.000000

Equinoxes and Solstices

The intersection of the ecliptic with celestial equator marks the equinoxes. At 0h is the vernal equinox and at 12h is the autumnal equinox. If you live in the northern hemisphere, the vernal equinox marks the transition to the summer months and the autumnal equinox marks the transition to the winter months.

The highest and lowest declinations of the Sun are the solstices. When the Sun reaches a declination of +23.5°, it is known as the summer solstice. When it reaches -23.5°, it is known as the winter solstice. On the Earth, the area between the latitudes that correspond to the solstices is known as the tropics. The 23.5° change is due to the tilt of Earth’s axis.