ΣΥΝΕΔΡΙΑ ΤΗΣ 19ΗΣ ΜΑΪΟΥ 1977

ΠΡΟΕΔΡΙΑ ΠΕΤΡΟΥ ΧΑΡΗ

ΑΣΤΡΟΝΟΜΙΑ.— **Measurements of the zenith brightness during the annular solar eclipse of April 29, 1976 at Thera - Greece,** *by Constantin J. Macris and Theodosius G. Zachariadis**. Ἀνεκοινώθη ὑπὸ τοῦ Ἀκαδημαϊκοῦ κ. Ι. Ξανθάκη.

A B S T R A C T

In this paper we give the results of the measurements of the zenith brightness in the wavelengths 6305 Å, 5575 Å, and 5250 Å, during the annular solar eclipse of April 29, 1976.

1. INTRODUCTION

After the total eclipse of June 19, 1936 and annular solar eclipse of May 20, 1966, the annular solar eclipse of April 29, 1976 is the last of this century, visible in Greece.

All elements for the annular solar eclipse of April 29, 1976 was calculated by Elias (1975). The climatological data were given by the Meteorological Institute of the National Observatory of Athens and the Greek Meteorological Service.

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* Κ. Ι. ΜΑΚΡΗ καὶ Θ. Γ. ΖΑΧΑΡΙΑΔΗ, **Μετρήσεις τῶν λαμπροτήτων τοῦ ζενίθ κατὰ τὴν διάρκειαν τῆς δακτυλιοειδοῦς ἡλιακῆς ἐκλείψεως τῆς 29ης Ἀπριλίου 1976, εἰς Θήραν.**

The Research Center for Astronomy and Applied Mathematics of the Academy of Athens organized a mission for the observation of the eclipse which has been financially supported by Empirikion Foundation and partly by the Ministry of Culture and Science. The staff of the mission were: C. J. Macris, Th. G. Zachariadis, M. Pesmatzoglou and P. Daniel. We settled on the island of Thera and at the region Acrotiri from where the central line of the eclipse zone was passing. This zone had a width of 225 km.

The phases of the eclipse were: First contact $8^h 56^m 11^s$, second contact $10^h 41^m 53{,}2^s$, third contact $10^h 48^m 29{,}3^s$ and fourth contact $12^h 33^m 06{,}1^s$ U.T. The annular phase took place at $10^h 45^m 12{,}25^s$ U.T.

In this paper we report the observations of the zenith sky intensity during the eclipse at three wavelengths, 5250 Å, 5575 Å and 6305 Å, using interference filters. The last two filters included the lines of the ionized oxygen 5575 Å and 6305 Å.

During April 27, 28 and 29, 1976 the sky was clear, only during the eclipse a small cloud passed from the point of zenith for a while without disturbing the observation.

2. INSTRUMENTATION

The photometers used for the eclipse observation were 1) The Link photometer (1958) where the photomultiplier is EMI 6094 B. The signal from the photomultiplier was being amplified and written down by a recorder EZ2. 2) The Fecker electrophotometer with a 1 P 21 photomultiplier whose indications after amplification was given on a milliamperometer. The Fecker photometer belongs to the Laboratory of the University of Saloniki, and was offered for our facilitation.

All field measurements have been made with the instruments pointing at a small region around the zenith.

The observations with the Link photometer were made with two interference filters: 5575 Å (transmission 15 %) and 6305 Å (transmission 10 %) and bandwidths 80 Å.

For the decrease of the brightness of the sky we used during the observation ($8^h 30^m$ - $12^h 40^m$ U. T.) a neutral filter (transmission 3 %) along with the 5575 Å filter.

The Link photometer was calibrated with a standard source. The indications of the wedge and the shunt of the photometer as well as of the used filters were expressed in optical densities.

The Fecker photometer measured the change of the zenith brightness with the filters 5250 Å (transmission 10%) and 6305 Å (transmission

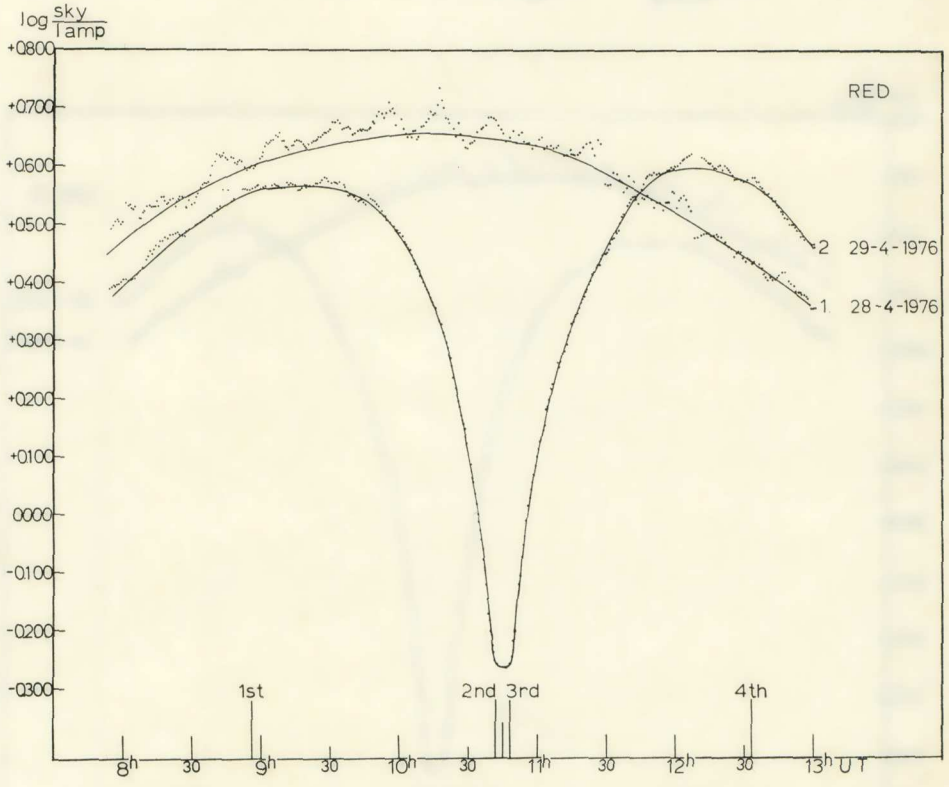

Fig. 1. The light brightness of the zenith during the eclipse day (April 29) and the previous one (April 28) for the red filter, 6305 Å (Link photometer).

10%). A series of neutral filters of known transmission were used for the decrease of the sky brightness.

3. RESULTS

The results of the measurements made by the Link photometer are given in figures 1 and 2 respectively for the wavelengths 6305 Å and

5575 Å for the same day of the eclipse April 29, 1976 as well as the previous one April 28, 1976 from $8^h 40^m$ till 13^h U. T.

The change of the zenith intensity for every moment was calculated by the relation :

$$\log \frac{\text{sky}}{\text{lamp}} = \log \frac{ds}{dl} + n_s - D - N + S_s + S_l$$

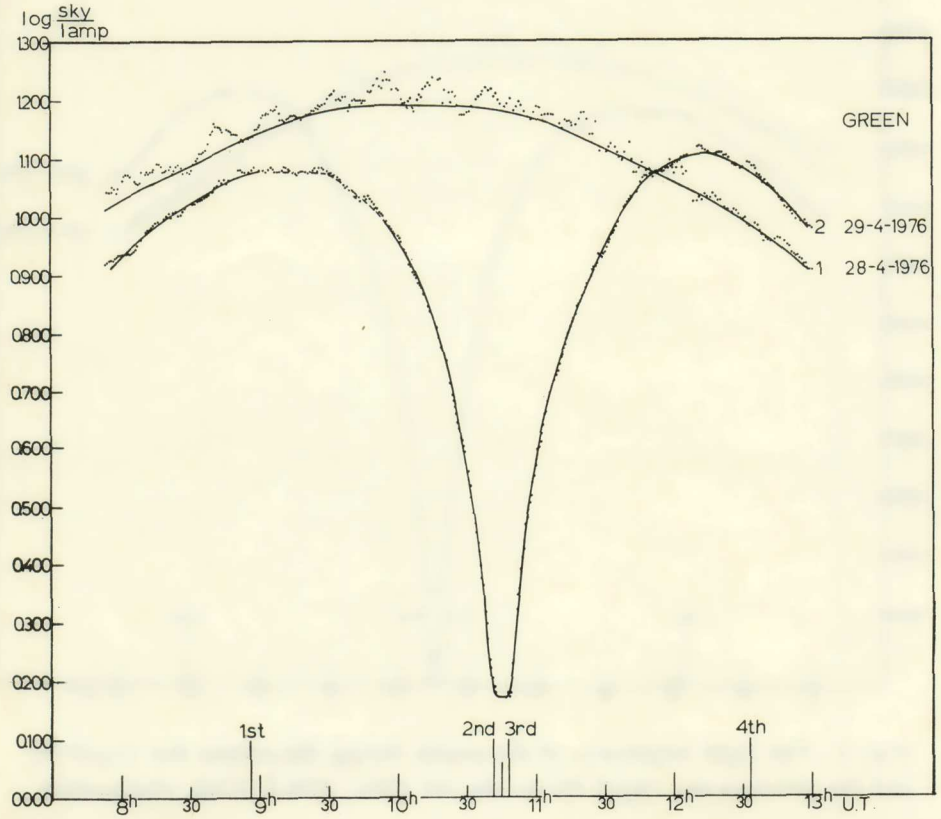

Fig. 2. The light brightness of the zenith during the eclipse day (April 29) and the previous one (April 28) for the green filter 5575 Å (Link photometer).

where ds, dl are the lengths of the pen deviations of the recording system for sky light and the light of the standard sourse respectively, n_s the optical density of the filter for the sky light, D the indication of the wedge of the photometer given in optical density for the coresponding interference filter, N the optical density of the filter of the standard

sourse whenever it is used, Ss and Se the shunt indications for the sky light and for the light of the standard source respectively exressed in

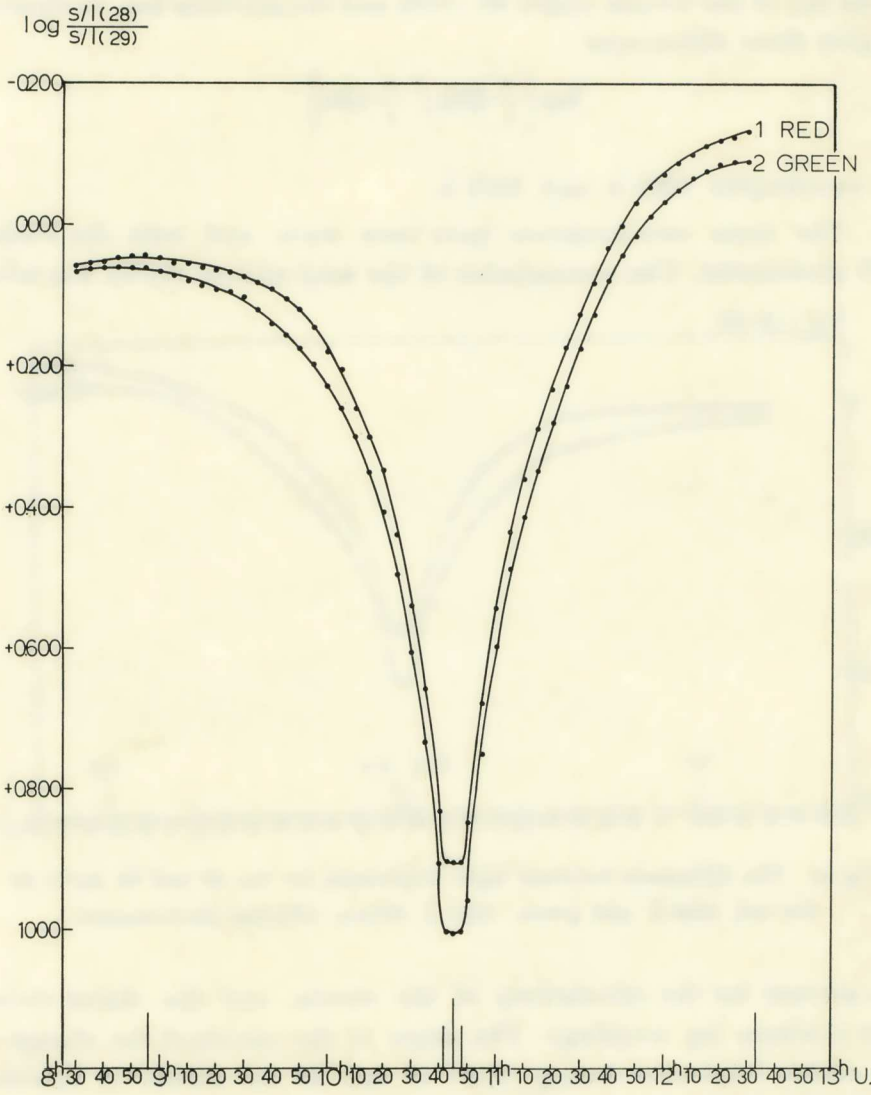

Fig. 3. The difference between light brightness for the 28 and 29 April for the red, 6305 Å and green (5575 Å) filters.

optical densities. In the previous relation we can eliminate the parameters that are not used.

In this way we determined the values log (Sky/lamp) for all the measurements we made.

From figures 1 and 2 we determined the differences of log (Sky/lamp) on the day of the eclipse (April 29, 1976) and the previous day. In figure 3 we give these differences

$$\log\left[\frac{s}{l}(28) \Big/ \frac{s}{l}(29)\right]$$

for wavelengths 6305 Å and 5575 Å.

The same measurements have been made and with the Fecker 1P21 photometer. The transmission of the used neutral filters was taken

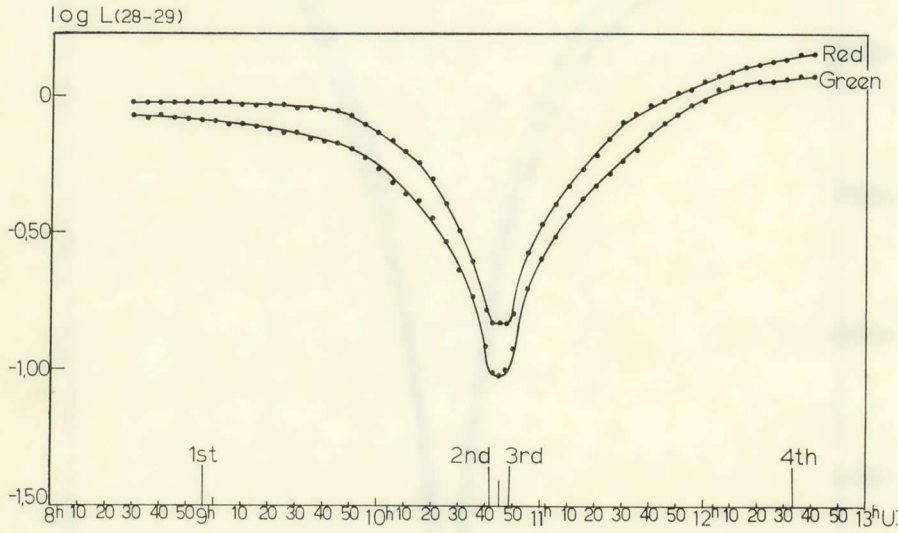

Fig. 4. The difference between light brightness for the 28 and 29 April for the red, 6305 Å and green, 5250 Å filters. (Fecker photometer).

into account for the calculations of the results, and the drawn curbes have abscissae log (reading). The shape of the curves of the change of the zenith brightness during April 28 and 29 are similar to figures 1 and 2. From the curves we determined the difference of log (reading) between the measurements of April 28 and 29. The differences log (28 - 29) for the filters 6305 Å and 5250 Å are given in figure 4. If we examine figures 3 and 4 we see that during the phases of the eclipse as well as during the main phase, when 89% of the solar disc was covered, the

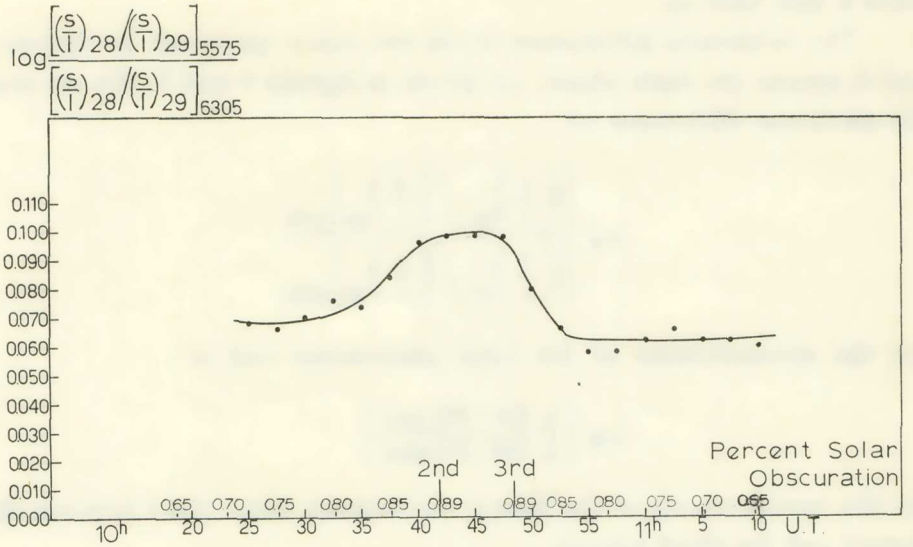

Fig. 5. The difference of the zenith brightness at 5575 Å and 6305 Å by the time of annular phase. (Link photometer).

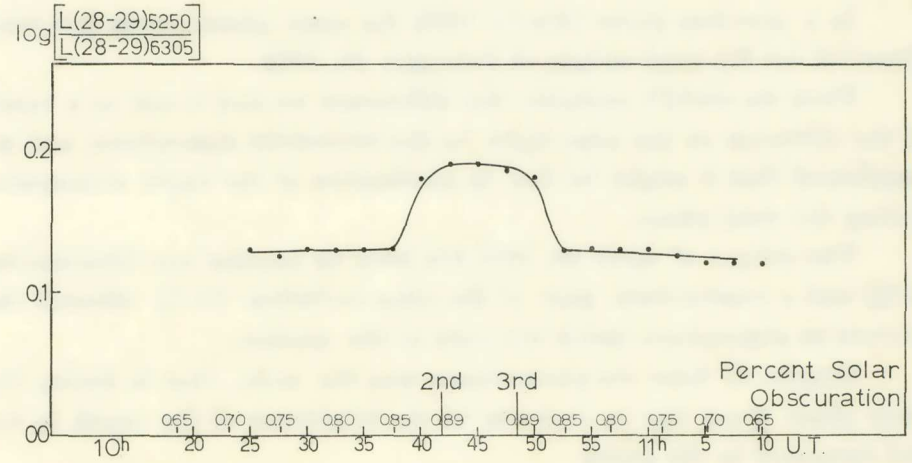

Fig. 6. The difference of the zenith brightness at 5250 Å and 6305 Å by the time of annular phase. (Fecker photometer).

brightness of the sky in greater in the red (6305 Å) that in the green (5575 Å and 5250 Å).

The brightness differences of the two colors measured in figures 3 and 4, arouns the main phase, are given in figures 5 and 6. We see that the maximum difference of

$$\log \frac{\left[\left(\frac{s}{l}\right)_{28} \Big/ \left(\frac{s}{l}\right)_{29}\right]_{5575}}{\left[\left(\frac{s}{l}\right)_{28} \Big/ \left(\frac{s}{l}\right)_{29}\right]_{6305}}$$

for the measurements of the Link photometer and of

$$\log \left[\frac{L\,(28-29)_{5250}}{L\,(28-29)_{6305}}\right]$$

for the measurements of the Fecker photometer taken place between the second and the third contact.

4. DISCUSSION

The measurements as one can see from figures 5 and 6, show that the difference green-red during the main phase increases.

In a previous paper (Macris 1955) the same phenomenon had been observed for the total eclipse of February 25, 1952.

Then we could't explaine the difference we had found as a result of the diffusion of the solar light by the terrestrial atmosphere, and we mentioned that it might be due to phenomena of the upper atmosphere during the total phase.

The eclipse of April 29, 1976 has been an annular one (obscuration 89%) and a consequence part of the solar radiation (11%) affected the terrestrial atmosphere inside the cone of the shadow.

Despite all these the phenomenon was the same, that is during the main phase there was an increase of the brightness of the zenith in the red compared to the green.

The measurements during the total eclipse of November 12, 1966 and March 7, 1970 (Velasquez, 1971, Lloyd and Silverman, 1971 and

Hall, 1971) give during the total phase a shift of the brightness of the sky in the zenith to the longer wavelength, from 4600 Å to 5400 Å and also a shift to the shorter wavelengths from 5400 Å to 6300 Å (Lloyd and Silverman).

Velasquez curves give also greater brightness of zenith in the red before the total phase while during the totality the brightness becomes greater in the shorter wavelengths.

Hall gives about the same results between blue and green. He notices however that it depent also from the solar elevation angle.

The annular eclipse of the April 29, 1976 can be considered as a pretotality phase of the total eclipse thus the measurements we made agree with the results of the above authors conserning the totality phase.

The cause of this phenomenon is about to be studied. We will try to find out whether the difference of the brightness of the zenith between green and red can be due to the difusion of the solar light outside the cone of the shadow or whether it is due to phenomena of the upper atmosphere concerning the ionization of the oxygen atoms because of the solar vadiation and their recombination during the eclipse.

The answer to this phenomenon is important and will progress the study of the upper atmosphere.

ACKNOWLEGEMENTS

We have the pleasure to express our gratitude to Empirikion Faundation for its financial support which enabled the realization of the present work.

We would also like to express our thanks to the Ministry of Culture and Science wich supported partially the present investigation.

ΠΕΡΙΛΗΨΙΣ

Κατὰ τὴν διάρκειαν τῆς δακτυλιοειδοῦς ἐκλείψεως τοῦ Ἡλίου τῆς 29ης Ἀπριλίου 1976, ἐμετρήθη ἡ λαμπρότης τοῦ ζενὶθ συναρτήσει τῶν φάσεων τῆς ἐκλείψεως, διὰ τῆς χρησιμοποιήσεως τῶν φωτοηλεκτρικῶν φωτομέτρων Link καὶ Fecker.

Αἱ μετρήσεις ἐξετελέσθησαν εἰς μονοχρωματικὸν φῶς διὰ τῆς χρησιμοποιήσεως ἡθμῶν συμβολῆς Schott τῶν ὁποίων ἡ διαπερῶσα ταινία ἀνέρχεται εἰς 80 Å. Ἐχρησιμοποιήθησαν οἱ ἡθμοὶ 5575 Å καὶ 6305 Å εἰς τὸ φωτόμετρον Link καὶ οἱ ἡθμοὶ 5250 Å καὶ 6305 Å εἰς τὸ φωτόμετρον Fecker.

Ἐχαράχθησαν αἱ καμπύλαι μεταβολῆς τῆς λαμπρότητος τοῦ οὐρανοῦ εἰς τὸ ζενὶθ κατὰ τὴν 28ην Ἀπριλίου, ἥτις ἐλήφθη ὡς ἡμέρα συγκρίσεως καὶ κατὰ τὴν ἡμέραν τῆς ἐκλείψεως.

Ἡ διαφορὰ τῶν τιμῶν τῶν λαμπροτήτων τοῦ ζενὶθ μεταξὺ 28ης καὶ 29ης Ἀπριλίου, κεχωρισμένως διὰ τὰ δύο χρώματα, ἀφ' ἑνὸς μὲν ἀπεκάλυψε τὴν πορείαν τοῦ φαινομένου, ὡς δεικνύουν αἱ δημοσιευόμεναι καμπύλαι, ἀφ' ἑτέρου δὲ ἔδειξεν ὅτι ἡ λαμπρότης τοῦ οὐρανοῦ εἰς τὸ ζενίθ, καθ' ὅλην τὴν διάρκειαν τῶν φάσεων τῆς ἐκλείψεως, ὑπῆρξε μεγαλυτέρα εἰς τὸ ἐρυθρόν, λαμβάνει δὲ τὴν μεγαλυτέραν τιμὴν μεταξὺ τῆς 2ας καὶ 3ης ἐπαφῆς.

Ἡ αἰτία ἡ προκαλοῦσα τὸ φαινόμενον θὰ μελετηθῇ εἰς ἑπομένην ἐργασίαν.

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Ὁ Ἀκαδημαϊκὸς κ. **Ἰω. Ξανθάκης** παρουσιάζων τὴν ἀνωτέρω ἀνακοίνωσιν εἶπε τὰ ἑξῆς:

Ἡ παροῦσα ἔρευνα ἀναφέρεται εἰς τὴν μεταβολὴν τὴν ὁποίαν ὑπέστη ἡ λαμπρότης τοῦ οὐρανοῦ εἰς τὸ ζενὶθ κατὰ τὴν διάρκειαν τῆς δακτυλιοειδοῦς ἐκλείψεως τοῦ Ἡλίου τῆς 29ης Ἀπριλίου 1976.

Τὸ Κέντρον Ἐρευνῶν Ἀστρονομίας καὶ Ἐφηρμοσμένων Μαθηματικῶν τῆς Ἀκαδημίας Ἀθηνῶν, ἔλαβε μέρος εἰς τὴν παρατήρησιν τῆς ἐκλείψεως καὶ ὀργάνωσε ἀποστολὴν ἐκ τῶν κυρίων Μακρῆ καὶ Ζαχαριάδη εἰς τὴν νῆσον Θήραν (Σαντορίνην), ὅπου ἐγκατέστησε δύο κατάλληλα πρὸς τὸν σκοπὸν αὐτὸν φωτοηλεκτρικὰ φωτόμετρα. 1) Τὸ φωτόμετρον Link μὲ φωτοπολλαπλασιαστὴν EMI 6094 B καὶ αὐτογραφικὸν σύστημα μεγάλης εὐαισθησίας. 2) Τὸ φωτόμετρον Fecker μὲ φωτοπολλαπλασιαστὴν 1P 21 τοῦ ὁποίου αἱ ἐνδείξεις ἐλαμβάνοντο δι' ἀμέσου ἀναγνώσεως ἐπὶ μιλιαμπερομέτρου. Ἡ ἔκλειψις εἰς τὴν νῆσον Θήραν, διὰ τῆς ὁποίας διήρχετο ἡ Κεντρικὴ γραμμὴ τῆς σκιᾶς τῆς Σελήνης, ἤρχισεν εἰς τὰς $8^h\,56^m\,11^s$ καὶ ἐτελείωσεν εἰς τὰς $12^h\,33^m\,06^{sec}$ U. T. Ἡ δακτυλιοειδὴς φάσις ἔλαβε χώραν τὴν $10^h\,45^m\,12{,}25^s$ U. T.

Ἡ μεταβολὴ τῆς λαμπρότητος μιᾶς μικρῆς περιοχῆς τοῦ οὐρανοῦ εἰς τὸ Ζενὶθ ἐμετρήθη κατὰ τὰς διαδοχικὰς φάσεις τῆς ἐκλείψεως εἰς μονοχρωματικὸν φῶς, διὰ τῆς χρησιμοποιήσεως ἡθμῶν συμβολῆς Schot τῶν ὁποίων ἡ διαπερῶσα ταινία ἀνήρχετο εἰς 80 Å. Εἰς τὰς ἐκτελεσθείσας μετρήσεις διὰ τοῦ φωτομέτρου Link ἐχρησιμοποιήθησαν οἱ ἡθμοὶ 5575 Å καὶ 6305 Å. Ἡ διαπερῶσα ταινία τῶν ἡθμῶν αὐτῶν περιεῖχε τὰς γραμμὰς 5575 Å καὶ 6305 Å τοῦ ἰονισμένου ὀξυγόνου. Εἰς τὰς ἐκτελεσθείσας μετρήσεις διὰ τοῦ φωτομέτρου Fecker ἐχρησιμοποιήθησαν οἱ ἡθμοὶ 5250 Å καὶ 6305 Å. Ἡ διαπερῶσα ταινία τοῦ πρώτου ἡθμοῦ ἀπετέλει μέρος τοῦ συνεχοῦς φάσματος.

Λόγῳ τῶν εὐνοϊκῶν μετεωρολογικῶν συνθηκῶν αἱ ὁποῖαι ἐπεκράτησαν κατὰ τὴν προτεραίαν καὶ κατὰ τὴν ἡμέραν τῆς ἐκλείψεως, αἱ παρατηρήσεις ὑπῆρξαν ἐπιτυχεῖς.

Ἀπὸ τὰς ἐκτελεσθείσας μετρήσεις οἱ κύριοι Μακρῆς καὶ Ζαχαριάδης, ὑπελόγισαν τὰς καμπύλας μεταβολῆς τῆς λαμπρότητος τοῦ οὐρανοῦ εἰς τὸ Ζενὶθ κατὰ τὴν 28ην Ἀπριλίου, ποὺ ἐλήφθη ὡς ἡμέρα συγκρίσεως καὶ κατὰ τὴν ἑπομένην ἡμέραν τῆς ἐκλείψεως. Ἡ διαφορὰ τῶν τιμῶν τῶν λαμπροτήτων τοῦ ζενὶθ μεταξὺ 28ης καὶ 29ης Ἀπριλίου, χωριστὰ διὰ τὰ δύο χρώματα, ἀπεκάλυψε ἀφ' ἑνὸς μὲν τὴν πορείαν τοῦ φαινομένου, ἀφ' ἑτέρου ἔδειξεν ὅτι ἡ λαμπρότης

τοῦ οὐρανοῦ εἰς τὸ ζενίθ, καθ' ὅλην τὴν διάρκειαν τῶν φάσεων τῆς ἐκλείψεως, ὑπῆρξε μεγαλυτέρα εἰς τὸ ἐρυθρόν.

Ἡ λαμπρότης δὲ εἰς τὸ ἐρυθρὸν λαμβάνει τὴν μεγαλυτέραν τιμὴν μεταξὺ 2ας καὶ 3ης ἐπαφῆς, κατὰ τὴν διάρκειαν δηλαδὴ τῆς δακτυλιοειδοῦς φάσεως.

Τὸ φαινόμενον ἐπιβεβαιεῖ προγενεστέραν παρατήρησιν ποὺ ἐγένετο ὑπὸ τοῦ κ. Μακρῆ, κατὰ τὴν ὁλικὴν ὅμως ἔκλειψιν τοῦ Ἡλίου τῆς 25ης Φεβρουαρίου 1952 εἰς τὸ SUDAN.

Ἡ αἰτία ποὺ προκαλεῖ τὸ φαινόμενον τοῦτο δὲν εἶναι ἀκόμη γνωστή. Οἱ κύριοι Μακρῆς καὶ Ζαχαριάδης προτίθενται νὰ ἐρευνήσουν προσεχῶς ἐὰν ἡ διαφορὰ αὕτη τῆς λαμπρότητος τοῦ ζενὶθ μεταξὺ ἐρυθροῦ καὶ πρασίνου δύναται νὰ ἀποδοθῇ εἰς φαινόμενα διαχύσεως τοῦ ἡλιακοῦ φωτὸς ὑπὸ τῶν ἐκτὸς τῆς σκιᾶς τμημάτων τῆς γηΐνης ἀτμοσφαίρας ἢ προέρχεται ἀπὸ φαινόμενα τῆς ἀνωτέρας ἀτμοσφαίρας τῆς Γῆς, φαινόμενα δηλαδὴ τὰ ὁποῖα ἀναφέρονται εἰς τὸν ἰονισμὸν τῶν ἀτόμων τοῦ ὀξυγόνου λόγῳ τῆς ἡλιακῆς ἀκτινοβολίας καὶ τὴν ἐπανασύνδεσιν αὐτῶν, κατὰ τὴν στιγμὴν τῆς ἐκλείψεως.