Re: Help with Declination Math

Source: http://sci.tech−archive.net/Archive/sci.astro.amateur/2005−06/msg00243.html

- *From*: "canopus56" <canopus56@xxxxxxxxx>
- *Date*: 3 Jun 2005 13:23:36 −0700

Mij Adyaw wrote:
> I would like to be able to perform a simple rough estimate calculation
> in my head to determine the altitude of a star in the sky at any time.
> . . . For example, I would like to calculate the altitude of Vega in the
> North−Eastern sky this evening at 04:00 UTC at my latitude of 33 degrees.
> The only information that I am given is the RA and DEC of Vega.

There is no simple algorithm to find the altitude of a celestial object, not a planet or the Moon, when the object is off of your local meridian. This is because to compute altitude from a catalogue's given declination, a 3−D spherical triangle on the imaginary surface of the celestrial sphere needs to be solved. The spherical triangle is formed by your local zenith, the object, and in your southern hemisphere case, the celestial south pole. In navigation with a sextant, solving this spherical triangle is simplified by using logarithmic lookup tables.

There is a special case in which solution of the 3−D spherical triangle is straight−forward and can be done on the back of napkin or "in your head" − when the celestial object is on your local meridian. Then the spherical triangle reduces to a 2 dimensional triangle on the great circle of your local meridian. Then altitude of the object can be estimated (ignoring atmospheric refraction) by differences involving the zenith, your latitude and the object's catalogue declination.

A simple geometric construction using my N 40 degree latitude and Vega at declination +38 deg 47 min. (or roughly declination +39°) suffices to illustrate the process. You can apply that method to your S 33 deg latitude. I hope the explanation is not too basic.

The following dragram illustrates the narrative of the geometric construction:

http://members.csolutions.net/fisherka/astronote/astromath/Decexmpl.gif

These geometric constructions are based on two sets of rights angles −

1) the right angle formed by your local zenith and local horizon.
2) the right angle formed by the celestial north or south pole and the celestial equator.

At my latitude, my zenith is at declination 40 degrees. There is a 50 degree (90−40) angle between Polaris and my local zenith. The celestial equator is 90 degrees away from Polaris. So, the angle between the celestial equator and my zenith, along my local meridian, is 40 degrees of arc and the altitude angle between the celestial equator above my local southern horizon is 50 deg (90=40+50) of arc.

An analogous situation applies to your south latitude position with respect to the South Celestial Pole.

At your latitude, your zenith is at declination −33 degrees. Along your local meridian, there is a 57 degree (abs(−90−(33))) angle between the SCP and your zenith. The celestial equator is 90 degrees away from the SCP. So, the angle between the celestial equator and your zenith, along your local meridian, is 33 degrees of arc and the altitude angle between the celestial equator above your local northern horizon is 57 deg of arc.

Vega is roughly, at 39 degrees declination. At my northern latitude, the celestial equator is at 50 degrees of arc in altitude above my local southern horizon. Vega appears at 89 degrees above my local southern horizon (39 declination plus 50 degrees altitude of the celestial equator above my local southern horizon).

An analogous situation applies to your south latitude position with respect to the Vega.

Vega is roughly, at 39 degrees declination. At your southern latitude, the celestial equator is 57 degrees of arc in altitude above your local northern horizon. Vega appears at 18 degrees above your local northern horizon (57 degrees altitude of the celestial equator minus 39 degrees declination). 18 degrees is about angle circumcized by two outstretched fists stacked next to each other or about 20 degrees of arc.

Let me know if this comports with your observed altitude of Vega as it crosses your local northern meridian. (However, at this time of the year for western hemisphere observers, Cygnus does not cross the meridian until very early in the morning.)

Once you understand these constructions, using similar simple hand−drawn diagrams, you can solve for the predicted altitude of an object, knowing it's catalogue declination, in the special case where the object crosses the meridian of your known southern latitude.

This special case does not apply to the general case where the position of the star is off of your local meridian. In those general cases, the solution of the 3−D spherical triangle on the imaginary surface of the celestial sphere, formed by your local zenith, the north or south celestial pole and the object, involves more complicated spherical

trignometry and/or the use of sextant navigation tables.

− Canopus56

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