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8 October 1953

HIGH ALTITUDE OBSERVATORY

Solar Research Memorandum

From: J. H. Rush

Subject: Utilization of Transit of Mercury for Research Purposes.

This memorandum summarizes the results of recent discussions among the HAO staff and others, particularly Roberts, Billings, Athay, Cooper, Hawkins, and J-C. Pecker.

I. Essential data on the transit. (more details in 1953 Ephemeris, p. 364,365.)

Date: 14 November 1953.

A. Time (approx.; see Ephemeris): Ingress, first contact, 1537 UT
Egress, fourth contact, 1811
Least distance of centers 1654
Apparent speed of Mercury relative to sun .085" per second.

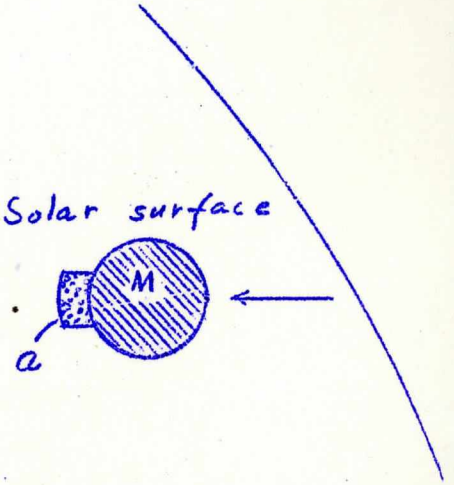
B. Position: Ingress, first contact, 51° 09' E of N Point
Egress, fourth contact, 4° 44' W of N Point

C. Dimensions: Sun's semidiameter 16' 10.21"
Mercury's semidiameter 4.93"
Least distance of centers 14' 21.5"

II. Possible utilizations.

A. Solar disk.

1. Hawkins has suggested that observations of the passage of the planet across the granulation might afford a means of estimating the dimensions of granular detail which is not directly resolved in photographs. In the figure, a small aperture (a) would be placed at the leading or trailing limb of the planet, and the time-fluctuations of light from this area analyzed. This analysis could be done directly by photometry - a tough instrumental job; or by microdensitometry of rapid-sequence pictures. We assume, on



the basis of turbulence theory, that the area (a) would include space-integrated light from unresolved granules, of the order of 0.1" in diameter, having considerable intrinsic contrast with the intervening space. Thus, so far as such fine detail is concerned, the illumination over (a) might be practically uniform, so that if (a) were moved across the disk no appreciable variation in the emission within the area would be noted. If, however, (a) is placed at the leading or trailing limb of the planet, the occultation of each invisible granule should subtract an appreciable fraction from the light passing through (a). The record of such abrupt fluctuations produced by occultation of unresolved details might, we believe, be sufficiently good to permit one at least to decide whether such sub-pictorial detail exists. Since the apparent speed of the planet across the sun is about 1/12" per second, and any unresolved detail must be assumed to be closely spaced, a picture rate of about 1/sec would be necessary to detect detail of the order of 0.1".

Seeing fluctuations would complicate the problem by introducing distortions of shape and brightness; but it should be possible to evaluate the seeing contributions by comparing the fluctuations observed at the limb of the planet with those occurring concurrently in one or more adjacent areas slightly removed from the limb. One problem is to keep the area (a) constant, since it must include the limb, but any variable obscuration of (a) by the limb would introduce spurious fluctuations in the light curve.

Of course, any photography even of the recognized granulation in the 0.1"-range requires very good seeing. The possibility of success in the suggested procedure during the transit therefore is not great; and it is worsened by the fact that the path of the transit lies so close to the limb of the sun. But the importance of the problem is such that any means of resolving it is worth considering where it has any chance of success. Various observational data, particularly that reported recently by Macris[1], indicates that the smallest observed granulation occurs most frequently at about 1.4", and does not extend much below 1"; but the theory of convection transport of energy through the photosphere, when applied to the known data on the granulation, appears to require that most of the energy be transported by turbulence cells

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1. C. Macris, Ann. d'Astroph. 16 19 1953

below the present limit of resolution - perhaps of the order of 0.1".[2]

2. Some useful information on the effects of seeing might be obtained from photographs of the granulation with the planet superimposed. The known disk of the planet would provide a precise basis for studying and possibly calibrating the effects of seeing on the granular structure itself.

B. Solar atmosphere.

1. If the planet approaches or leaves the sun through a prominence or a field of spicules, this circumstance might afford a means of estimating the dimensions of prominence filaments or spicule details below the limit of pictorial resolution, by the scheme discussed above with application to the granulation. Instead of granules, thin filamentary segments across the aperture (a) would be occulted by the planet. The fluctuations of light from this process would not be so abrupt as in the occultations of granules, but still might yield some indication of structure. The same problem of compensating for the effects of seeing would apply. If filaments lay, not perpendicular to the path of the planet, but with a component parallel to it, then the indicated dimension would be greater than the actual, and the fluctuations less abrupt. The method suggested would give only an upper limit, so far as this factor is concerned.

2. Billings suggests that the passage of the planet across the corona might offer an opportunity to obtain an absolute measurement of terrestrial scattering, free from the contribution of the corona. Measurement would be difficult, because of the small size of the disk of the planet, within which scatter brightness would have to be measured; and it might be very difficult to locate the planet accurately before the beginning of its transit of the disk. Its path might be plotted by extrapolation at the end of the transit; but in any case some nice instrumental work seems to be indicated.

III. General remarks.

Most, if not all, of the special observations of the type proposed here could be done during even a partial eclipse as well as during a transit. However, the transit offers the opportunity to a large number of fixed observatories, with all the advantages of economy, use of familiar and proved instruments, and absence of distracting circumstances that go with a fixed location.

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2. Richardson and Schwarzchild, Ap. J. 111 351 1950.

HAO proposes to try for H-alpha movies of the transit through the region immediately above the chromosphere, so far as visibility permits; and for white-light movies of the granulation if seeing should be good enough to justify. We hope that these suggestions will be of use to others who are interested in the transit; and we will appreciate any comments or further suggestions.

Distribution: Roberts, Rush, Billings, Athay, Dr. and Mrs. Pecker, Trotter, Hawkins, Cooper, Roy Lee, Climax(2), Evans(3), Miller(3), Menzel, B. Bell, Dunn, Warwick, Schnable.