JOURNAL OF THE PHYSICAL SOCIETY OF JAPAN Vol. 17, SUPPLEMENT A-I, 1962
INTERNATIONAL CONFERENCE ON COSMIC RAYS AND THE EARTH STORM Part I

I-4-P2. Characteristics of Aurora*

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Discussion

Hines, C. O.: This summary is indeed of very great value to the theorists. In particular, I would like to draw one sweeping conclusion from the pattern of auroral forms which has been presented (from T. N. Davis' summary), and enquire whether this conclusion is reasonable. Would it be proper to conclude that pre-midnight quiet arcs remain relatively quiet, moving of the westward as the observer rotates with the earth underneath, and do not themselves break up in the course of time to produce the irregular post-midnight conditions. That, instead, the apparent time-variation suggested by the word "break-up" is rather to be envisaged as a result of the observers' rotation into a region where the irregular characteristics were already in existence? It is the continuity of arcs from high to low latitudes just before midnight that particularly impresses me in drawing this conclusion.

Elvey, C. T.: It is probably a combination—break-up tends to occur near midnight. It is variable, however, and may differ from magnetic midnight by ±2 hours or more. During sunspot minimum when displays are on a smaller scale, there is greater regularity. One should probably determine events on a "display-time" basis or a normalized time or phase form say " break-up." See T. N. Davis for additional remarks.

Davis, T. N.: The sequence of auroral forms observed at a given stations appears to be governed mainly by the position of the station beneath the fixed auroral pattern but temporal effects seem to exist as well. In particular the onset of the breakup phase is often more rapid than would be expected from a fixed excitation pattern alone.

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INTERNATIONAL CONFERENCE ON COSMIC RAYS AND THE EARTH STORM Part I

I-4-P3. Investigations of Auroral Planetary Distribution*

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The basic materials of the investigations given below are ascafilms of 35 Soviet stations and ascaplots of 77 stations (55 of them in the Northern hemisphere, and 24 in the Southern) obtained during the IGY.

To determine the location of the zone with the maximum frequency of aurora appearance in the zenith, two parameters were used, which are determined by ascaplots for each station. The ascaplots are the diagrams defining for half-hour intervals the distribution of aurorae about the sky, and their brightness in the zenith[1].

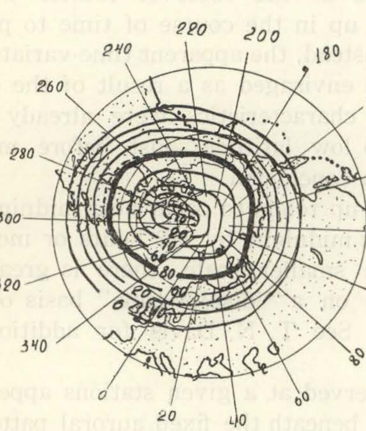
1) The ratio of the number of half-hour intervals with aurorae in the zenith, to the total number of intervals of the investiga-

* Both manuscript and preprint have not been received.

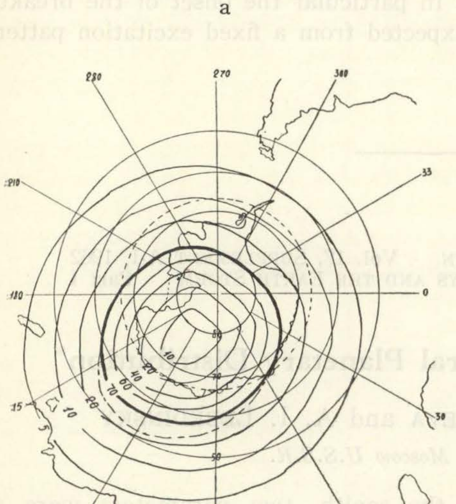
tions in darkness with favourable meteorological conditions.

2) The ratio of the number of half-hour intervals with aurora in the North, to the number of the same intervals in the South.

Fig. 1 a, b presents isoaurorae for the Northern and Southern hemispheres, which are lines of equal probability of aurora appearance in the zenith. The maximum isoaurora (the aurora zone) has been drawn with the most authenticity, the others being supposed similar to it. The dotted line shows



a



b

Fig. 1. Isoaurorae of aurora appearance frequency.
a—in the Northern hemisphere.
b—in the Southern hemisphere.
Figures in the isolines gaps represent aurora appearance frequency in percentage. A dotted line is a theoretical value according to (2).

isolines of the adiabatic invariant I, calculated by Vestine and Sibley[2] for the value $I=15.7$ and magnetic intensity in the point of reflection 0.5 oersted. For the Northern hemishere the coincidence with the aurora zone is good, while for the Southern hemisphere it is somewhat worse, which is accounted for by the lack of observation material.

The maps analogous to Fig. 1 a, b were also separately drawn by magnetically-disturbed and magnetically-quiet days. Magnetically-disturbed days were those for which the index sum K, according to[3], during 8 periods, was >30; magnetically-quiet days were those for which the sum was <20. Comparison with magnetically-quiet and magnetically-disturbed days selected by the planetary index K_p of Bartels, has shown good agreement of both methods of selection of days with different magnetic activity level.

Fig. 2 shows, for the Northern hemisphere, the latitudinal distribution of aurora appearance in the zenith. Zero on the X-axis

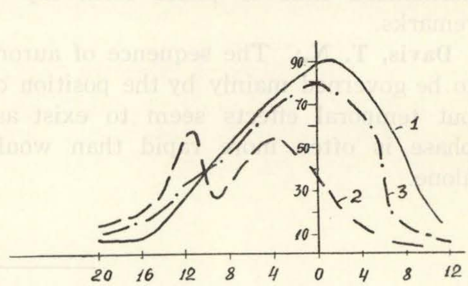


Fig. 2. Latitudinal distribution of aurora appearance frequency in the zenith in the Northern hemisphere.
1—magnetically-disturbed days.
2—magnetically-quiet days.
3—all days.

corresponds to the aurora zone for all days. To the right, from the zero in latitudinal degrees is given the distance from the zone to the South; to the left from the zero is given the distance to the North. It is clear from the figure that on magnetically-disturbed days the aurora zone moves away from the pole in comparison with magnetically-quiet days. This shift differs somewhat on the various meridians, and varies from 3 to 6 degrees both in the Northern and Southern hemispheres. On magnetically-quiet days the aurora zone splits, and a second

Table I.

Station	College			Arctica II 1957/58		
Index Q	M	Aurora	No aurora	M	Aurora	No aurora
0	0.20	0	0.8	0.9	0.5	1.0
1	7.0	0.8	25.0	10.8	14.6	10.0
2	12.5	3.3	38.0	34.5	45.0	32.3
3	14.0	12.0	21.0	36.2	27.7	38.0
4	14.0	15.3	9.0	12.8	8.6	13.8
5	20.0	26.0	4.0	3.3	1.0	3.8
6	16.5	22.0	1.5	1.3	2.6	1.1
7	13.7	18.0	0.7	—	—	—
>7	2.1	2.6	0	—	—	—

zone appears. It is clear from the figure that during quiet days the probability of appearance in the zenith, at the stations situated deep in the zone, is comparable with the probability of their appearance in the aurora zone, and considerably higher than it is at the same latitudes during magnetically-disturbed days.

The presence of aurorae in the zenith was compared with an hourly index Q of magnetic activity and the appearance of a sporadical layer E_s and full absorption of radio waves according to the data of aurora zone stations (College) and the near-pole region (Arctica II 1957–1958, Arctica II 1958–1959, Arctica II-6 and Resolute Bay). The result is presented in Tables I and II.

Table I shows the frequency of appearance of the given magnetic activity force in the presence and absence of aurora in the zenith, for the College station, and Arctica II for the period of 1957–1958. The table also shows the percentage of appearance of the given magnetic activity force independently of the presence of aurora (M). The rest of the near-pole stations give the result similar to Arctica II. As is clear from Table I, in the aurora zone (College), aurora appearance in the zenith is most often accompanied by magnetic activity of force 5–6; the absence

Table II.

Station	P
College	98.5
Arctica II, 1957-1958	21.4
Arctica II, 1958-1959	39.0
Resolute Bay	49.0

cf aurorae is accompanied by magnetic activity of force 1–3. On the contrary, at high-latitude stations magnetic activity is approximately identical, both in the presence and in the absence of aurorae, and in the main has force 2–3. From more careful analysis we can even discover a slight tendency towards aurora appearance with a quieter field.

Table II presents (in precentage) the frequency P of any sporadical layer E_s apperance, and full absorption of radiowaves in the presence of aurorae in the zenith. It is obvious, that at College aurora apperance is practically always accompanied by layer E_s appearance, whereas at the near-pole stations such connection has not been observed.

It is possible, that these effects are due to the fact that at high latitudes corpuscular particles are slowed down at high altitudes, causing auroral there, and to not reach altitudes, of the layer E.

The forms of the diurnal variation of aurora appearence frequency in the zenith are roughly identical both in the Southern and Northern hemispheres, and are better controlled by distance from aurora zone than by the geomagnetic latitude.

In the auroral zone the diurnal variation is characterized by only one maximum, which falls on the midnight hours of local geomagnetic time. At the lower latitudes this maximum shifts towards the morning hours. Within the aurora zone, the diurnal variation is characterized by two maxima: the morning and the night maxima. In this case, with the increase of the distance from the aurora zone the morning maximum shifts to the day hours of the local geomagnetic time, and the night maximum to the evening hours.

For the Northern hemisphere more detailed investigation has been carried out of the aurora space-time distribution according to ascafilms of the Soviet stations, obtained by uniform unaberration chambers of the all-sky on a panchromatic 35 mm film and are photometrically standardized.

As an object of observation from all the 32 Soviet stations of the Northern hemisphere[4] a chain has been selected which is situated in the region with geomagnetic latitudes of 60°-80° and geographical longitudes of 33°-190°, which allowed observation of intervals of longitudes up to 180°.

The research material covers 4 months (from Dec. 1957 to March 1958). After exclusion of moonlight periods, 42 nights of simultaneous observations were selected, at stations lying not less than 50° from each other in longitude (~2000 km), i.e. such stations which cannot see one and the same aurora.

During the period under consideration the aurorae were extremely intensive. Among the 42 nights selected for processing there was no one at which aurora was absolutely absent. There were only 6 nights when during several hours running aurora was not observed simultaneously at all operating stations. Detailed consideration of these cases shows that the aurora absence at these nights was due to its longitudinal shift, so the aurora disappeared from stations' field of vision.

Statistic show that in 95% of the time of synchronous observations the aurora was simultaneously present at all the longitudes observed, independently of the value of the longitudinal interval.

Fig. 3 gives a picture of observations typical of March of 1958, the results of the processing of which have not been included in the above statistics because of the short nights. As is obvious from the figure, aurorae were observed at all the stations (where was clear between dusk and twilight), appearing and disappearing on their background. With due account of the results of the winter processing, the picture obtained may be explained by simultaneous presence of aurora in a big latitudinal interval, when it was observed by all the stations at the approach of darkness. If that is so, it means that aurora is, apparently, not limited by the night side of the Earth, but spreads over its day side.

To solve the question: what are the aurorae observed simultaneously at varied longitudes, 17 nights were selected, during which simultaneous work by several stations continued for not less than 5 hours running. For these nights there has been drawn the dependence of aurora brightness on time. Aurora brightness has been expressed by the 4-force scale. Fig. 4a gives an example of one such night. For the same nights diagrams similar to the diagram given in Fig. 4b were drawn, where the X-axis is time, and the Y-axis is angular distance along the meridian counting from the southern horizon of the station. Regions occupied by aurora are shaded.

On the basis of this analysis we have drawn the conclusion that aurorae, simultaneously observed at various longitudes, form a continuous band along all of which brightness changes synchronously. This band can move along a latitude, at the same time changing its width.

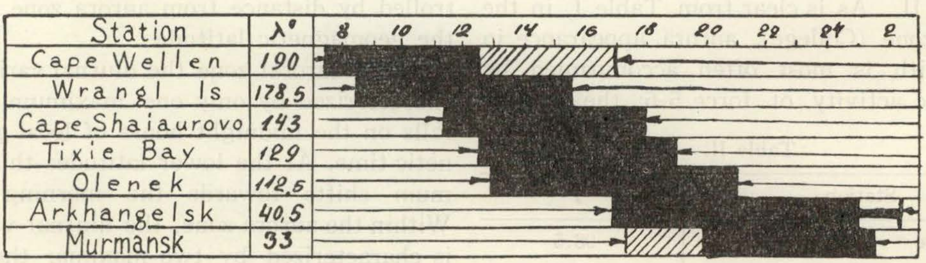


Fig. 3. Results of investigations carried out by a number of stations on March 24, 1958. Arrows limit the light time, shading—cloudness, blackened places are periods with aurorae. Universal time.

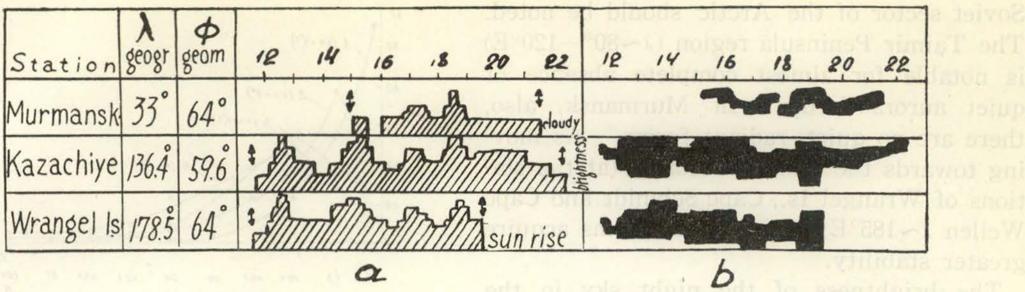


Fig. 4. Time-dependence at various stations, *a*—aurora brightness; *b*—position on the sky. January 23, 1958. Universal time. Arrows indicate the beginning and end of the photography.

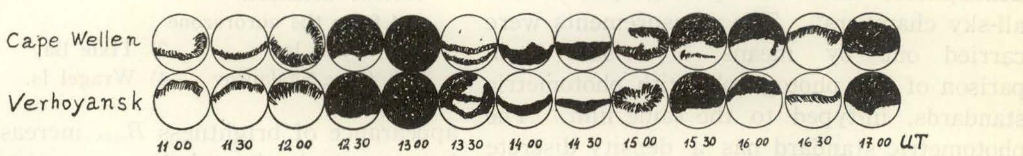


Fig. 5. Forms and locations of aurorae, simultaneously observed on February 17, 1958, at the stations of Cape Wellen and Verkhoyansk. Universal time.

Even by photographs of distant stations, situated at equal distances from the aurora zone (such as Wrangel Is. Kazachiye or Cape Wellen-Verkhoyansk), development of aurora identical forms during long intervals of time is often but not always observed (Fig. 5). It is obvious that the aurora band tends to spread along the aurora zone. But as the zone is presented as the average of multi-diurnal observations and must change not only from day to day, but also during twenty-four hours, it is natural that such a band will also vary with time. Therefore, each time, some definite chain of stations will be under conditions favourable for observation of this band.

More detailed analysis has been carried out of homogeneous arcs by photographs of the stations: Dixon Is., Cape Schmidt, Wiese Is., Pyramida, Oasis and Mirny[5),6)]. It turned out that their directions coincide, on an average with the lines of equal adiabatic invariants, which only slightly differ from those calculated by Hultqvist[7)]. At local midnights for all stations observed this coincidence is practically complete. At the same time systematic changes of azimuths of arcs during a day were observed—a decrease from the evening hours towards the morning hours in the Northern hemisphere, and an increase in the Southern hemisphere. In both hemispheres azimuths were counted clockwise from the direction towards the corresponding pole.

Consideration of simultaneous photographs of various stations permitted observation of arcs stretching over 3000 km. Fig. 6 gives an example of such arcs, both homogeneous and radiant, at various times of the day.

During observation of arc azimuths at high-latitudinal stations in both hemispheres (Arctica II 1957–1958, Arctica II 1958–1959, Vostok) a 360° arc rotation was found during the day. A similar result has been obtained by Davis[8)].

A feature of aurora forms observed in the

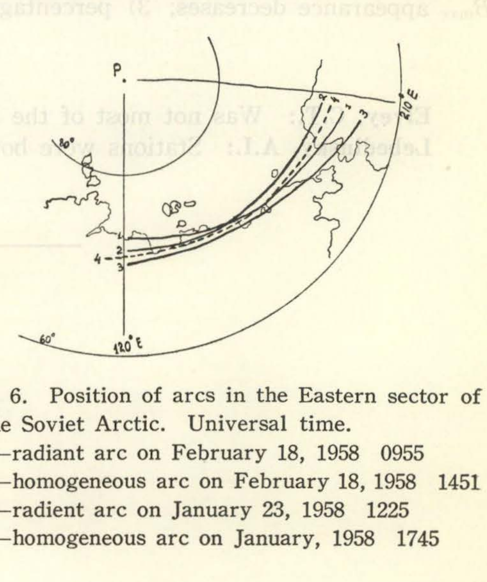


Fig. 6. Position of arcs in the Eastern sector of the Soviet Arctic. Universal time.
1—radiant arc on February 18, 1958 0955
2—homogeneous arc on February 18, 1958 1451
3—radient arc on January 23, 1958 1225
4—homogeneous arc on January, 1958 1745

Soviet sector of the Arctic should be noted. The Taimir Peninsula region ($\lambda \sim 80° - 120°E$) is notable for almost complete absence of quiet aurora forms. In Murmansk, also, there are no quiet radiant forms. As moving towards the East, to Alaska (at the stations of Wrangel Is., Cape Schmidt and Cape Wellen $\lambda \sim 185°E$) even radiant forms acquire greater stability.

The brightness of the night sky in the magnetic zenith region was measured for a number of polar stations of the Northern hemisphere, also from photographs of the all-sky chambers[9]. The measurements were carried out by means of visual comparison of sky photographs with photometric standards, in-typed to the same film. The photometric standard has a density discrete scale varying according to the longitudinal law.

Fig. 7 shows the result of these measurements for stations at various distances (positive towards the North) from the aurora zone. Along the X-axis the logarithms of brightness B are given (the lower scale shows values of brightness itself in units of 10^{-8} stb) along the Y-axis appearance frequency of the given brightness (in percentage) has been shown.

It is obvious from the figure that with approaching the aurora zone (both from the North and the South), 1) the value of the maximum brightness occurring in the zenith increases; 2) the value of the most possible brightness B_{max} increases, and percentage of B_{max} appearance decreases; 3) percentage of appearance of brightness B_{max} increases, owing to which the whole curve acquires a more smooth decrease.

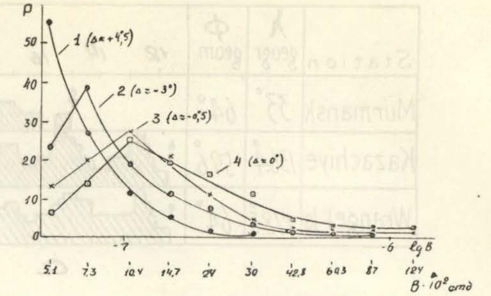


Fig. 7. Function of night-sky brightness distribution in the magnetic zenith at the stations at various distances.

Δ from the aurorazone

1) Wiese Is. 2) Tixie Bay

3) Cape Shalaurov 4) Wragel Is.

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Discussion

Elvey, C.T.: Was not most of the Soviet stations south of the auroral zone?

Lebedinsky, A.I.: Stations were both sides of the auroral zone.