ΙΟΝΟΣΦΑΙΡΑ.— **Some measurements of the signal strenght of radio waves reflected from the ionosphere during the 1976 April 29 annular solar eclipse,** *by Michael Anastassiadis and George Stefanou**. Ἀνεκοινώθη ὑπὸ τοῦ Ἀκαδημαϊκοῦ κ. Ἰ. Ξανθάκη.

Measurements made at Ierapetra (Crete island) during the solar eclipse of 1976 April 29, showed a significant increase of signal strenght on 3.44 Mcs transmitted from Athens (distance 380 klm).

ANNULAR SOLAR ECLIPSE OF 1976 APRIL 29

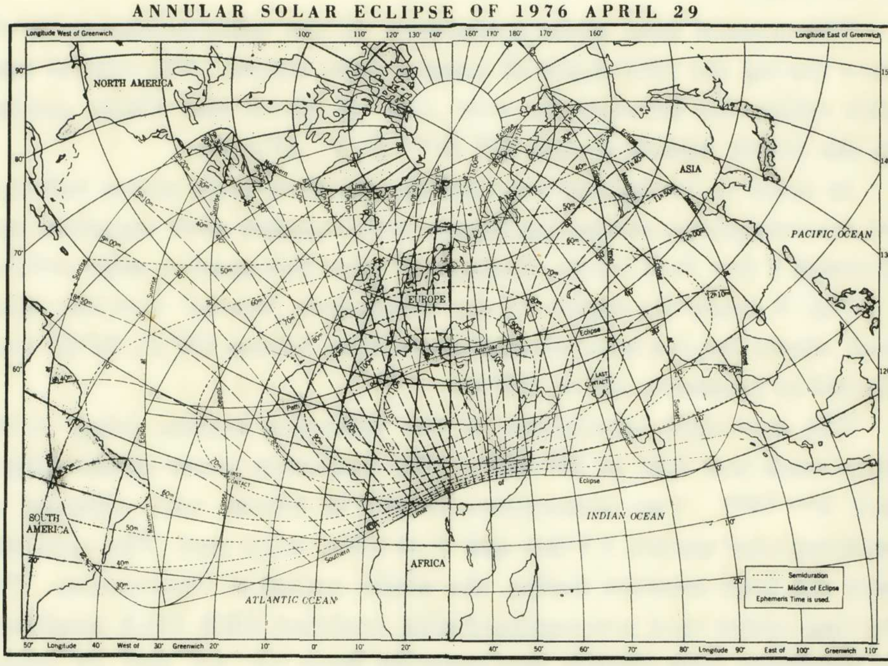

Fig. 1. From the American Ephemeris and Nautical Almanac, 1976.

Field strenght increases, however, of signals reflected from the ionosphere in oblique incidence during eclipses, are not always observed. During the 1954 June 30 solar eclipse, the Netherlands PTT [**1**] from

* Μ. ΑΝΑΣΤΑΣΙΑΔΗ καὶ Γ. ΣΤΕΦΑΝΟΥ, **Μετρήσεις τινὲς τῆς ἐντάσεως τῶν ραδιοηλεκτρικῶν κυμάτων ἀνακλωμένων ἐπὶ τῆς ἰονοσφαίρας κατὰ τὴν ἡλιακὴν ἔκλειψιν τῆς 29ης Ἀπριλίου 1976.**

measurements made on an number of wavelenghts and for several radio links between Netherland, Scandinavia Indonesia and Japan, reported either a decrease or a not definite change.

Decreases are also reported by the Canadian Broadcasting Corporation on BBC transmission. The above decreases refer to H. F. signals and for paths of the order of several hundreds kilometers.

On the contrary, very characteristic increases were observed by Rastogi and al [2] in the London-Ahmedabad multi-hope path. The distance between these two points is 6800 klm and the frequency used was 15.07 Mcs.

The present note gives a summary of the observations made in Greece during the 1976 April 29 annular solar eclipse. The central zone of this eclipse lay between the west part of Africa and China passing over the Greek islands around 10^{h} 44^{min} U. T. (Fig. 1).

In order to investigate solar eclipse effect on radio waves reflected from the ionosphere, oblique incidence measurements were organized and performed a few days before, during and after this annular solar eclipse.

Fig. 2 shows the region of the ionosphere located over the Milos island, where the one hope transmissions from Athens (38^{0} N, 24^{0} E) were reflected to Ierapetra (35^{0} N, 26^{0} E).

The maximum occultation of the reflecting region, lying in the eclipse track was 0,88 at 10^{h} 44^{min}. The maximum phase of the eclipse lasted 6^{min} 34^{sec}. Two transmitters located in Athens and radiating on omnidirectional aerials 7.9 Mcs and 3.44 MHz, were used. The radiating power was kept constant during the whole period of observations. The receiving center used was equipped with modified URR 390 A receivers. The automatic gain control was removed from the RF and IF stages and an external gain control was used for reasons of calibration. The outputs of the receivers were recorded on SEFRAM recorders through Unitron D^{C}. amplifiers.

The signal strenghts of Athens transmissions on both frequencies were recorded between 11.30 and 16.00 L. T. on each day from April 25 till May 3.

Some signals received on 8.9 Mcs during control days showed a completely anomalous behaviour. However duringt he eclipse day and well before the first contact a significant increase was observed followed by a deep decrease just at the eclipse beginning. The signal disappeared a little before the eclipse maximum and reappeared for a few minutes after the third contact as an increase, and then it disappeared com-

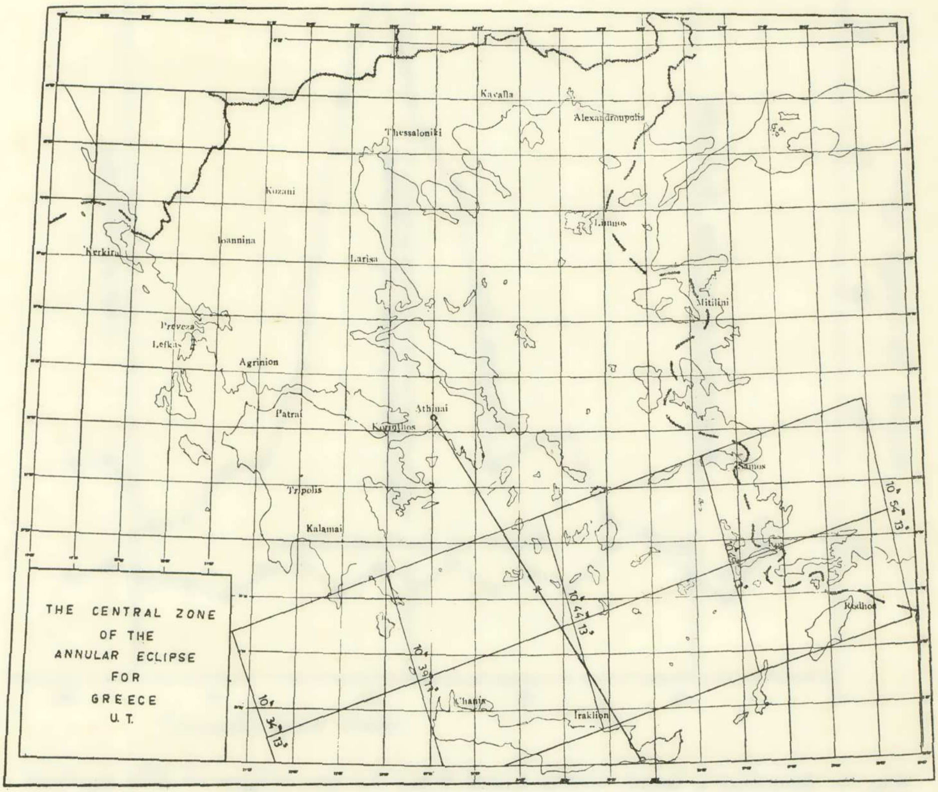

Fig. 2. From the Memoires of the National Observatory of Athens. (by D. P. Elias)

Series 1 Astronomy Numbeɹ 18.

pletely. Unfortunately the anomalous behaviour of the control days does not permit any comparison between control and eclipse days and hence conclusions for the behaviour of the responsible for the ionospheric layers cannot be made, based on measurements on this frequency.

On the other hand, the 3.44 MHz transmissions showed a clear dependence on the eclipse effect Fig. 3. The signal strenght began to increase just at the beginning and reached its maximum value a little after the eclipse maximum. It then dropped fairly rapidly towards the normal control days value which however did not attain even after the

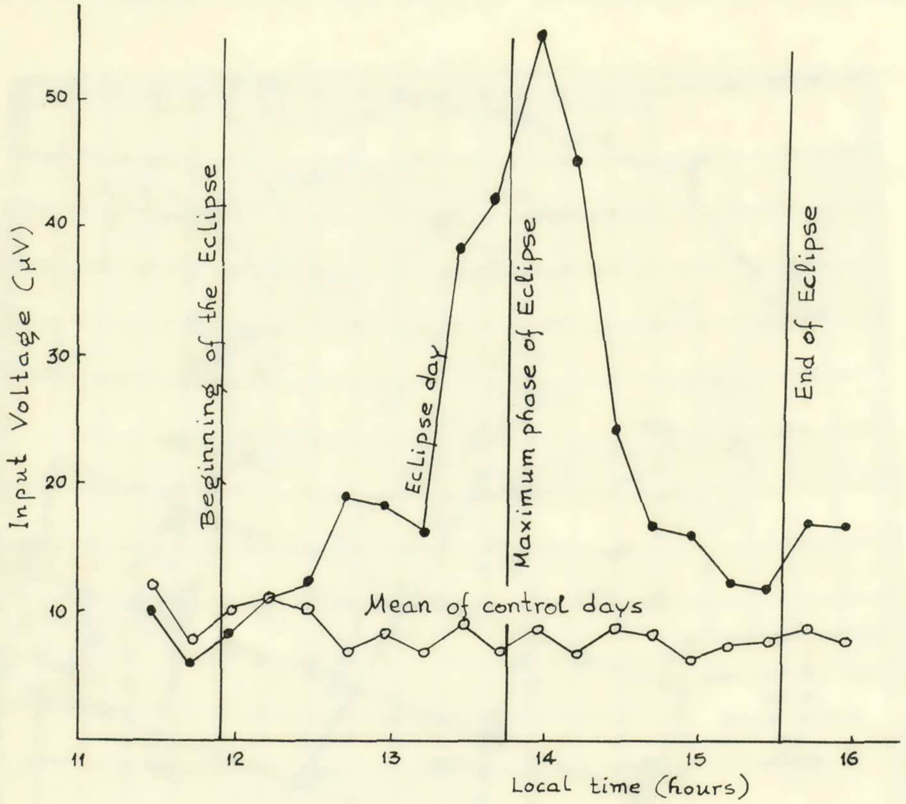

Fig. 3. Receiver's input versus Local Time for the eclipse of 1976 April 29 and mean value of control days.

eclipse end. The peak signal strenght is about seven times the strenght on control days.

Similar increase was also observed during the total eclipse of 1955 June 20 [**3**] over Ceylon (Fig. 4). The signal strenght of Colombo transmissions on 4.87 Mcs was measured at Trivandrum (8,5^{0}N. 77,0^{0}E) between 0030 to 0500 GMT.

This was an early morning eclipse. The distance between Colombo and Trivanderum is 420 klm, almost of the same order as the Athens-

Ierapetra path. Comparing Fig. 3 to Fig. 4 we notice the remarkably similar behaviour concerning the increase of field strenght associated with the eclipse effect.

There are however some differences especially refering to the amount of influence of solar disc occultation. This influence in the Ceylon total eclipse, is restricted between the beginning and well before the end of the eclipse, while in the 1976 June 29 solar eclipse this influence, lasts even after the end of it.

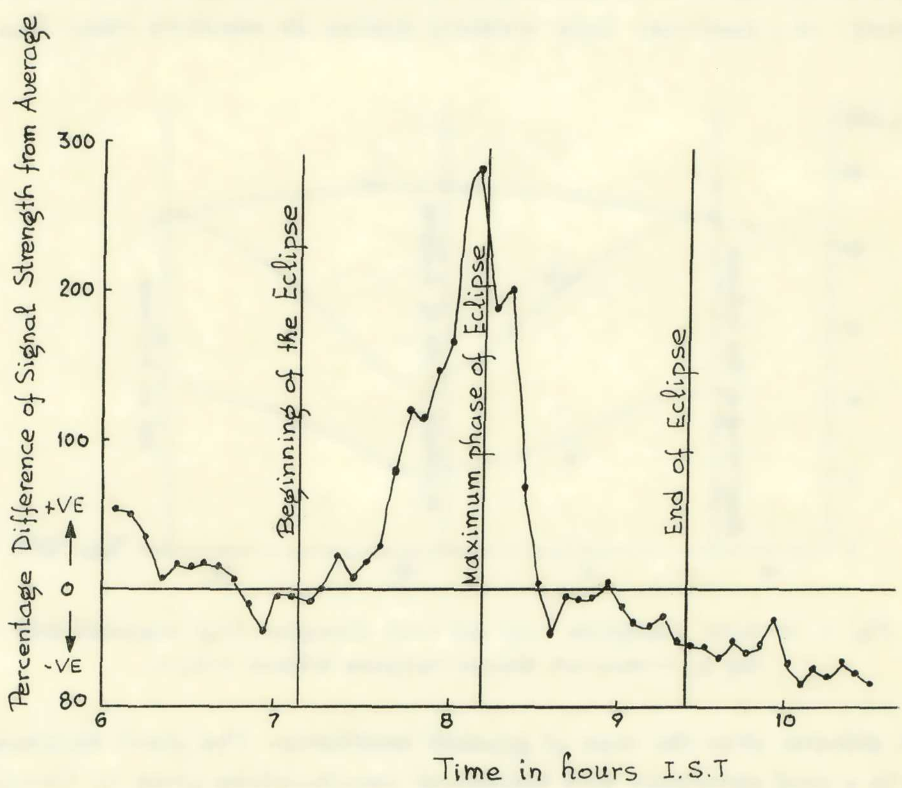

Fig. 4. Signal strenght difference from average versus time.

Concerning the eclipse influence we can say that, field strenght increases are remarkably pronounced only when the solar disc occultation effects strongly the electron densities of the ionospheric layers.

We also notice a time delay difference between field strenght maximum and maximum of occultation. In Fig. 3 maximum of optical occultation is observed before the field strenght maximum, while this is reversed for the case of Fig. 4. This time lag following our measurements is approximately 8 minutes.

Both phenomena, field strength increase and time lag are consistant with the eclipse effect on the ionosphere and must be expected since, ionospheric equilibrium is not instantaneous and the maximum electron density of a particular layer normally attains its minimum value N_{min},

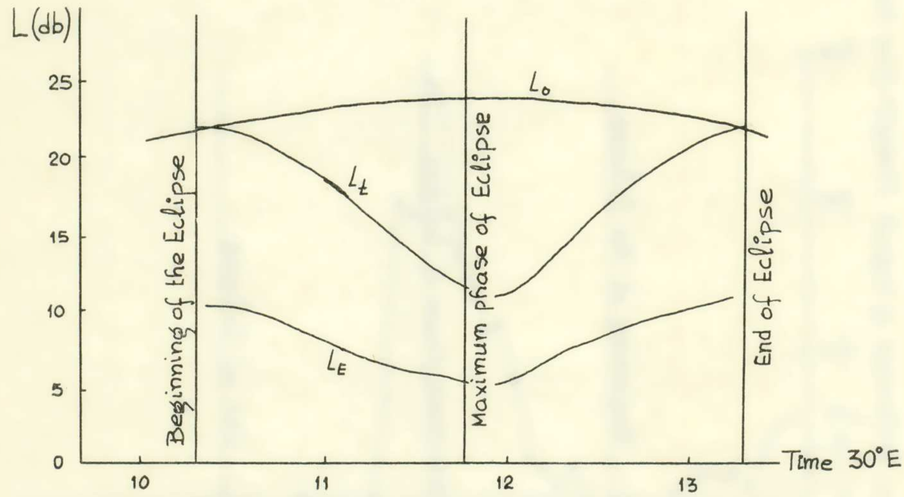

Fig. 5. E - layer absorption (L_E) and total absorption (L_t) compared with the L_o = observed diurnal variation without eclipse.

At minutes after the time of greatest occultation. The above statement is in a good agreement with theoritical considerations given by Thomas and Rycroft [5] as well as with a large number of experimental observations. It is therefore justified to consider the case reffered by Rastogi (Fig. 4) as an abnormal one.

Bishoff and Taubenheim [4] after their measurements on 3.86 Mcs in Mitchurin during the 1966 may 20 solar eclipse reported a decrease of absorption interpreted by a two layer model, dividing the total absorption into a contribution from a parabolic E layer, and an idealized «thin» D layer, obeying an effective recombination law. Fig. 5 shows the control days, the total and the E layer absorption decrease and also the time lag between minimum of absorption and maximum of occultation.

The same authors discussed the results of similar AI absorption measurements carried out at the same time in Scaramanga near Athens on 1.98 Mcs [5]. On 1.98 Mcs reflected in the lower part of the E-layer, absorption at the time of maximum was about 20 db. and occured after the maximum of occultation.

After their model it would be expected that the non-deviative D-region absorption (below 95 klm) Fig. 6 on 1.98 Mcs would be in fact

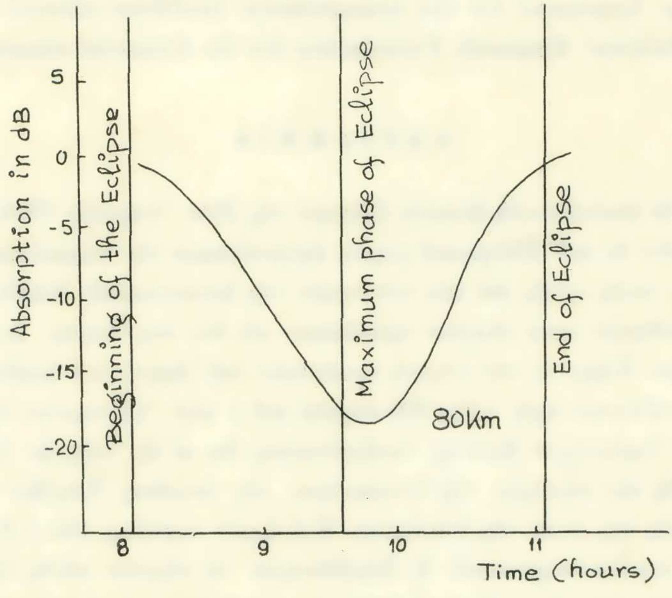

Fig. 6. Smoothed absorption curve obtained by the Al pulse technique on 1.98 MHz.

diminished by about 18.5 db. at maximum eclipse. The slightly higher amount of the observed eclipse effect on 1.98 Mcs is certainly due to the contribution of the reflecting region.

Considering that the signal strength increase of Fig. 3 is the result of a decrease of absorption only, we find that this increase which is seven times the strength on control days requires a 17 db corresponding decrease of absorption, consistant in magnitude with the absorption decrease reported above (Fig. 6).

We may now assume that the most probable explanation for the observed increase of the field strength on 3.44 MHz, supported by Fig. 5

and Fig. 6 is that the electron density decrease caused by the eclipse, mainly produced a decrease of the absorption of the ionospheric layers located below the reflecting region and hence an increase of the received field strength.

ΑΚΝOWLEDGEMENT

The authors express their many thanks to the Hellenic Military Signal Corp. Command for the transmission facilities offered and to the Hellenic National Research Foundation for its financial support.

ΠΕΡΙΛΗΨΙΣ

Κατὰ τὴν δακτυλιοειδῆ ἡλιακὴν ἔκλειψιν τῆς 29ης Ἀπριλίου 1976, τῆς ὁποίας ἡ σκιὰ διῆλθεν ἐκ τοῦ Ἑλληνικοῦ χώρου, ὠργανώσαμεν τὴν παρατήρησιν τῶν ἐπιδράσεων τῆς σκιᾶς αὐτῆς ἐπὶ τῶν συνθηκῶν τῆς ἰονοσφαιρικῆς διαδόσεως ἐκπέμποντες ἐξ Ἀθηνῶν κατὰ πλαγίαν πρόσπτωσιν εἰς δύο συχνότητας ἤτοι 7,9 Μγκ καὶ 3.44 Μγκ. Χάρις εἰς τὴν εὐγενῆ προσφορὰν τοῦ Ἀρχηγείου Διαβιβάσεων τοῦ Στρατοῦ, διετέθησαν πρὸς τοῦτο δύο πομποὶ τοῦ 1 κλβ. Ὡς σημεῖον λήψεως ἐπελέξαμεν τὴν Ἱεράπετραν Κρήτης, ὑπολογίσαντες ὅτι αἱ ἐξ Ἀθηνῶν ἐκπομπαὶ θὰ ἀνεκλῶντο εἰς τὰς περιοχὰς τῆς ἰονοσφαίρας τὰς κειμένας ὕπερθεν τῆς Μήλου, δηλονότι ἐντὸς τῆς σκιᾶς τῆς ἐκλείψεως. Καὶ ἡ μὲν συχνότης τῶν 7,9 Μγκ οὐδόλως ἔδειξεν σημεῖα ἐπηρεασμοῦ ἢ ἀκριβέστερον τὰ σήματα αὐτῆς ἐνεγράφησαν εἰς Ἱεράπετραν λίαν ἀνωμάλως τόσον κατὰ τὴν ἡμέραν τῆς ἐκλείψεως, ὅσον καὶ τὰς προηγουμένας καὶ ἑπομένας ἡμέρας ἐλέγχου. Ἀντιθέτως αἱ εἰς 3.44 Μγκ ἐκπομπαὶ ἐδημιούργησαν ἰσχυρὸν πεδίον σημάτων εἰς Ἱεράπετραν μὲ ἐλαφρὰν μόνον εναλλαγὴν κατὰ τὰς ἡμέρας ἐλέγχου, ἐνῷ ἀντιθέτως κατὰ τὴν ἡμέραν τῆς ἐκλείψεως ἐσημειώθη ἔντονος ἔξαρσις τοῦ σήματος τῆς τάξεως τῶν 17 ντεσιμπέλ. Ἀνάλογον ἔξαρσιν παρετήρησε καὶ ὁ Rastogi κατὰ τὴν ἔκλειψιν τῆς 20 Ἰουνίου 1955 κατὰ πλαγίαν πρόσπτωσιν συνδέσεως Κεϋλάνης - Colombo εἰς τὴν συχνότητα τῶν 4,87 Μγκ. Αἱ δύο περιπτώσεις ὡς λίαν γειτονικῆς μορφῆς ἐξητάσθησαν καὶ ἐπεσημάνθησαν αἱ διαφοραί των, ἰδίᾳ ὅσον ἀφορᾷ τὸν προβλεπόμενον χρόνον τοῦ μεγίστου τῆς καλύψεως καὶ τοῦ μεγίστου τῆς ἐξάρσεως, ὅστις συμφωνεῖ πλήρως μὲ τὰς ἐξ Ἀθηνῶν παρατηρήσεις. Ἡ ἑρμηνεία τῆς ἐξάρσεως τοῦ σήματος τῶν 3.44 μγκ. ἀναφέρεται εἰς τὴν μείωσιν τῆς ἀπορροφήσεως ἥτις προκαλεῖται ἀπὸ τὴν μείωσιν τῆς ἠλεκτρονικῆς πυκνότητος τῆς ἀνακλώσης περιοχῆς τῆς Ἰονοσφαίρας ὡς αὕτη παρετηρεῖται κατὰ τὰς ἐκλείψεις.

Καμπύλαι τοιαύτης μειώσεως τῆς ἀπορροφήσεως συσχετιζόμεναι μὲ τὴν φάσιν μεγίστης καλύψεως τοῦ ἡλιακοῦ δίσκου τόσον ἐκ Μιτσούριν ὅσον καὶ ἐξ Ἀθηνῶν ἐπιβεβαιοῦν τὰ ἀνωτέρω.

REFERENCES

1. Netherlands PTT and Canadian Broadcasting Corporation Reports on 1954 June 30 solar eclipse. Solar Eclipse and the Ionosphere, Pergamon Press 1956.
2. Rastogi and al., Solar eclipses and the Ionosphere. Special Suppl. Vol. 6 to J. Atm. Terr. Phys. Pergamon Press 1956.
3. Bischoff and Taubenheim, Journal of Atm. and Terr. Physics Vol. 20, pp. 1063 - 1069.
4. Anastasiadis and al., Ionospheric Inst. Nat. Obs. Athens. Scient. Rep. No IIA009.
5. Thomas and Rycroft, Solar Eclipses and the ionosphere, Plenum Press, 1970.

★

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

Ὡς γνωστὸν αἱ ἡλιακαὶ ἐκλείψεις ἐπιδροῦν ἐπὶ τῆς φυσικῆς καταστάσεως τῶν διαφόρων στρωμάτων τῆς Ἰονοσφαίρας καὶ τοῦτο, διότι κατὰ τὴν διάρκειαν τῆς ἐκλείψεως μεταβάλλεται ὁ παράγων, ὅστις ἐξιονίζει τὰς διαφόρους περιοχὰς τῆς Ἰονοσφαίρας.

Δύο μέθοδοι χρησιμοποιοῦνται διὰ τὴν μελέτην τῆς μεταβολῆς τοῦ ἐξιονίζοντος παράγοντος. Ἡ μία μέθοδος διερευνᾷ τὴν μεταβολὴν ταύτην κατὰ κατακόρυφον διερεύνησιν ἡ δὲ ἄλλη κατὰ πλαγίαν πρόσπτωσιν.

Εἰς τὴν παροῦσαν ἀνακοίνωσιν ἐχρησιμοποιήθη ὑπὸ τῶν ἐρευνητῶν ἡ δευτέρα μέθοδος. Πρὸς τοῦτο ἐφηρμόσθησαν δύο συχνότητες μία εἰς 7,9 Mc καὶ ἡ ἄλλη 3,44 Mc, τοῦτο δὲ διὰ νὰ μελετηθῇ ἡ συμπεριφορὰ περιοχῶν τῆς Ἰονοσφαίρας εἰς διάφορα ὕψη.

Ὡς σταθμοὶ παρατηρήσεως ἐπελέγησαν αἱ Ἀθῆναι διὰ τὴν ἐκπομπὴν καὶ ἡ Ἱεράπετρα Κρήτης διὰ τὴν λῆψιν καὶ τοῦτο, ἵνα αἱ ἐξ Ἀθηνῶν ἐκπομπαὶ ανακλῶνται εἰς τὰς περιοχὰς τῆς Ἰονοσφαίρας τὰς κειμένας ἄνωθεν τῆς Μήλου, δηλαδὴ ἐντὸς τῆς σκιᾶς τῆς ἐκλείψεως.

Αἱ γενόμεναι ἔρευναι ἀπεκάλυψαν ὅτι ἡ συχνότης τῶν 7,9 Mc δὲν παρέχει ἐνδείξεις ἐπηρεασμοῦ ὥστε νὰ ἐξαχθοῦν ἐξ αὐτῶν ἀσφαλῆ συμπεράσματα. Ἀντιθέτως αἱ ἐκπομπαὶ αἱ γενόμεναι εἰς 3,44 Mc ἐδημιούργησαν ἔντονον πεδίον σημάτων εἰς Ἱεράπετραν, τῆς τάξεως τῶν 17 ντεσιμπέλ. Δέον νὰ σημειωθῇ ὅτι ἀνάλογον ἔξαρσιν παρετήρησε καὶ ὁ Rastogi κατὰ τὴν δακτυλιοειδῆ ἔκλειψιν τοῦ Ἡλίου τῆς 20ῆς Ἰουνίου 1955, διὰ τῆς ἐφαρμογῆς τῆς ἰδίας μεθόδου μεταξὺ Κεϋλάνης καὶ Κολόμπο, δηλαδὴ εἰς ἀπόστασιν ἀνάλογον τῆς ἀποστάσεως Ἀθηνῶν - Ἱεραπέτρας.

Ἡ ἑρμηνεία τῆς παρατηρηθείσης ἐξάρσεως τοῦ σήματος τῶν 3,44 Mc ἀποδίδεται ὑπὸ τῶν ἐρευνητῶν εἰς τὴν μείωσιν τῆς ἀπορροφήσεως τῶν ἠλεκτρομαγνητικῶν κυμάτων ἥτις προκαλεῖται ἀπὸ τὴν μείωσιν τῆς ἠλεκτρονικῆς πυκνότητος τῆς ἀνακλώσης περιοχῆς τῆς ἀτμοσφαίρας. Ἡ ἑρμηνεία δὲ αὕτη συμφωνεῖ μὲ τὴν γενικὴν συμπεριφορὰν τῆς ἀπορροφήσεως κατὰ τὰς ἐκλείψεις τοῦ Ἡλίου.