

The Dial of Ahaz

"And Isaiah said, This sign shalt thou have of the LORD, that the LORD will do the thing that he hath spoken: shall the shadow go forward ten degrees, or go back ten degrees? And Hezekiah answered, It is a light thing for the shadow to go down ten degrees: nay, but let the shadow return backward ten degrees. And Isaiah the prophet cried unto the LORD: and he brought the shadow ten degrees backward, by which it had gone down in the dial of Ahaz" (2Ki.20:9-11).

The words *shadow*, *degrees*, *backward* and *dial* suggest reference is made to a sundial of some description that was commissioned by Ahaz. The word translated "degrees" has also been rendered as "steps".

There have been many attempts to explain how this backward movement happened, many of which suggest a miraculous interruption of the natural rotation of the earth and/or a miraculous change in the movement of the sun and moon. There are two objections to this, one being that such a disruption would interrupt the marking of time and the seasons, which, according to the Bible, was the reason given for the sun and moon, besides giving light. The other reason is that such an intervention is not necessary.

In days before clocks were in everyday use, dawn and dusk gave the start and finish of daytime activities. Noon and north could be determined by the shortest shadow cast from an object by the sun, and this allowed for a midday meal-break. No other division of the day was really needed in a slave-culture and the chief function of the sundial was to determine the passage of days.¹ This was achieved by incorporating solar declination-bands on a dial, thus 'backwards' could refer to a backwards movement of the shadow away from the normal band for that day².

There is in fact a natural phenomenon by which a shadow may move outside a declination-band and that is during a partial solar eclipse.

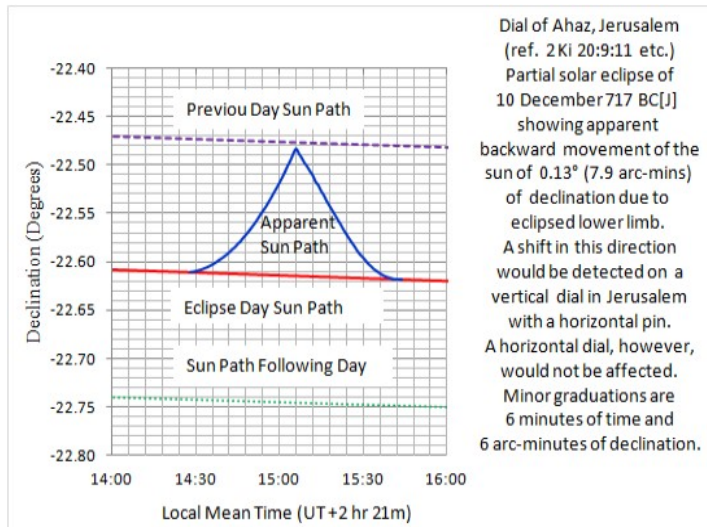
The declination of the sun increases from a maximum negative value of nearly -24° at the south solstice to a maximum at the north solstice of nearly $+24^{\circ}$. It then decreases for the rest of the solstice year. The daily change in declination is a maximum at the equinoxes when the sun crosses the equator and a minimum at the solstices when the sun reaches the furthest north or south. The date of the eclipse, therefore, has a bearing on the direction of the shift and its magnitude. The shift magnitude and direction is also determined by the distance and location of the observer from the eclipse path. The table in the appendix shows that only the combinations of the season and the position of the observer need be considered, since the sign of the declination does not alter the direction of the shift.

Hezekiah chose to see the shadow moving backwards because, *"It is a light thing for the shadow to go down ten degrees: nay, but let the shadow return backward ten degrees"* (2 Kings 20:10). This may mean that he was merely thinking of the daily movement of the shadow, or it could mean he

¹ PRICE, Derek J. Desolla. "Vistas in Astronomy" Vol. 9, p. 41

² The declination of the sun continuously varies throughout the year, with a maximum and minimum rate of change at the equinoxes and solstices respectively.

had already seen it move forward outside a declination-band. For brevity, I shall confine my analysis to horizontal and vertical sundials because this is the simplest way to show the phenomenon.

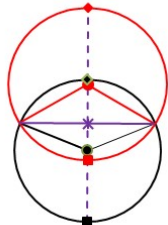


Without getting sidetracked by the chronological problems of this era, it is to be noted that there were fifteen partial solar eclipses that were viewable from Jerusalem in the period 733 to 700 BC³. Most of these show a negligible effect but the first definite viewable backward shift was the eclipse of 10 December 717 BC[J] and it appeared to show a backward motion towards the previous day's track as in the graph. Actually, the tracks are only a snapshot of the full

tracks and the eclipse day track will join up at the start of the day (in this case after the previous sunset with the previous day's track and with the next day's track after the next sunset, thus the tracks really ought to be shown as broad bands on a practical dial.

This shadow-offset would have been observable on a vertical dial fitted with a horizontal pin rather than a gnomon. This diagram is theoretical and ignores fringing and the effect of shift in the time direction. It looks to be a large shift but that is only in relation to the declination which changes quite slowly 8 days before the south solstice. The maximum shift occurs when the moon and the sun have the same azimuth as in the diagram shown. The shadow would normally be given by the bottom of the

Eclipse at Jerusalem 10 Dec 717 BC[J]



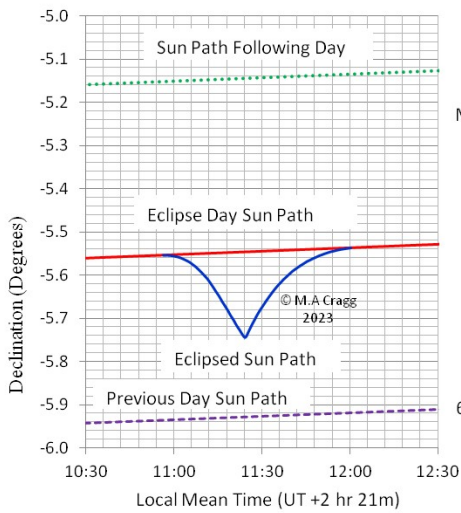
the sun but, since that is eclipsed, it is given by the lower of the two horns of the lune, which in this case are equal. It is also the maximum theoretical shift.

The total shift for the ten graduations is 0.13° which equates to a single "step" of 0.79 arc-minutes. It would require a large sundial to show this movement.

The next viewable eclipse from Jerusalem was 10 October 714 BC[J] but the small effect, if it had been viewable, would have moved the shadow forward towards the following day's track. However the eclipse of 14 March 711 BC[J] would have been viewable on a horizontal dial with a vertical pin because in this case the moon is above the sun and thus eclipses the top of the sun. This date is two weeks before the northward equinox with a negative declination, increasing towards zero at the equinox where the maximum rate of change takes place. This chart shows the effect which is smaller in relation to the daily declination movement but actually, at 0.2°, (12 arc-minutes) is larger than was the case in 717 BC. It may be significant that the width of the daytime declination-band at the northward equinox is 0.2° which gives a clue to the graduation in use. The day is slightly longer than

³ <https://eclipse.gsfc.nasa.gov/JSEX/JSEX-AS.html>

twelve hours at the equinox because of the subtended diameter of the sun and the effect of atmospheric refraction, and 0.2° is slightly more than half of the total excursion at the equinox.



Dial of Ahaz, Jerusalem (Ref. 2 Ki 20:9:11 etc.)
 Partial solar scclipse of Monday 14 March 711 BC[J]. Track showing apparent regression of the sun of 0.2 Degrees of declination due to eclipsed upper limb, as it would have appeared on a horizontal dial with a vertical pin.
 Minor graduations are 6 minutes of time and 6 arc-minutes of declination.

This eclipse is of particular interest because the path starts at latitude ~22°N, Longitude ~22°S (south and west of Jerusalem), reaches the latitude of Jerusalem at Long. ~22°E (shortly before its maximum magnitude over Greece) and continues travelling North East, reaching the longitude of Jerusalem at latitude 54° to 55°N. This steep change of path in conjunction with the theoretical observations at Jerusalem should enable a much more

accurate value for Delta T to be calculated than has hitherto been possible.

The other five eclipses down to 700BC inclusive would all cause a shadow to advance towards the following day. It appears from the above, and from the large sample of eclipses, that there are only two choices for Hezekiah's observation on the Dial of Ahaz, although I have listed five later eclipses ranging down to 689 BC, all of which could indicate a backward movement but some of these (italicised) would be negligible.

Conclusions

A natural astronomical explanation has been shown for two basic sundials that demonstrate the retrograde movement of the sun under certain conditions. Some may think that a lack of a miracle detracts from the Biblical narrative. I believe that it enhances it because it demonstrates the accuracy of the record and it was sign, not only to Hezekiah and his contemporaries, but to the later scientific generation who have the wherewithal to analyse it. The Bible is there to teach everyone, everywhere and in all generations, everything they need to know about life, death, and the whole purpose of existence.

Appendix

Eclipse Classification: 737 BC to 689 BC (Dates are given as astronomical whence BC yr = 1 – Ayear).

A. Season	M	S	D	B/F	H	V	Eclipse: Season & Position	Example Eclipse (Astronomical) Dates			
Spring	-1	1	1	B	0	1	Spring: N of Observer.	-7320515	-7230506		
Summer	1	-1	1	B	1	0	Summer: S of Observer	-7360726	-6900718	-6890718	-6890718
Autumn	1	-1	-1	B	0	1	Autumn: S of Observer.	-7161210			
Winter	-1	1	-1	B	1	0	Winter: N of Observer	-7200304	-7171222	-7100314	-6941010 -6880111
Spring	1	1	1	F	1	0	Spring: S of Observer.	-7220425	-7040505	-7010305	
Summer	-1	-1	1	F	0	1	Summer: N of Observer	-7080717	-6990806		
Autumn	-1	-1	-1	F	1	0	Autumn: N of Observer.	-7031019	-7010305		
Winter	1	1	-1	F	0	1	Winter: S of Observer	-7290314	-7171222	-7171222	-7010305

Key: M: -1 Moon above sun; 1 Moon below sun. S (Season): 1 Declination increasing, -1 decreasing.

D: 1 Positive, -1 Negative (neither affects the result). B: Back, F: Forward shift of shadow.

Condition for backward movement: M and S must be of opposite sign.