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I-4-P4. Airglow and Earth Storm

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True effects of earth storms on airglow 6300 have been detected at the low latitude station Tamanrasset. These effects are connected with disturbances in the ionospheric F layer.

It is now well known that during earth storms the polar aurora extends farther to the south than during undisturbed conditions. The aurora, in the subauroral zone, is most easily detected in 6300 Å radiation; it can be visual or subvisual. For instance at the Haute-Provence Observatory (geomagnetic latitude 44°N.) the aurora is nearly always present when $K_p > 5$. It has been shown there that sometimes low latitude aurorae form a stable, long lived arc which seems to be monochromatic.

Thus during an earth storm the spreading towards the south of the aurora prevents observation of its effects on the true airglow, at least in middle latitude stations. Nevertheless it has been disclosed that the twilight emission of 6300 Å is stronger and displaced to the north when the magnetic activity is large[1].

Observations made at Tamanrasset, at a lower latitude (geomagnetic latitude 25°N), with a polar, eight colors photometer have shown a few sunlit aurorae through the shorter wave length filters (especially 3670 Å) but their appearance in 6300 Å remained doubtfull.

In November 1960 a rotating photomerer was operated at the Tamanrasset Observatory, scanning the sky at a zenith distance 75°. It has been stated former[2] that the airglow during the night Nov. 12–13 was quite different from normal.

Let us remember first the principal facts concerning the normal emission of 6300 in the equatorial zone: there are two intertropical arcs, about 500 km half width, centered on isoclines ±30°[3]. One of these arcs is crossing the sky at Tamanrasset where it has been extensively studied in January 1960[4] and again in November 1960[5]; its altitude is variable; figures between 240 and 400 kms have been derived by triangulation from two stations. The latitude of the Tamanrasset arc is lower during the second part of the night and meanwhile its intensity is weaker. There are random fluctuations in the properties of the arc but, under normal conditions, changes from night to night are not very important.

During Nov. 1960, two earth storms have been observed, the first one starting Nov. 12 at 13 h 50 m U. T. and the second one Nov. 15 at 13 h 05 m. Observations of the 6300 line were carried on until moonrise. Fig. 1 shows observations for the first earth storm

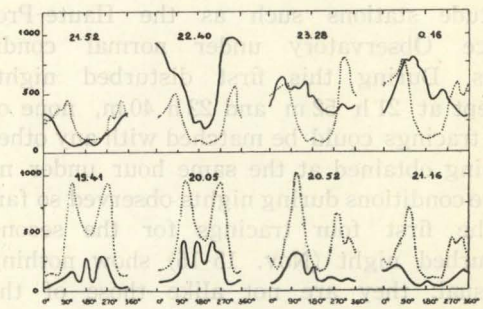

Fig. 1. Intensity of the red line at zenith distance 75°, around the horizon. Heavy line: earth storm 12–13 Nov. 1960, dotted line: normal night 14–15 Nov. 1960.

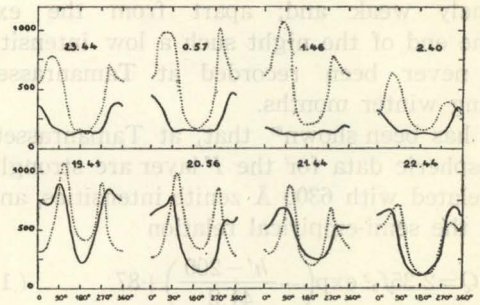

Fig. 2. Intensity of the red line at zenith distance 75°, around the horizon. Heavy line: earth storm 15–16 Nov. 1960, dotted line: normal night 16–17 Nov. 1960.

(Nov. 12–13) and for sake of comparison for a normal night (Nov. 14–15). Fig. 2 shows observations for the second earth storm (Nov. 15–16) and for another normal night (Nov. 16–17).

Tracings on Fig. 1 disclose an enhancement of intensity to the north (azimuth 180°) which is very conspicuous until 20 h 52 m and then declines and disappears (0 h 16 m). This enhancement is most probably a true auroral feature. Apart from this phenomenon and until 21 h 52 m, with an exception for the tracing at 20 h 52 m, there seems to be an arc which recedes to the south. Intensities at the beginning of the night are extremely weak, much weaker than for the reference night. At 22 h 40 m, intensity has resumed a normal value and the tracing could be interpreted as an arc far to the south or rather to the south-south-east. At 23 h 28 m and 0 h 16 m the shapes of the tracings have no bearing to the normal arc, though the intensity is rather large, much larger anyway than the intensity at mid-latitude stations such as the Haute-Provence Observatory under normal conditions. During this first disturbed night, except at 21 h 52 m and 22 h 40 m, none of the tracings could be matched with any other tracing obtained at the same hour under no more conditions during nights observed so far.

The first four tracings for the second disturbed night (Nov. 15–16) show nothing unusual; they are not alike those of the reference night, but not substantially different.

Later it seems that the arc recedes to the south and consequently the intensity of 6300 decreases. At 1 h 46 m the intensity is extremely weak and; apart from the extreme end of the night such a low intensity has never been recorded at Tamanrasset during winter months.

It has been shown[6] that, at Tamanrasset, ionospheric data for the F layer are strongly correlated with 6300 Å zenith intensities, and that the semi-empirical relation

$$Q=2.35 f_0^2 \exp\left(-\frac{h'-200}{41.2}\right)+87 \qquad (1)$$

holds.

In this relation Q is the zenith intensity in rayleighs of 6300 Å, f_0 the critical frequency of the F layer expressed in kilocycles and h' its minimum virtual height. The first term represents the intensity of 6300 Å due to the dissociative recombination process, and the second term, generally much weaker, the mean of the intensity of 6300 Å due to other processes.

During the November observations we had no zenith measurements but it turns out that the means of intensities measured east and west at zenith distance 75° are proportional to the intensities computed according to eq. (1) (Fig. 3). The interesting point is that under disturbed conditions, 12–13 Nov. (circled crosses) and 15–16 Nov. after 23 h U. T. (stars) observations check the same relation and that means that the disturbance produced by the earth storm on the 6300 Å emission at Tamanrasset is not due to a change in excitation mechanism (dissociative recombination) as it would be in case of aurora but to a change in the rate of this mechanism.

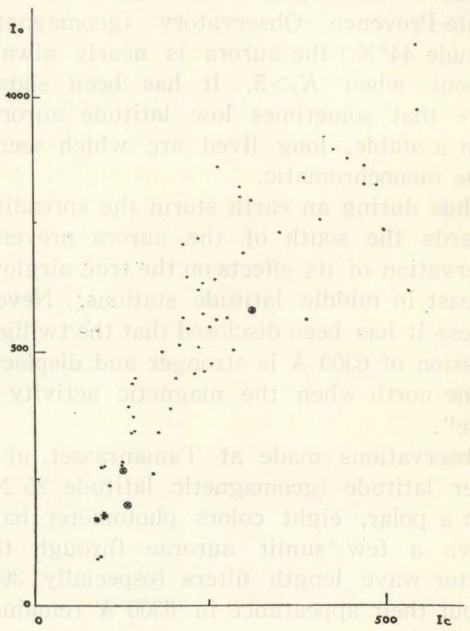

Fig. 3. Abscissa: zenith intensity computed according to ionospheric data. Ordinate: mean of the intensities measured east and west at zenith distance 75°. Dots refer to normal conditions, circled crosses refer to the first earth storm (12–13 Nov.) and stars to the second earth storm (15–16 Nov. end of the night).

During the night 12–13 Nov. the f_0F values at Tamanrasset are normal but the h'_F are

rather large until 22 h U. T. and then they are normal again. It is interesting to note that normal values of f_0 and h' do not disclose that the ionosphere is strongly perturbed as it is shown by the last two tracings for this night.

For the other disturbed night (Nov. 15–16) ionospheric conditions are normal in Tamanrasset until 0h 00m U. T., when f_0 begins to be rather weak and at the same time h' very large.

Thus we can see that an earth storm brings trouble in the 6300 emission of the airglow in equatorial regions, in relation with the properties of the F layer. Up to now, observations of the airglow during earth storms are too scanty to help in deriving the theory of their effects on the F layer.

During the night Nov. 12–13 at 0h 10m U. T., Mr. Weill and myself were able to see an extended light in the sky in the direction NW. It was weak but distinct. The emission of 6300 was probably much too weak to explain this appearance but in low latitude regions, 5577 has not only the ordinary low altitude component but a high altitude one too, which varies just alike 6300. According to favorable circumstances it was possible to detect this light. We might wonder if, during certain phases of very large earth storms, this light could not be strong enough to be seen in equatorial regions by unwarned people. It could thus be possible that tropical auroras[7] are not, strictly speaking, true auroras but airglow enhancements connected with earth storms. Intensity of the real aurora is decreasing very fast when the distance to the geomagnetic pole is increasing. On Nov. 12–13 the sky was completely cloudy at the Haute-Provence Observatory but from my experience and from visual observations made in northern France, I can check an intensity for the 6300 radiation of about 30,000 rayleighs north of the station at the zenith distance 75°. The highest intensity recorded at Tamanrasset is about 100 times weaker (Fig. 1 at 19.41 U. T.) and moreover the spectrum of the aurora is probably nearly limited to the 6300 radiation; accordingly it seems unlikely that any aurora could be detected visually at zenith in Tamanrasset and less again nearer to the equator.

I am indebted to Mademoiselle Pillet who has sent me the ionospheric data, in advance of publication.

Appendix

Table I shows values of the intensity of 6300, f_0 and h'_F. Barred values are means taken, under normal conditions, between Nov. 13 and Nov. 24. Q is the mean of the intensities at 75° zenith distance, east and west, which is representative of the intensity at zenith.

Table I.

U.T.	19	20	21	22	23	0	1	2	3	4
$\bar{Q}$	730	700	700	710	570	550	500	390	390	320
Q(12–13 Nov.)		210	270	210	500	660				
Q(15–16 Nov.)	1070	800	520	660	280	170	150	130	170	
$\bar{f}_0$	15.7	15.1	14.4	12.6	13.2	13.1	11.0	9.4	8.0	5.5
f_0(12–13 Nov.)			12.8	15.0	>13.2	13.0	>11.5			7.0
f_0(15–16 Nov.)		13.3	13.1	13.0	> 7.0	9.0	8.0	4.8	4.4	3.8
$\bar{h}'$	240	240	235	230	235	240	235	240	230	240
h'(12–13 Nov.)	260	285	295	300	245	245	260		285	200
h'(15–16 Nov.)	215	225	250	240	235	325			350	410

References

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7) S. Chapman: Nature **179** (1957) 7.

Discussion

Martyn, D. F.: In your slide showing red arcs at Tamanrasset and at other latitudes from aeroplanes, what are the latitudes coordinate geographic or geomagnetic?

Barbier, D.: Geographic.