6.4: Conversion Between Equatorial and Altazimuth Coordinates

Whereabouts in the sky will a given star be at a certain time? This as a typical problem involving conversion between equatorial and altazimuth coordinates. We have to solve a spherical triangle. That is no problem – we already know how to do that. The problem is: which triangle?

The first problem, however, arises from the phrase "at a certain time". In particular, if we want to know where a star is, for example, at 2002 November 24, at 10:00 p.m. Pacific Standard Time as seen from Victoria, whose longitude is $123^\circ\ 25'.0\ \mathrm{W}$, we need to know the *local sidereal time* at that instant.

The calculation might go something like this.

From the *Astronomical Almanac* we find that the local sidereal times at Greenwich at 0^h UT on November 25 and 26, 2002, are

November 25: $04^\mathrm{h}\ 16^\mathrm{m} 59^\mathrm{s}$
November 26: $04\ \ 20\ \ 56$

We want the local sidereal time at November $24^\mathrm{d}\ 22^\mathrm{h}\ 00^\mathrm{m}$ PST
= November $25^\mathrm{d}\ 06^\mathrm{h}\ 00^\mathrm{m}$ UT

By interpolation we find that the local sidereal time at Greenwich at that instant is $10^\mathrm{h}\ 17^\mathrm{m}\ 58^\mathrm{s}$.

The longitude of Victoria is $08^\mathrm{h}\ 13^\mathrm{m}\ 40^\mathrm{s}$, and therefore the local sidereal time at Victoria is $02^\mathrm{h}\ 04^\mathrm{m}\ 18^\mathrm{s}$.

We have overcome the first obstacle, and we now know the local sidereal time (LST).

We'll ask ourselves now what are the altitude and azimuth of a star whose right ascension and declination are α and δ. We also need the latitude of the observer (= altitude of the north celestial pole), which I'll call ϕ. The hour angle H of the star is $\mathrm{LST} - \alpha$.

The triangle that we have to solve is the triangle PZX. Here P, Z and X are, respectively, the north celestial pole, the zenith and the star. That is, we solve the triangle formed by *the star and the poles of the two coordinate systems* of interest. I draw the celestial sphere in figure VI.3 as seen from the west. I have marked in the hour angle H, the codeclination $90^\circ - \delta$, the altitude ϕ of the pole, the zenith distance z and the azimuth A measured from the north point westwards.

In triangle PZX, we know ϕ, δ and H, so we immediately find the zenith distance z by application of the cosine formula (Equation 3.5.2) and the azimuth A from the cotangent formula (Equation 3.5.5).

Problem. Show that the hour angle H of a star of declination δ when it sets for an observer at latitude ϕ is given by $\cos H = -\tan\delta\tan\phi$. This will enable you now to find the Local Sidereal Time of starset, since $\mathrm{LST} = \text{hour angle plus right ascension}$, and then you can convert to your zone solar time.

Show also that the azimuth A of starset, westward from the north point, is given by $\tan A = -\sin\phi\tan H$.

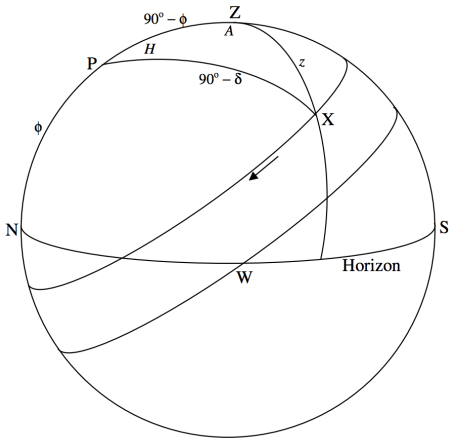

FIGURE VI.3

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