AD NUMBER

AD286275

NEW LIMITATION CHANGE

TO

Approved for public release, distribution unlimited

FROM

Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; 27 Sep 1962. Other requests shall be referred to the Library of Congress, Aerospace Technology Divison, Washington, DC.

AUTHORITY

CFSTI per ATD ltr, 2 Dec 1965

AD 286 275

AID Report 62-135

27 September 1962

PHENOMENA IN THE UPPER ATMOSPHERE

REVIEW OF SOVIET LITERATURE

AID Work Assignment No. 3

Report 28

Aerospace Information Division

AID Report 62-135 27 September 1962

PHENOMENA IN THE UPPER ATMOSPHERE

REVIEW OF SOVIET LITERATURE

AID Work Assignment No. 3

Report 28

Aerospace Information Division

SUBJECT: Monthly Report - AID Work Assignment No. 3

PERIOD: August 1962

This is the twenty-eighth in a monthly report series reviewing Soviet developments in selected problems in astrophysics and geophysics. It is based on materials received at the Aerospace Information Division in August.

Materials in this report deal with the following topics:

II. Solar radiation and the ionosphere
IV. Telluric currents
V. Atmospheric electricity
VII. Satellite and missile data

SUBJECT: Monthly Report - AID Work Assignment No. 3

PERIOD: August 1962

TOPIC II. SOLAR RADIATION AND THE IONOSPHERE

1) Neshpor, Yu. I. On the depth of penetration of ionizing radiation from chromospheric flares. IN: Akademiya nauk SSSR. Krymskaya astrofizicheskaya observatoriya. Izvestiya, v. 26, 1961, 156-160.

An attempt is made to determine the depth of penetration of the ionizing radiation of flares on the basis of studies of the frequency dependence of signal attenuation. The location and certain characteristics of the absorbing layer are also considered.

The following formulas are used in the study: The absorption ρ of cosmic radio emission E is determined by the formula

$$\rho = ln \frac{E}{E_0} = - \int kdz,$$

where K is the absorption coefficient, which for ordinary waves can be found by the formula:

$$K = \frac{2 \pi e^2}{mc} \frac{N\nu}{\nu^2 + (\omega + \omega_L)^2} .$$

In studying the frequency dependence of signal attenuation, data on the absorption of cosmic radio emissions on two frequencies (26.7 and 32.5 mc) were used. The time march of excess absorption during sudden ionospheric disturbances on 26.7 mc was computed and, on the assumption that signal attenuation is inversely proportional to the square of the frequency, the excess absorption on 32.5 mc was computed. The computed curve was then compared with an experimental curve. In six out of eight cases, the two curves coincided.

For the disturbances of 1 April and 12 November 1960 the computed curve was higher than the experimental. This means that

$$\frac{\Delta\rho\omega_1}{\Delta\rho\omega_2} = \left(\frac{\omega_2 + \omega_L}{\omega_1 + \omega_L}\right)^n ,$$

where $\Delta\rho\omega_1$ is the excess absorption on frequency ω_1; $\Delta\rho\omega_2$ is the excess absorption on frequency ω_2; ω_L is the gyrofrequency; and $0 < n < 2$. It is concluded that on 1 April and 12 November 1960 the noticeable increase of ionization during sudden ionospheric disturbances took place at the level where the frequency of collision of electrons ν is comparable to or higher than the working frequency ($\sim 10^8$). On the basis of data on the height distribution of the frequency of collisions, it is concluded that a height of $\sim$50 km satisfies the indicated ν values. On the basis of results of measurements of hard radiation, it may be assumed that in the spectrum of flare radiation, radiation with a wavelength of $\sim$1 to 2 Å is present.

2) Stepanyan, N.N. Sequence of appearance of lines of different elements in flares. IN: Akademiya nauk SSSR. Krymskaya astrofizicheskaya observatoriya. Izvestiya, v. 26, 1961, 41-44.

Two series of spectra for the flares of 17 August 1959 and 11 October 1960 were studied to determine the sequence of appearance of lines of different elements. The results of processing data for the 17 August flare are shown in Fig. 1.

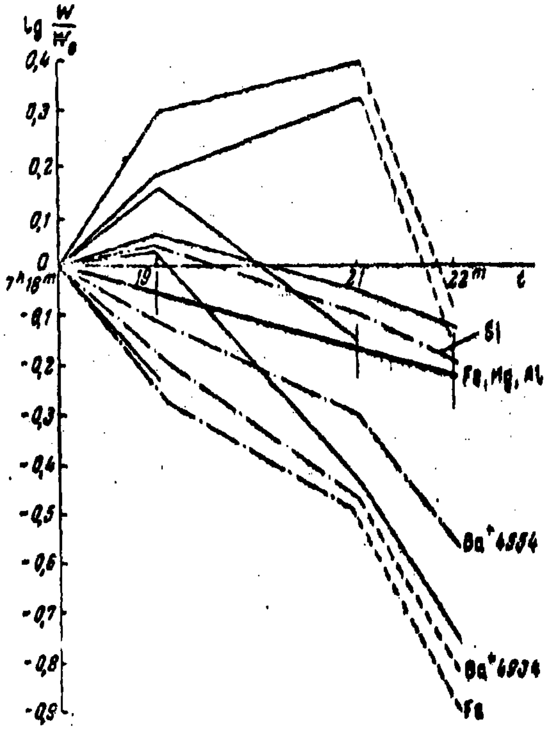


Fig. 1. Change of lg W/W_0 with time for different lines in the flare of 17 Aug 1959 (Thin solid lines denote rare-earth elements.)

The time of observation is plotted along the abscissa, while lg W/W_0 -- i.e., the logarithm of the ratio of W (width of flare

]

emission) at the moment of observation to W at the first moment -- is plotted along the ordinate.

Almost all Fe, Mg, and Al lines yield approximately similar curves. Broken lines indicate cases where the line did not exhibit emission during the last moment of observation, and where consequently lg $W/W_0 = -\infty$. The behavior of the rare-earth and Ba^+ and Si lines differs from the others. Five of the six rare-earth lines reach a brightness maximum about five minutes later than the maximum in H_α. The rare earths are brighter in flares where the H_α wings are smaller.

The delay in the maximum of the rare earths relative to the other elements is attributed to the fact that the former belong not to the flare itself but to the lower layers of the chromosphere. The exciting radiation from a flare in the higher layers of the chromosphere reaches the lower layers only after some delay when the optical thickness of the chromosphere for this radiation is great.

3) Yeryushev, N. N. On the determination of the relative variation of the effective conductivity of the lower ionosphere at 22 kc during solar flares. IN: Akademiya nauk SSSR. Krymskaya astrofizicheskaya observatoriya. Izvestiya, v. 26, 1961, 144-148.

The problem of determining the relative variation of effective conductivity σ_{eff} of the lower ionosphere at 22 kc during solar flares is considered. On the basis of Al'pert's work [reference given], the relative change $\mathcal{E}$ of amplitude of the long-wave field caused by variations in electron density and thus in the conductivity of the lower ionosphere may be represented in the form

$$\mathcal{E} = \frac{E_t}{E_{t_0}} = Pe^{k_0 \Delta S r} , \qquad (1)$$

where E is the field intensity; $k_0 = 2\pi/2$; λ is the wavelength in km; r is the distance in km between the source and the receiving point; $P = P_t/P_{t_0}$; and $\Delta S = S_{s}t - S_{s}t_0$. The indices t_0 and t designate the values for a quiet and disturbed ionosphere, respectively. The values P and S_s are parameters of the theory of long radio wave propagation and have a definite connection with the conductivity of the ionosphere $\sigma \sim N/\nu$, where N is the electron concentration and ν is the frequency of collisions.

The expression

$$\frac{\sigma_{eff}}{\sigma_{eff_0}} = e^{a(r)\, ln \mathcal{E}}$$

is derived, where

$$a(r) = \frac{ln\left(\frac{\sigma_{eff}}{\sigma_{eff_0}}\right)_{t_1}}{ln\,\mathcal{E}_{t_1}} \qquad (2)$$

Values of a(r) were determined for different distances r and $1.1 \leqslant \left(\frac{\sigma_{eff}}{\sigma_{eff_0}}\right)_{t_1} \leqslant 5$ by computing the appropriate $\mathcal{E}_t$ according to formula (1). The results obtained are presented in the table below.

$\frac{\sigma_{eff}}{\sigma_{eff_0}}$	a (r)					
	$r = 10^3$	$2 \cdot 10^3$	$3 \cdot 10^3$	$5 \cdot 10^3$	$7 \cdot 10^3$	10^4 км
1,1	7,94	5,60	4,33	3,07	2,51	1,83
1,2	7,59	5,69	4,45	3,09	2,43	1,79
1,3	7,72	5,58	4,37	3,02	2,36	1,75
1,4	7,48	5,43	4,26	2,98	2,29	1,69
1,5	7,51	5,41	4,22	2,96	2,29	1,67
1,6	7,70	5,66	4,43	3,11	2,39	1,79
1,8	7,35	5,29	4,17	2,91	2,24	1,65
2,0	7,45	5,37	4,23	2,95	2,26	1,67
3,0	7,85	5,69	4,46	3,13	2,40	1,78
4,0	8,06	5,85	4,59	3,22	2,47	1,83
5,0	8,17	5,89	4,61	3,22	2,47	1,83
Average	7,71	5,59	4,37	3,06	2,37	1,75

It is seen from the table that the values of a(r) are practically independent of the choice of point t_1, that is, independent of the state of ionospheric disturbance. Insofar as value a(r) is a function of distance r, it may be called a distance parameter. It must be noted that formula (2) with the obtained values of parameter a(r) is correct only for a frequency of 22 kc. For other frequencies (in particular, for f = 13.27 and 32 kc) a more complex relationship between ΔS and $\sigma_{eff}/\sigma_{eff_0}$ obtains.

Thus, the process of determining the relative variation of the effective conductivity σ_{eff} for f = 22 kc on the basis of formula (2) is reduced to simple computations. The value of $\mathcal{E}$ is determined experimentally, while the value of a(r) for a prescribed distance is taken from the table.

Fig. 1. Variation of $\sigma_{eff}/\sigma_{eff_0}$ for f = 22 kc during solar flare of 22 August 1958

solid line - formula (1); small crosses - formula (2).

The graph at left (Fig. 1) shows the relative variation of σ_{eff} for f = 22 kc during the solar flare of 22 August 1958, computed according to formulas (1) and (2). The value of δ was determined from records of atmospherics. As is seen from the diagram, the degree of error of formula (2) does not exceed 5%. At greater disturbance values, however, the accuracy of formula (2) diminishes. Since especially great disturbances are not as a rule observed for f = 22 kc, i.e., $\sigma_{eff}/\sigma_{eff_0} \leq 7$, formula (2) may be used for processing practically all observed effects.

4) Morozov, V. M. On the inconstancy of the spectral composition of the continuum in night airglow. IN: Akademiya nauk SSSR. Izvestiya. Seriya geofizicheskaya, no. 4, 1962, 573-576.

Photoelectric observations of night airglow during the IGY and IGC at the Zvenigorod station provided additional data on the continuum. On the basis of photoelectric measurements in two sectors of the spectrum near 5300 and 5890 Å, it was shown that: 1) The ratio of intensities of the continuum in night airglow near the two wavelengths 5280 and 5890 Å is much closer to the spectral composition of class G2 stars than the data of Barbier and Glaume [reference given] indicate. 2) Photoelectric data on the ratio of intensities of the continuum in the indicated regions of the spectrum practically coincide with the results of determination of the ratio of the mean intensities of the continuum from spectrographic measurements in the same sectors of the spectrum. Consequently, near 5900 Å there is no supplementary component of the continuum that does not correlate with the main continuum. 3) There are no great variations of the spectral composition of the continuum such as Shefov [references given] reported. 4) The dispersion of experimental points on graphs showing the dependence of emission v at 5890 Å on emission x at 5280 Å, constructed on the basis of photoelectric data, is chiefly caused by variations of emission NaD 5893 and OH (8,2). Other causes (change in spectral composition of background and errors in photoelectric measurements) may play a secondary role.

The author compares his views with those advanced by Krasovskiy and Shefov.

Author's Association: Institute of Physics of the Atmosphere, Academy of Sciences USSR.

5) Fedorova, M. I. Twilight fluorescence of helium emission λ10,830 Å. IN: Akademiya nauk SSSR. Izvestiya. Seriya geofizicheskaya, no. 4, 1962, 538-547.

Special observations of the twilight flash of helium line λ10,830 A have been conducted at Loparskaya station since autumn 1960. A standard infrared SP-50 spectrograph was used in conjunction with an image converter with a dispersion of 100 Å/mm and resolution of 5 Å. The spectrograph was set for the 10,200 - 11,500 Å region so that two hydroxyl bands could also be obtained. Helium line λ10,830 Å had first been obtained at the Zvenigorod station during a strong aurora on 10 - 11 Feb 1958. Shefov [see AID Work Assignment No. 3, Report 25, Topic II, Abstract 4] has suggested that emission He I 2^3S - 2^3P λ10,830 Å is attributable to the fluorescence of helium atoms in the metastable state 2^3S under solar illumination.

Preliminary processing of spectra shows that emission λ10,830 Å He I is observed only in twilight spectra. At night He I emission is not observed even during auroras. No correlation is detected between He I emission and any emission or form of auroras. The distribution of He I intensity with height, illuminated by the sun, shows that helium emits radiation in a rather broad layer of the order of several hundred kilometers. The lower boundary of He I emission is ~150 to 170 km; the upper boundary is ~500 km. The highest percentage of emitting He I atoms occurs at a height of 200 to 300 km.

Author's Association: Institute of Physics of the Atmosphere, Academy of Sciences USSR.

6) Krüger, A. Investigations of solar radio bursts in the centimeter and low decimeter range. IN: Akademie der Wissenschaften, Berlin. Monatsberichte, v. 4, no. 2, 1962, 97-105.

The results of observations of solar radio bursts conducted by the Heinrich Hertz Institute during the IGY are reviewed. The sun was observed daily on frequencies of 9400, 3000, 2000, and 1500 mc. A total of 970 bursts were measured during the IGY. At 9400 mc, 0.17 bursts per hour were noted; at 3000 and 2000 mc, 0.15 bursts per hour; and at 1500 mc, 0.12 bursts per hour.

The relationship between burst duration and frequency was studied, and it was found that as the wavelength becomes shorter, the frequency of longer-lasting effects increases. A definite asymmetry is seen in the form of the bursts. Correlations were made between the occurrence of bursts, flares, and SID's. These are shown in Table 1.

Table 1. Number of flares, cm-dm-bursts, and SID's and their correlations during the IGY observations of the Heinrich Hertz Institute

	Correlations with			
	Flares	Bursts	SID's	
Flares	6239	787	428	
	100%	12.6 %	6.9%	(based on total number of flares)
Bursts	787	970	446	
	81.1%	100%	45.8%	(based on total number of bursts)
SID's	428	446	494	
	86.6%	90.3%	100%	(based on total number of SID's)

The data in the table indicate a much higher frequency of flares than of bursts and a high degree of correlation between bursts and flares and between SID's and bursts. An even closer relationship is observed between SID's and cm-bursts. It may be assumed that every SID-effect is related to a cm-burst. The total energy emitted in the cm-range may be taken as a criterion of the probability of the simultaneous occurrence of a SID and a burst. Bursts are seen to lag two to three minutes behind flares, while SID's show a lag of one to three minutes behind bursts.

On the basis of data from the Ondřejov Astronomical Observatory near Prague and the Potsdam-Tremsdorf Astrophysical Observatory, comparisons were made between bursts in the cm-dm and meter ranges.

The correlation of geomagnetic solar flare effects with flares and cm-dm-bursts is held to be satisfactorily established; according to the author, it is unnecessary to establish such a close relationship of these flare effects to SID's and bursts of the meter range. The author concludes with observations on the relationship between sunspots and bursts.

Author's Association: Heinrich Hertz Institute, German Academy of Sciences in Berlin.

7) Chistyakov, V. F. On the observed depths of sunspots. Astronomicheskiy zhurnal, v. 39, no. 3, 1962, 459-467.

In an earlier work [see AID Work Assignment No. 3, Report 20, Topic II, Abstract 4] the author adduced geometric proofs supporting Wilson's view of spots as depressions in the solar surface. In this paper the physical nature of the spot depth effect is discussed on the basis of ideas advanced by Krat, Michard, and Sweet (references given). Facts cited as supporting the theory are: 1) spots are less dense and more transparent than the photosphere; 2) the substance of the spots and of the photosphere is in a state of radiative equilibrium. Determination of depth was heretofore complicated by two drawbacks: 1) calculations were usually made only for spots showing the Wilson effect, while spots showing a "negative" or "neutral" effect were generally not selected (if they were, they showed "heights" rather than "depths"); and 2) spots were usually chosen near the edge of the solar disk, while in actuality the Wilson effect may be observed at all points of the disk. To overcome these shortcomings, two new statistical methods, based on the assumption of statistical uniformity of penumbra width, are proposed for the estimation of spot depths. In the first method single uniform round spots are selected. Micrometric measurement is made of the width of the penumbra in two directions: a) in the direction of a radius of the solar disk, the width of the penumbra is measured on the side of the spot facing limb B_1, and on the side of the spot facing the center of the disk B_2; and b) in a direction perpendicular to the radius, the width of the penumbra B_0 is measured (twice). On the basis of micrometric measurements, determinations are made of the ratios B_1/B_0 and B_2/B_0, which are seen as functions of the angle θ (the heliocentric angle). The values of the functions of the perspective foreshortening of the penumbra (B_1/B_0 and B_2/B_0) for each θ can be reliably determined only as mean values for a large number of spots. The final formula for determining the relative depth of the spot, taking into account the curvature of the solar surface, has the form

$$h = B_0 \operatorname{ctg} \theta \left(\frac{B_1}{B_0} - \frac{B_2}{B_0}\right)\left(\frac{B_1}{B_0} + \frac{B_2}{B_0}\right)^{-1} + R_{\odot}(\cos \rho_u - \cos \rho_s),$$

where $R_{\odot}$ is the linear radius of the sun, and ρ_u and ρ_s are the angular radii of the umbra and of the entire spot in heliocentric measurement. The second method is a simplification of the first, insofar as the width of the penumbra is only measured in the direction of a radius of the solar disk, i.e., only B_1 and B_2 are measured.

Extensive data, including the results of micrometric measurements made independently by Chevalier and the author, were processed by these methods. Smoothed curves of the functions B_1/B_0 and B_2/B_0, obtained separately on the basis of data supplied by the author and those supplied by Chevalier, were compared with generalized curves derived from all data. It was concluded that the form of the functions

B_1/B_0 and B_2/B_0 for spots of different sizes with a penumbra width within the limits $\beta_0 = 20 - 70'$ is independent of the size of the penumbra. It is finally concluded that: 1) the depth of spots h^* diminishes with growth of ϑ, while at the same time an especially sharp foreshortening of depths takes place near the limb ($\vartheta > 50°$), i.e., in the area where the Wilson effect is most clearly defined; and 2) larger spots are also deeper (this is a consequence of the fact that the functions B_1/B_0 and B_2/B_0 are independent of the size of the penumbra), and changes in their depth, depending upon angle ϑ, occur within wider limits.

Author's Association: Far East Branch, Siberian Division, Academy of Sciences USSR.

8) Dvoryashin, A. S., L. S. Levitskiy, and A. K. Pankratov. Flare emission in the X-ray region of the spectrum. Astronomicheskiy zhurnal, v. 39, no. 3, 1962, 428-438.

In earlier papers [see AID Work Assignment No. 3, Report 17, Topic II, Abstract 8] the authors observed that the development of solar flares is in some cases accompanied by the generation of high-energy protons, the energy spectrum of which often reaches relativistic energies. It has also been established that such proton flares are accompanied by a strong type-IV radio burst. It is considered possible that X-ray quanta may be generated by the bremsstrahlung of electrons accelerated in the flare. A study is made of the relationship between these phenomena (the generation of a stream of high-energy protons, radio burst, and the emission of hard photons in the X-ray region of the spectrum) and the development of the flare and change in the structure of the magnetic field of the active regions. The X-radiation of the flares is investigated on the basis of data on the minimum frequencies of reflection (f_{min}) obtained from a world-wide network of ionospheric stations. In comparing the moment of the chromospheric flare at stations throughout the world, a time difference is noted, indicating that the path followed by the radiation in the terrestrial atmosphere differs. Investigation of the time-relationship between flare, radio burst on the centimeter wavelengths, and X-radiation shows: 1) As a rule, a radio burst on the centimeter wavelengths accompanies increased f_{min} values. 2) The moment of f_{min} increase follows the beginning of the burst much more regularly than it follows the flare. 3) Apparently, the moment of f_{min} increase coincides with the onset of the radio burst on the centimeter range. 4) Comparison of the times of flare and burst onset shows that the flare begins in almost all cases earlier than the burst on the centimeter waves. On the average the burst lags about 6 minutes behind the flare. 5) In most cases the time of flare maximum does not differ by more than 9 min from the time of burst maximum, and often the difference is less. 6) The maximum f_{min} coincides closely with the flare and burst maximum. 7) Comparison of the durations of flare, burst, and increased f_{min} shows that in the majority of cases the flare has the longest duration.

The considerable increase of f_{min} caused by these flares, observed at the moment when the sun is at the horizon, indicates that a strong spectrum hardening is characteristic of the X-radiation of these flares. Rocket investigations made close to sunrise and sunset have shown that X-radiation of considerable intensity is recorded only at heights above ~90 km. This coincides closely with the base of the E layer. Consequently, the ionizing radiation has to penetrate to a greater depth if it is to cause a noticeable increase in f_{min} or total absorption. If it is assumed that the extra ionization of the ionosphere, caused by these flares, takes place at a height of 60-70 km, it may be concluded that these flares generated superhard photons with an energy $E \sim 0.1$ Mev. It may naturally be expected that proton flares emit a more significant stream of hard photons, sufficient to form noticeable extra ionization of the D layer at high zenith angles.

Authors' Association: Crimean Astrophysics Laboratory, Academy of Sciences USSR.

9) Romanchuk, P. R. Visibility of spots on the solar disk and the east-west asymmetry of solar activity. Part II. Astronomicheskiy zhurnal, v. 39, no. 3, 1962, 445-458.

Part I of this work [see AID Work Assignment No. 3, Report 24, Topic II, Abstract 18] showed that the function of visibility of spots on the solar disk coincides with the function of their perspective foreshortening. Part II deals with the determination of spot boundaries as dependent on their location on the disk, the shape of the spots, and the inclination of the spot axes. The influence of these factors on spot visibility is discussed. The conditions of spot visibility are studied through the use of photometric cross-sections of the spots. It is found that in the marginal zone of the disk the visible boundary of the spot is determined at a higher relative intensity of the penumbra and photosphere (0.91) than in the central region (0.77). These results are in good agreement with the psychophysical law. The absence of a lowering in the estimates of spot areas in the marginal zone is explained by the conditions found for determining the visible boundary of the spots.

The relationship between the visible and photometric dimensions is studied for radial and tangential cross-sections. It is noted that in the marginal zone the intensity gradient at the visible boundary of the spot is larger for the tangential than for the radial cross-section. This is connected with the dissimilar shortening of the tangential dimensions and the increase in the radial dimensions of the "visible" and the "photometric" spot.

The visible and photometric forms of 165 spots were studied. An appreciable extension of the spots in the radial direction, increasing toward the limb, is found. Spots with relatively small areas (5 - 120 millionths of the hemisphere) have the greatest extension. No extension is observed for spots with areas exceeding 200 millionths of the hemisphere. The inclination of the axes of the spots toward the direction of solar rotation, 2° 20' ± 1° 30', was determined from the difference in the extension of spots in the eastern and western parts of the disk (extension of spots in the eastern hemisphere is greater).

It is concluded that the inclination effect of the spots cannot be detected in the Solar Service data because the precision of spot measurement is too low. Consequently, the east-west asymmetry of spot formation is not connected with the inclination of the axes of the spots.

The radial extension of spots is explained by the simultaneous shortening of the tangential dimensions and the increase of the radial dimensions of the spots. It is shown that the shortening of the visible tangential dimensions of small spots (25 units) may be due to nonresolution of the edges of the spots, caused by perspective foreshortening. The shortening of large spots is apparently also a result of the change in the spot boundary due to the structure of the spot. The increase in the reduced radial dimensions of the "visible" spots is explained by high-frequency fluctuations of the images with an amplitude of 0.5".

Author's Association: Kiyev State University imeni T. G. Shevchenko.

10) Sodin, L. G., S. Ya. Braude, and A. V. Men'. Observations of the spectra of very intense solar bursts in the 10- to 25-mc range on 14 and 18 July 1961. Astronomicheskiy zhurnal, v. 39, no. 3, 1962, 542-544.

The results of observations of spectra of very intense bursts of solar radio emission on July 14 and 18, 1961, in the 10- to 25-mc range are given. The following conclusions are drawn: 1) The bursts coincide with strong chromospheric flares. 2) The onset of the bursts coincides with the growth of ionospheric absorption. This phenomenon is possibly connected with an increase of solar ultraviolet radiation. 3) In the initial stage a slow frequency drift of the burst in the direction of the low frequencies is observed. 4) In the steady stage the radio emission consists of several different bursts, chaotically and independently intermixing with a velocity of the order of 1 mc/s, towards the low as well as towards the high frequencies. The width of the spectrum of each separate burst varies within the limits of 0.5 to 5 mc.

11) Krasovskiy, V. I. Helium in the upper terrestrial atmosphere. IN: Akademiya nauk SSSR. Vestnik, no. 6, 1962, 50-52.

The author reviews recent investigations made by Soviet scientists of the upper atmosphere through the use of image converters operating in the infrared region of the spectrum. A description is given of the spectrographic equipment used in investigating infrared emissions.

Shefov, Prokudina, and Mironov detected very intensive infrared helium emission on the wavelength of 10,830 Å on 11 Feb 1958 [see AID Work Assignment No. 3, Report 25, Topic II, Abstract 4]. Fedorova conducted regular observations of this emission at twilight. Shcheglov obtained photographs of the twilight helium emission in the form of concentric interference rings. As a result of these investigations a strong twilight helium emission of the upper atmosphere, becoming increasingly strong during auroras, was detected. At night it has never been detected. Shefov thinks that it arises as a result of fluorescence of certain metastable orthohelium atoms in the upper part of the atmosphere under solar illumination. His qualitative analysis of the physical conditions of the upper atmosphere, as well as of data on twilight helium emission, showed that metastable orthohelium atoms are formed in the upper atmosphere from ordinary parahelium atoms in three ways: 1) as a result of collisions of ordinary parahelium atoms with recently formed high-energy photoelectrons during the ionization of atoms and molecules of the upper atmosphere by solar radiation, chiefly with wavelengths shorter than 304 Å; 2) as a result of the excitation of ordinary parahelium atoms by solar helium radiation with a wavelength of 584 Å with successive transitions, first into the metastable state of parahelium and then, in collisions with ordinary ionospheric electrons, into metastable orthohelium atoms; and 3) as a result of the excitation of ordinary parahelium by secondary electrons arising in the bombardment of atoms and molecules of the upper atmosphere by harder electrons, causing auroras.

Thus, ground observations of infrared helium emission make it possible to obtain information on solar short-wave and corpuscular radiation. The method is held to be a more economical way of investigating physical properties of the ionosphere than the use of rockets and satellites.

12) Ivanov-Kholodnyy, G. S., and G. M. Nikol'skiy. Identification of solar emission lines in the short-wave region of the spectrum $\lambda \leqslant 1100$ Å. Geomagnetizm i aeronomiya, v. 2, no. 3, 1962, 425-442.

Investigations of the intensity of solar radiation in the short-wave region of the spectrum are important in understanding the ionization of the chromosphere and solar prominences, interplanetary medium, and the terrestrial ionosphere. Since 1958 rocket measurements have been made of the solar spectrum in the region $\lambda < 1100$ Å. Some 180 solar emission lines observed in the 60 to 1100 Å region have been identified. A list of lines and intensities in the short-wave spectrum is presented. The results of a comparison of theoretically predicted data with experimentally obtained data are given in the table. A critical analysis is made of identifications made in earlier works. The spectral distribution of energy of short-wave solar emission is analyzed. Maxima are detected in the wavelength region 60 to 100 (corona), 200 to 450 (upper part of transition region), 550 to 650, 750 to 850, and 950 to 1050 Å. The total energy of line emission for $\lambda < 1100$ Å is estimated at not less than 14.7 erg/cm^2 sec at the earth. Half of this energy is concentrated in the 250-400 Å region. The relative content of nitrogen on the sun is found to be $[N] / [H] = 3 \cdot 10^{-5}$, i.e., three times less than the value obtained by Goldberg, Müller, and Aller, or ten times less than the generally accepted value.

Authors' Associations: Institute of Applied Geophysics, Academy of Sciences USSR, and Institute of Terrestrial Magnetism, Ionosphere, and Radio Wave Propagation, Academy of Sciences USSR.

13) Fel'dshteyn, Ya. I. On changes in the position of the auroral zone in relation to the solar activity cycle. Geomagnetizm i aeronomiya, v. 2, no. 3, 1962, 571-572.

The frequency of occurrence of auroras varies substantially with the solar activity cycle. On the basis of data from Scandinavian sources, covering several centuries, Ol' has shown that in the middle latitudes the number of auroras increases sharply in years of maximum solar activity [see AID Work Assignment No. 3, Report 3, Topic II, Abstract 4]. In addition to an 11-year periodicity, a certain anomaly in the cyclic changes in the frequency of occurrence of auroras, caused by slow variations in solar activity, was demonstrated. In the circumpolar regions, on the other hand, auroras occur more frequently in years of minimal solar activity than in years of maximal activity. This phenomenon has been attributed to the shifting position of the auroral zone, which moves toward the pole in years of minimal activity and away from it in years of maximal activity (Fig. 1).

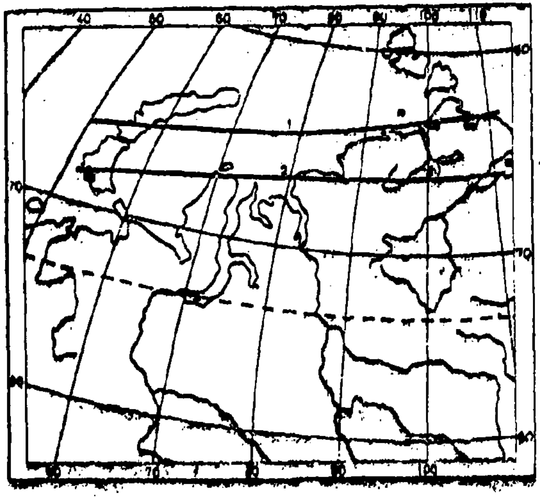


Fig. 1. Shift in the position of the auroral zone

1 - position of auroral zone during winter of 1954-1955 (minimal activity); 2 - position of auroral zone during winter of 1957-1958 (maximal activity).

The small (2.5° to 3°) shift toward the pole is not considered sufficient to be the main reason for the increase in frequency of occurrence of auroras in the circumpolar regions in years of maximal solar activity.

It is suggested that a satisfactory explanation must be one for which the regularities in aurora distribution characteristic of years of maximum solar activity remain valid for years of minimum activity. It has been shown that in the circumpolar region auroras in the zenith are more frequent on magnetically quiet than on magnetically stormy days. The rarity of magnetic disturbances in years of minimum solar activity, and the predominance of magnetically quiet days, may explain the increased number of auroras observed at circumpolar stations during the transition from years of maximum to years of minimum activity.

Statistically, the auroral zone is a projection of the outer zone of corpuscular radiation onto the upper layers of the atmosphere. During the IGY, the auroral zones corresponded with the outer radiation zone, which was located in the equatorial plane at an average distance of 6.5 earth radii from the center of the earth. Computations show that a 2.5° to 3° shift of the auroral zone toward the pole in years of minimum activity is equivalent to movement of the outer radiation zone 1.5 earth radii further away in the equatorial plane. It may be expected that during the coming International Quiet Sun Year, the outer radiation zone will be located in the equatorial plane of the terrestrial dipole about 8 earth radii from the center of the earth.

Cyclical changes in the position of the outer radiation zone relative to the earth may also contribute to secular geomagnetic field variations. Kalinin [reference given] has demonstrated the presence in the geomagnetic field of secular variations a part of which are created by extraterrestrial processes and related to the earth's radiation belts.

Author's Association: Institute of Terrestrial Magnetism, Ionosphere, and Radio Wave Propagation, Academy of Sciences USSR.

14) Pletnev, V. D., and Temnyy, V. V. On the interaction between a solar corpuscular stream and the outer geomagnetic field during the first phase of a magnetic storm. IN: Akademiya nauk SSSR. Izvestiya. Seriya geofizicheskaya, no. 7, 1962, 978-980.

Solar corpuscular streams approaching the earth compress the terrestrial outer magnetic field, forming a region of instability. Some particles penetrate into the magnetic field, forming a transitional layer, and interact with the field. The field intensity increases under the magnetohydrodynamic pressure of the stream. The particles lose some energy gained in the first phase of the storm. The energy change is expressed by the formula

where $\dot{K}$ is the velocity of energy increase of the particle, e its charge, M is the magnetic moment, Φ and Ψ are potentials of the constant and quasi-stationary components of the electric field, B is the intensity of the magnetic field, u_{dr} is the drift velocity of particles, and W is the intensity of the electric field in the direction of drift.

The drift velocity of particles is expressed by the formula

$$\dot{K} = e\frac{\partial}{\partial t}\left(\Phi - \Psi + \frac{M}{v}B\right) + \frac{e}{c}u_{dr}W,$$

where R is the distance of the force line in the equatorial plane; ω is the frequency; and $v_\perp$ and $v_\parallel$ are perpendicular and parallel components of the particle velocity.

Assuming a slow change of Φ and Ψ, the velocity of the particle-energy increase can be written in the form

$$u_{dr} = \frac{3}{R\omega}\left[\frac{v_\perp^2}{2} + v_\parallel^2\right],$$

where E is the intensity of the electric field. Using the formulas given, the authors determined K at given values of B, E, and particle density.

The numerical value of $\dot{K}$ in electron-volts, relative to an oscillation period of 40 seconds, may be written

$$\dot{K} = M\frac{\partial B}{\partial t} + eEu_{dr},$$

where a is the earth's equatorial radius.

Authors' Association: Institute of Physics of the Atmosphere, Academy of Sciences USSR.

$$(\dot{K})_{40} = 1760 + 9{,}9\cdot10^{-8}K\,(R/a)^{8} - \frac{1{,}3\cdot10^{4}}{R/a}\,.$$

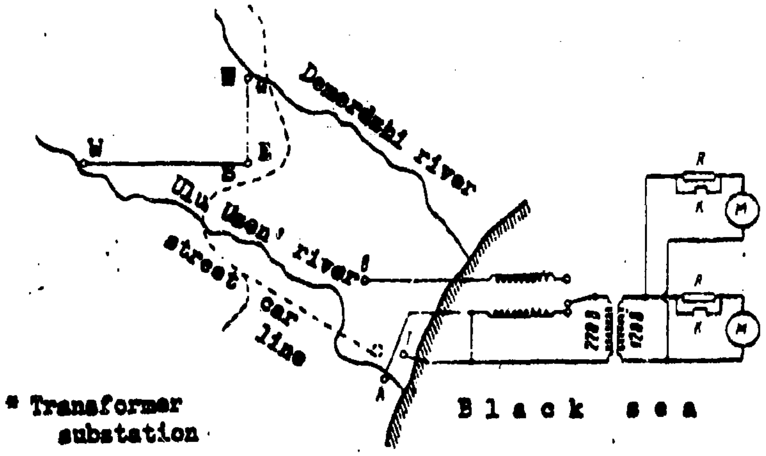
SUBJECT: Monthly Report - AID Work Assignment No. 3

PERIOD: August 1962

TOPIC IV. TELLURIC CURRENTS

1) Rokityanskiy, I. I. On interference observed in recording rapid earth-current oscillations. IN: Akademiya nauk SSSR. Izvestiya. Seriya geofizicheskaya, no. 7, 1962, 943-945.

Earth-current stations operating according to the IGY program use two units: the first records at a rate of 90 mm/hr, making it possible to study oscillations with periods of from 15 sec to an hour; the second unit records at a rate of 30 mm/min and investigates oscillations with a period of from 0.5 to 20 sec. Owing to new construction in the vicinity of the Alushta station, recording of oscillations with periods of a second or less has been made more difficult as a result of background noises and interference. A main cause of sinusoidal noise was traced to the power-supply circuits of the motors of local telegraph equipment. Change in the current of the supply circuit corresponds to a change in the current of the primary winding of the transformer, one end of which is connected to the 220-v phase, while the other end is grounded. The telegraph supply line switch (shared in common with the radio and telephone stations) makes it possible to receive 220 v from one of two transformer substations. One substation is located at point A (see Fig. 1), the second at point B. The zero wire is constantly grounded at points A and T (telegraph). Thus, when the telegraph is fed from substation B, the primary circuit is closed through the ground, and the current flows into the ground between point B, on one side, and points A and T on the other. The distances TB and AB are 300 - 400 m, and the envelope of this current,



with a frequency of about 1 cps, is recorded from station lines NS, EW at a rate of 30 mm/min. The signal is 1.5 - 2 times greater on the NS line than on the EW. A streetcar line passes within 70 m of the geophysical station, while a transformer substation is located 100 m from the north electrode.

Author's Association: Institute of Physics of the Earth, Academy of Sciences, USSR.

SUBJECT: Monthly Report - AID Work Assignment No. 3

PERIOD: August 1962

TOPIC V. ATMOSPHERIC ELECTRICITY

1) Lukomski, H. A contribution to our knowledge of the electric state of clouds in stormless periods. Acta geophysica polonica, v. 10, no. 2, 1962, 183-190.

Corona discharge (flow of an electric charge into the atmosphere) from a wire 0.03 cm in diameter was studied. One end of the wire was attached to an insulator, the other to a balloon which reached a height of about 400 m above the ground. Measurements were made in late autumn when thunderstorms do not generally occur under conditions of a low cloud ceiling and occasional rainfall. The spontaneous current (i.e., not antenna-fed current) flowing between antenna and air after grounding of the antenna was also measured. Considerable local differences were observed in the density of the electric space charges and their signs in relatively small areas of the troposphere. The results of measurements and observations support the assumption that the mixing of air layers in which local differences in the signs of electric space charges occur favors the development of precipitation.

Comment: This investigation is a continuation of an earlier work. See AID Work Assignment No. 3, Report 20, Topic II, Abstract 1.

2) Alizade, A. S., and D. A. Kuliyev. Investigation of some questions of thunderstorm phenomena in the Shemakha field laboratory. IN: Akademiya nauk Azerbaydzhanskoy SSR. Izvestiya. Seriya fiziko-matematicheskikh i tekhnicheskikh nauk, no. 2, 1962, 57-68.

The field laboratory for the study of thunderstorms of the Power Engineering Institute of the Azerbaydzhan Academy of Sciences has been in operation since 1960. It is located near the Astrophysical Observatory, 25 km to the north of Mt. Shemakha, at an elevation of 1510 m above sea level. The laboratory was established: 1) to study thunderstorm phenomena in the area; 2) to measure the intensity of the atmospheric electric field; 3) to measure atmospheric conductivity; 4) to explain the laws of development of lightning discharge. A photograph of the laboratory, as well as a description of the equipment used, is provided.

In the period April-September 1960 twenty storms were recorded, half of which occurred during the day and half at night. Six were near (within 5 km), 14 were distant (beyond 5 km). Most storms (7) were noted in June. The electric field was measured three times daily (0800, 1300, and 1900 hours). The values obtained were always positive, though they varied greatly: in clear weather from 0 to +100 v/m;

for cloudy weather from 0 to +170 v/m. In both cases the intensity of the electric field was 30 to 70 v/m. Measurements of air conductivity showed variations from $1 \cdot 10^{-5}$ to $60 \cdot 10^{-5}$ sec^{-1}. The mean value of conductivity was $15 \cdot 10^{-5}$ sec^{-1}. Measurements of the electric field made on two days in 1960 during thunderstorms showed that the storm cloud passed over the laboratory, carrying in its front a positive charge reaching +200 v/m; the charge gradually dropped to zero and was later followed by a negative charge of about -600 v/m. The intensity of the electric field during storms was seen to change with great frequency and within wide limits.

SUBJECT: Monthly Report - AID Work Assignment No. 3

PERIOD: August 1962

TOPIC VII. SATELLITE AND MISSILE DATA

1) Al'pert, Ya. L., E. F. Chudesenko, and B. S. Shapiro. Results of investigation of the outer region of the ionosphere based on observations of radio signals of the first artificial earth satellite. IN: Akademiya nauk SSSR. Mezhduvedomstvennyy komitet po provedeniyu MGG. XI razdel programmy. Rakety i sputniki, no. 1, 1958, 40-52.

A method of investigating the outer ionosphere by observing the moments of "radio rise" and "radio set" of the satellite is described. The results of theoretical computation of the maximum horizontal range of signal reception, based on a spherical earth, are presented. Tabulation of the elliptical integral was made on the BESM computer of the USSR Academy of Sciences. For purposes of computation, the parabolic model of the lower ionosphere and the exponential decrease of electron concentration in the outer part were accepted as valid.

The method of observation and the analysis of experimental data consisted in the following. At each revolution of the satellite around the earth, the moments of radio-signal appearance and disappearance at a given point were noted. Since the intensity of the signal received varies very sharply at the moments of "radio rise" or "radio set", because of a barrier-type effect, a reasonably close fix, accurate to within 5 to 6 seconds, could be made of the moments. The height of the satellite, the coordinates of the subsatellite point on the earth, and the horizontal distance r_m were determined on maps of true trajectories of the satellite flight, computed chiefly on the basis of ballistic data. Further, with the aid of specially constructed synoptic maps showing the isolines of critical frequencies f_c and maps showing the heights of the beginning z_o and maximum z_m of the F region of the ionosphere, the values of these parameters were determined at three points for each moment of time, selected from the observational data, along arcs of a great circle: above observational point 1, point 2 where the beam enters the F region, and at point 4, above which the satellite is located.

To process the experimental data, use was made of parameters of the lower ionosphere, obtained from observations of ionospheric stations, and of satellite altitudes, as well as of maximum ranges of signal reception, obtained from ballistic data and studies of the true trajectories of satellite flight.

It was found that the electron concentration of the ionosphere N above its maximum N_m decreases considerably more slowly than it increases up to the height of N_m. For model $N(z) \sim N_m e^{-kz}$ the value of k (the effective characteristic of decrease of electron concentration) $\simeq 3.5 \cdot 10^{-3}$ 1/km. This yields a number of electrons in the outer part of the ionosphere about 3.6 times greater than in the lower part. Extrapolation of data obtained from observations for heights $z \sim 300$ to 650 to 700 km to $z \sim 3000$ km shows that at $z \sim 2000$ to 3000 km, $N \sim 200$ to 300 el/cm^3. On the basis of the electron lifetime and time between the different acts of ionization, a density curve of neutral particles $n(z)$ was constructed. The value $n \sim 1$/cm^3 at the same heights. The supposition is expressed that the height of the "boundary" of the atmosphere, i.e., of the region where it apparently meets with interplanetary gas, is of the order of 2000 to 3000 km.

SUBJECT: Monthly Report - AID Work Assignment No. 3

PERIOD: August 1962

BIBLIOGRAPHY

1.) Alizade, A. S., and D. A. Kuliyev. Investigations of some questions of thunderstorm phenomena in the Shemakha field laboratory. IN: Akademiya nauk Azerbaydzhanskoy SSR. Izvestiya. Seriya fiziko-matematicheskikh i tekhnicheskikh nauk, no. 2, 1962, 57-68.

2.) Al'pert, Ya. L., E. F. Chudesenko, and B. S. Shapiro. Results of investigation of the outer region of the ionosphere based on observations of radio signals of the first artificial earth satellite. IN: Akademiya nauk SSSR. Mezhduvedomstvennyy komitet po provedeniyu MGG. XI razdel programmy. Rakety i sputniki, no. 1, 1958, 40-52.

3.) Chistyakov, V. F. On the observed depths of sunspots. Astronomicheskiy zhurnal v. 39, no. 3, 1962, 459-467. QB1.A47

4.) Dvoryashin, A. S., L. S. Levitskiy, and A. K. Pankratov. Flare emission in the X-ray region of the spectrum. Astronomicheskiy zhurnal, v. 39, no. 3, 1962, 428-438. QB1.A47

5.) Fedorova, N. I. Twilight fluorescence of helium emission $\lambda 10{,}830$ Å. IN: Akademiya nauk SSSR. Izvestiya. Seriya geofizicheskaya, no. 4, 1962, 538-547. QC801.A35

6.) Fel'dshteyn, Ya. I. On changes in the position of the auroral zone in relation to the solar activity cycle. Geomagnetizm i aeronomiya, v. 2, no. 3, 1962, 571-572.

7.) Ivanov-Kholodnyy, G. S., and G. M. Nikol'skiy. Identification of solar emission lines in the short-wave region of the spectrum $\lambda \leq 1100$ Å. Geomagnetizm i aeronomiya, v. 2, no. 3, 1962, 425-442.

8.) Krasovskiy, V. I. Helium in the upper terrestrial atmosphere. IN: Akademiya nauk SSSR. Vestnik, no. 6, 1962, 50-52. AS262.A627

9.) Krüger, A. Investigations of solar radio bursts in the centimeter and low decimeter range. IN: Akademie der Wissenschaften, Berlin. Monatsberichte, v. 4, no. 2, 1962, 97-105.

10.) Lukomski, H. A contribution to our knowledge of the electric state of clouds in stormless periods. Acta Geophysica Polonica, v. 10, no. 2, 1962, 183-190.

11.) Morozov, V. M. On the inconstancy of the spectral composition of the continuum in night airglow. IN: Akademiya nauk SSSR. Izvestiya. Seriya geofizicheskaya, no. 4, 1962, 573-576. QC801.A35

12.) Neshpor, Yu. I. On the depth of penetration of ionizing radiation from chromospheric flares. IN: Akademiya nauk SSSR. Krymskaya astrofizicheskaya observatoriya. Izvestiya, v. 26, 1961, 156-160. QB1.A17642

13.) Pletnev, V. D., and V. V. Temnyy. On the interaction between a solar corpuscular stream and the outer geomagnetic field during the first phase of a magnetic storm. IN: Akademiya nauk SSSR. Izvestiya. Seriya geofizicheskaya, no. 7, 1962, 978-980. QC801.A35

14.) Rokityanskiy, I. I. On interference observed in recording rapid earth current variations. IN: Akademiya nauk SSSR. Izvestiya. Seriya geofizicheskaya, no. 7, 1962, 943-945. QC801.A35

15.) Romanchuk, P. R. Visibility of spots on the solar disk and the east-west asymmetry of solar activity. Part II. Astronomicheskiy zhurnal, v. 39, no. 3, 1962, 445-458. QB1.A47

16.) Sodin, L. G., S. Ya. Braude, and A. V. Men'. Observations of the spectra of very intense solar bursts in the 10- to 25-mc range on 14 and 18 July 1961. Astronomicheskiy zhurnal, v. 39, no. 3, 1962, 542-544.

17.) Stepanyan, N. N. Sequence of appearance of lines of different elements in flares. IN: Akademiya nauk SSSR. Krymskaya astrofizicheskaya observatoriya. Izvestiya, v. 26, 1961, 41-44. QB1.A17642

18.) Yeryushev, N. N. On the determination of the relative variation of the effective conductivity of the lower ionosphere at 22 kc during solar flares. IN: Akademiya nauk SSSR. Krymskaya astrofizicheskaya observatoriya. Izvestiya, v. 26, 1961, 144-148. QB1.A17642