The parallactic angle and the solar observer

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This paper describes the orientation of the Sun when using an altazimuth telescope mounting, which depends on the time of day as well as the solar declination. Also explained is how the solar disk cardinal points are rotated by the parallactic angle.

Introduction

Over recent years compact telescopes for solar observing have become more popular due to their small size and light weight, especially if fitted to an altazimuth mounting. They are easily moved around the garden to take advantage of available sunlight and can easily be transported to view events such as solar eclipses. These compact telescopes are available for both white light observing (with a suitable full aperture filter) and for hydrogen alpha observing.

One disadvantage of using an altazimuth telescope mounting is that the cardinal points of the Sun (north, east, south and west) are more difficult to determine than if an equatorial type of mounting were used. With a telescope on an equatorial mounting, the top and bottom points on the solar disk are on a great circle that passes through the celestial pole. This means that the north and south cardinal points are always at the top or bottom of the solar disk and the east and west cardinal points are to the left or right. (The exact orientation depends on whether the solar image is mirrored and/or flipped.) Using an altazimuth mounting the top and bottom points on the solar disk are on a great circle that passes through the zenith. Now the cardinal points of the solar disk slowly change from sunrise to sunset. Only when the Sun is on the meridian are the cardinal points coincident with the top, bottom, left and right points of the solar disk.

Warning: never look at the Sun with the naked eye or with any optical instrument unless you are familiar with safe solar observing methods.

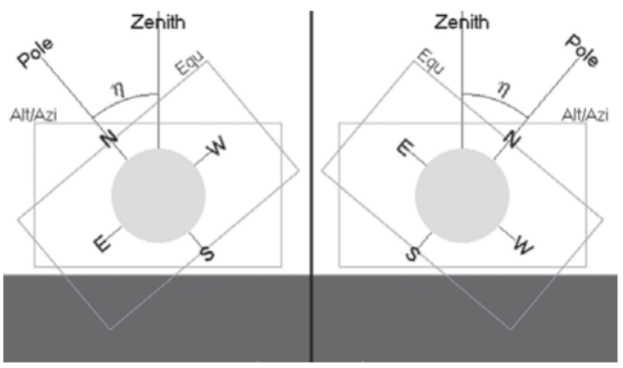

Figure 1. The naked eye view of the Sun just after sunrise *(left)* and just before sunset *(right)* at one of the equinoxes for an observer at 50°N. The two rectangles show the field of view for an alt/az and equatorial telescope mounting.

The parallactic angle

The differences in orientation of the Sun for the two telescope mounting types are illustrated in Figure 1, when the Sun has just risen and is just about to set at one of the equinoxes (i.e. when the Sun is on the celestial equator) for an observer at 50°N. For illustrative purposes, a rectangular field of view is shown for the two mounting types. The angle between these fields of view is the same angle as between the great circles that pass through the middle of the Sun and the celestial pole and the zenith. This angle is known as the parallactic angle[1] (η) and is also shown in Figure 1. Only when the Sun is on the meridian do the two fields of view coincide.

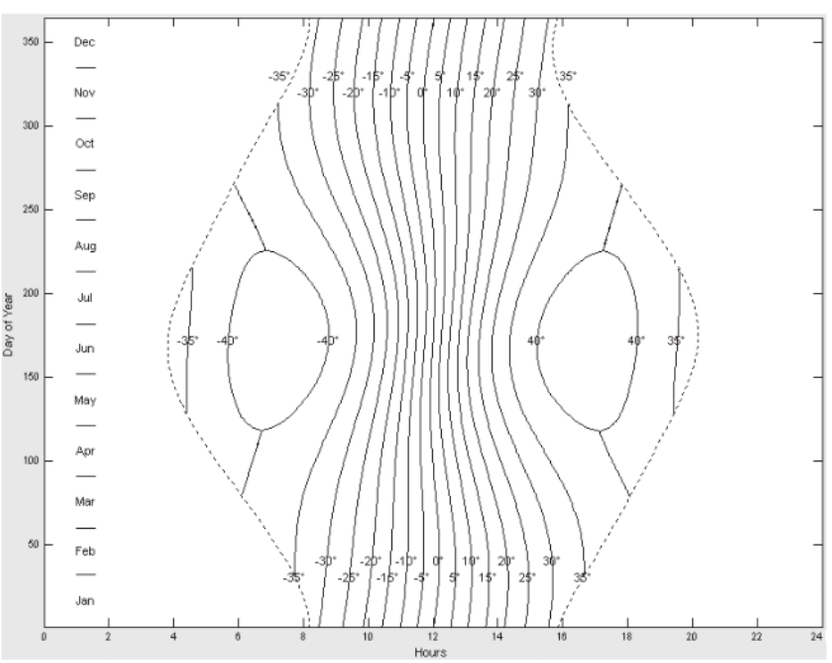

Figure 2(a). Solar parallactic angles for an observer at London (51.5°N, 0.0°E) during the period of a year. Times in UT. At this latitude the maximum and minimum values of η, which occur at the summer solstice, are −42.7° and 42.7°.

The parallactic angle can be calculated using one of the expressions given below:

$$\sin(\eta) = \sin(A).\cos(\varphi)/\cos(\delta)$$

$$\cos(\eta) = (\sin(\varphi) - \sin(\delta).\cos(z))/(\cos(\delta).\sin(z))$$

$$\cos(\eta) = (\sin(\varphi).\sin(z) - \cos(\varphi).\cos(z).\cos(A))/\cos(\delta)$$

where φ = observer latitude, δ = declination of the Sun, z = zenith distance (altitude = 90−z) and A is the azimuth angle of the Sun.

The ranges of values of the parallactic angle, η, for an observer at London and Edinburgh are shown in Figure 2. The dotted lines show when the Sun is on the horizon (i.e. at the time of sunrise and sunset). The curve for an η angle of 0° is when the Sun is on the meridian (i.e. due south). The parallactic angle has a positive value if the Sun is to the west of the meridian and negative to the east. Figure 2 also shows that η changes fastest during midsummer at the time when the Sun is on the meridian; for example at London η changes by a maximum of 19° per hour while at Edinburgh it changes by a maximum of 15° per hour. The largest parallactic angle also occurs in midsummer but much earlier and much later in the day. During midwinter the parallactic angle changes much slower when the Sun is on the meridian; for example 10° per hour for London and 8° per hour for Edinburgh.

The parallactic angle is calculated and displayed in the freeware solar observing program *Helio*.[2]

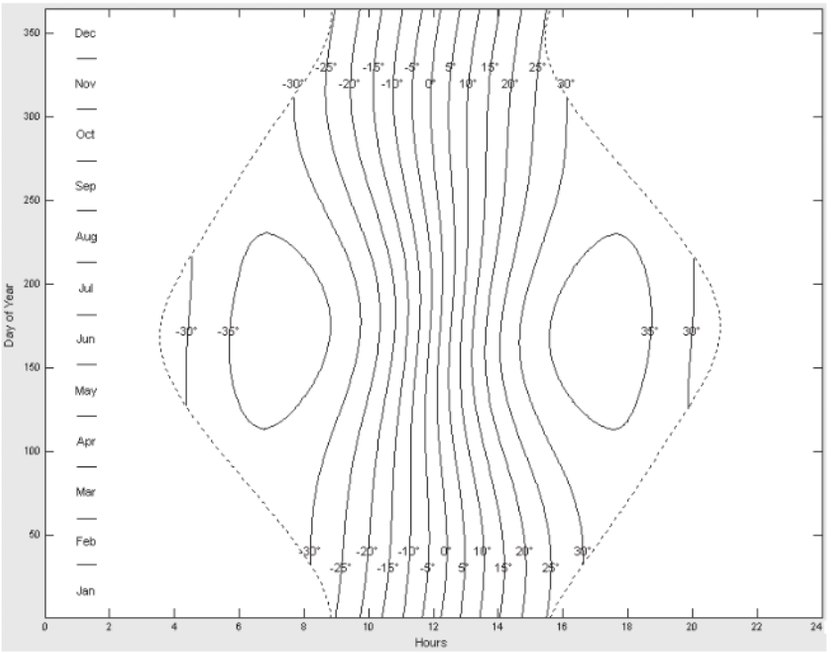

Figure 2(b). Solar parallactic angles for an observer at Edinburgh (56.0°N, 3.2°W) during the period of a year. Times in UT. At this latitude the maximum and minimum values of η, which occur at the summer solstice, are −37.6° and 37.6°.

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References

1 Smart W. M., *Text-Book on Spherical Astronomy*, fifth edn, Cambridge University Press, 1971

2 Meadows P. J., 'Solar Observing': **http://www.petermeadows.com**

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