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ECLIPSE RADIUS MEASUREMENTS*

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ABSTRACT

We have improved methods for predicting the path edges and reducing observations of total solar eclipses for determining variations of the solar radius. Recently-analyzed observations of the 1925 January eclipse show a 0".7 (arc second) decrease in the solar radius during the past fifty years.

INTRODUCTION

Methods for predicting the location of the edges of paths of total solar eclipses, methods of reducing timed observations made just inside the edges of the path, and accuracies of the solar radius variations determined from these data, are described elsewhere (ref. 1). Results for the eclipses of 1715, 1976, and 1979 have been reported (ref. 2).

IMPROVED RESULTS

Our previous procedure for computing the non-spherical corrections for eclipse path edges (ref. 1) has been replaced by a non-iterative scheme and has been largely automated. Similarly, we have written computer programs to efficiently reduce reported Baily bead and contact timings, permitting more comprehensive analyses of the data. The method of reduction has been described elsewhere (ref. 3). For a reported timing, the computer programs print a plot showing the lunar limb derived from a U. S. Naval Observatory magnetic disk file of limb correction data (ref. 4), the solar limb, and a pointer indicating the lunar feature which probably caused the event.

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The selected lunar feature can be replaced with another choice, if this seems appropriate after examining the plots. See Fig. 1.

Besides the above improvements, some of our other recently-published results have been superceded because the observed events used in the analysis were not restricted to position angles within 30° of the lunar axis of rotation (ref. 5 and 6), in the polar regions where our arguments about minimal libration-dependent errors are valid, or because some of the computed results were misinterpreted (ref. 7).

THE 1925 ECLIPSE

As a result of E. W. Brown's efforts, the total solar eclipse of 1925 January 24 was well-observed from sites near both the northern and southern limits (ref. 8). Brown noted that the observations determined the location of the actual path edges very accurately, but that the result could not be used due to lack of knowledge of the location of the lunar valley bottoms, which caused the observed contacts, with respect to the moon's center of mass. Although the southern-limit observations made from New York City were published (ref. 9), the reports from the northern limit collected by Brown have apparently been lost. Fortunately, we found a report made at a professional observatory situated very close to the northern limit (ref. 10). We have measured the positions of the observers from 1:24,000-scale topographic maps of the U. S. Geological Survey. These positions are accurate to about 1" in geographic latitude, which contributes an error of only 0".01 to our determination of the solar radius from the observations.

The correction to the standard solar radius (959".63 at a distance of 1 astronomical unit) derived from the 1925 eclipse, along with improved values for the corrections for previously-studied eclipses, and the standard errors of the corrections, are given in Table 1. The lunar valleys which produced the observed contacts at the limits of the 1925 eclipse also produced events which were timed in 1979 (two contacts and one Baily bead event) and in 1980 (three Baily bead events). The solar radius corrections derived from solutions using only these observations are also listed.

CONCLUDING REMARKS

While no significant change in the solar radius can be deduced from observations of recent eclipses, the data show that the radius decreased by at least 0".5 (0.05% or 350 km) between 1925 and 1979. These two eclipses have special significance since they are three Saros cycles apart, producing similar geometries, especially similar lunar librations. The decrease is 0".70 ±0".13 if all polar timings are used. This result is confirmed (0".51 ±0".24), to less precision, if only those lunar features producing observed events during both eclipses are used. Unlike the result for the 1715 eclipse, there is no significant uncertainty in the coordinates of the observers of this century's eclipses. The physical significance of variations of the solar radius is discussed in other papers in these proceedings.

REFERENCES

1. Sofia, S.; Dunham, D. W.; and Fiala, A. D.: Determination of Variations of the Solar Radius from Solar Eclipse Observations. Proc. Conf. Ancient Sun, 1980, pp. 147-157.

2. Dunham, D. W.; Sofia, S.; Fiala, A. D.; Herald, D.; and Muller, P. M.: Observations of a Probable Change in the Solar Radius Between 1715 and 1979. Science, vol. 210, no. 4475, 12 Dec. 1980, pp. 1243-1245.

3. Herald, D.: Observations of Baily's Beads from Near the Northern Limit of the Total Solar Eclipse of June 20, 1974. The Moon, vol. 16, 1976, pp. 91-100.

4. Watts, C.B.: The Marginal Zone of the Moon. Astron. Papers Amer. Ephem., vol. 17, 1963.

5. Fiala, A. D.; Dunham, D. W.; and Dunham, J. B.: Preliminary Results from Observations made near the Edges of the Path of the 1980 February 16 Total Solar Eclipse. Bull. Amer. Astron. Soc., vol. 12, no. 2, 1980, p. 474.

6. Fiala, A. D.; Dunham, D. W.; and Dunham, J. B.: Observations of Baily's Beads from the Edges of the Path of the Total Solar Eclipse of 1980 February 16. Bull. Indian Astron. Soc., vol. 8, no. 2&3, 1980, pp. 81-82.

7. Dunham, J. B.; Dunham, D. W.; and Fiala, A. D.: Solar Radius Variations from Observations of Four Eclipses. Bull. Amer. Astron. Soc., vol. 12, no. 4, 1980, p. 832.

8. Brown, E. W.: Discussion of Observations of the Moon at or near the Eclipse of 1925 January 24. Astron. J., vol. 37, 1926, pp. 9-19.

9. Magalhaes, F. V.; Law, C. L.; and Lieb, J. W.: Observations of the Total Solar Eclipse of January 24, 1925, made by Electric Companies Affiliated with the Consolidated Gas Company of New York. Trans. Illumin. Eng. Soc., vol. 20, no. 6, 1925, pp. 565-628.

10. Seagrave, F. E.: Short Eclipse Notes: At North Scituate, Rhode Island. Pop. Astron., vol. 33, 1925, p. 279.

TABLE I. SOLAR RADIUS CORRECTIONS DETERMINED FROM OBSERVATIONS NEAR ECLIPSE PATH EDGES

Date	Timings within 30° of lunar axis		Timings using features determining 1925 events		Lunar librations	
	No.	$\Delta r_\odot$	No.	$\Delta r_\odot$	long.	lat.
1715 May 3	4	+0".52 ±0".2	0	--	+1°.8	-0°.2
1925 Jan. 24	4	+0.62 ±0.08	4	+0".62 ±0".08	+2.5	-0.2
1976 Oct. 23	15	-0.23 ±0.14	0	--	-1.4	+0.1
1979 Feb. 26	33	-0.08 ±0.09	3	+0.11 ±0.23	+1.7	-0.3
1980 Feb. 16	55	-0.03 ±0.04	3	-0.05 ±0.35	-3.0	-0.1

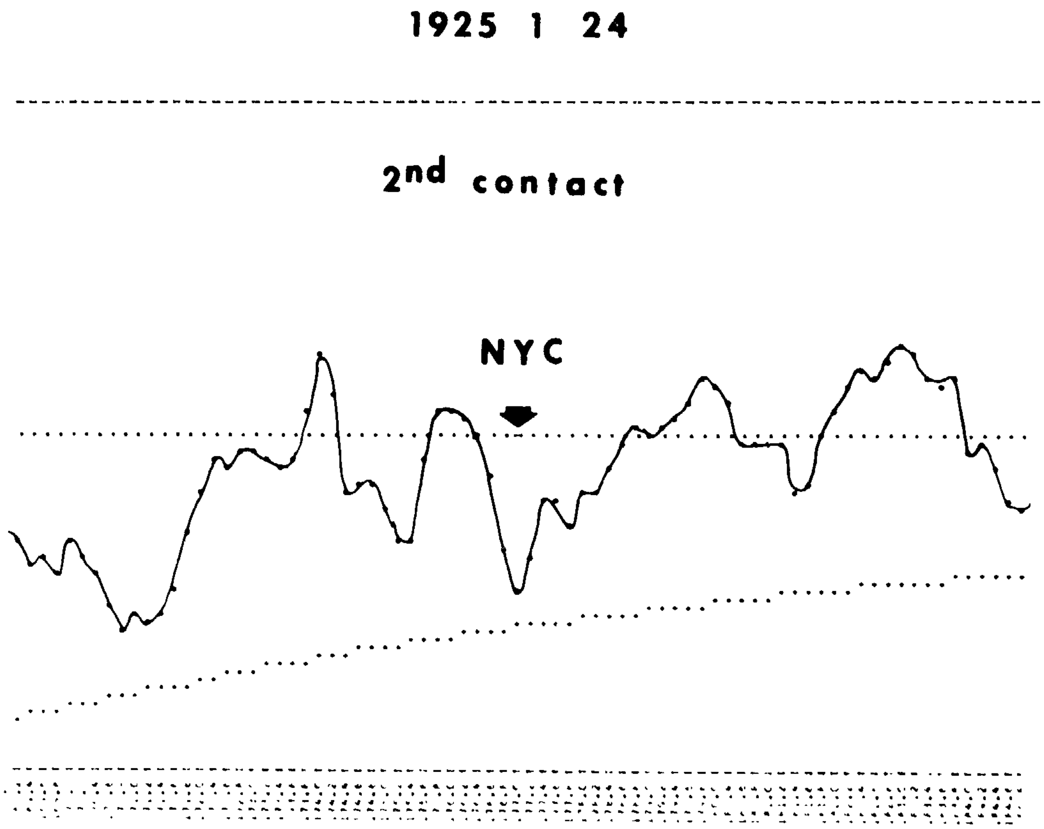

Figure 1. This printer plot shows the predicted positions of the lunar and solar limbs computed for the time of second contact for the observer in New York City closest to the southern limit of the 1925 January 24th total eclipse path. The horizontal line of dots marks the Moon's mean limb. Sideways I's at the top and bottom indicate distances 4" above and below the mean lunar limb, respectively. Asterisks connected with a hand-drawn curve show the actual lunar profile according to Watts' charts (ref. 4). Pluses mark the solar limb. The vertical scale is exaggerated 27 times relative to the horizontal scale. Position angles measured in degrees from the Moon's northern axis as defined by Watts are given at the bottom. The dot in the mean limb line which is replaced by a sideways number 1 indicates the computer-selected choice of the valley which produced second contact, where the predicted separation of the actual lunar limb and the solar limb was minimized.