Description of a method for determining the position of sunspots in the solar disc

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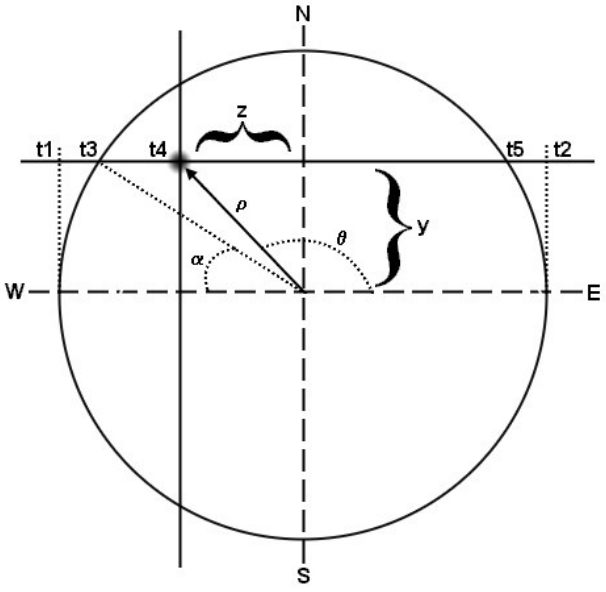
To define the position of a sunspot in the image of the solar disc we will employ polar coordinates ρ and θ, where ρ is the distance from the spot to the centre of the disc and θ is the angle formed by the line going from the centre of the disc to the spot and the East direction in the sky, measured northwards (see figure). The true position of the spots on the surface of the Sun, expressed in heliographic coordinates can be obtained from the values of ρ and θ.

Determination of ρ and θ is made through the measurement of times, as explained below.

A reticule eyepiece is used. One of its lines is oriented in the East-West direction. A reasonable orientation can be obtained by placing a sunspot at the centre of the reticule and moving the telescope back and forth around the right ascension axis and observing how much does the spot move away from the line that is being oriented in the east-west direction. The reticule is oriented correctly if the spot does not move away from the line noticeably.



Next, the reticule is centred in the sunspot whose coordinates we want to find. The telescope is moved westward until the centre of the reticule is outside the solar disc. With the tracking system of the telescope turned off, the image is left to pas across the field westward. The following times are measured: the time at which the west solar limb crosses the centre of the reticule (t_3), the time at which the spot we are interested in crosses the centre of the reticule (t_4) and finally the time at which the east limb crosses the centre of the reticule (t_5).

This procedure is repeated for all the spots whose positions we want to know.

As a final step, we measure the time at which the west limb touches the north-south oriented line of the reticule (t_1) and the time at which at which the east limb does it (t_2).

To obtain the polar coordinates ρ and θ, we will make use of the following auxiliary expressions:

$$z = \frac{t_5 - t_3}{2} - (t_4 - t_3)$$

$$\alpha = \arccos\left(\frac{t_5 - t_3}{t_2 - t_1}\right)$$

$$y = \mathrm{sen}(\alpha)\left(\frac{t_2 - t_1}{2}\right)$$

Since the method does not distinguish between spots located in the northern half of the disc from those located in the southern half, the expression for the angle θ given below depends on the sign of y. A positive y implies that the spot is on the northern half of the disc, while a negative *y* means the spot is located in the southern half.

$$\rho = \frac{2\sqrt{z^2 + y^2}}{t_2 - t_1}$$

$$\theta = \begin{cases} \frac{\pi}{2} + \mathrm{arctg}\left(\frac{z}{|y|}\right) & \text{si } y > 0 \\ \frac{3\pi}{2} - \mathrm{arctg}\left(\frac{z}{|y|}\right) & \text{si } y < 0 \end{cases}$$

The radius ρ is expressed in units of the radius of the Sun image. For example, ρ=1 means that the spot is located exactly on the limb of the solar disc.