FIELD STRENGTHS OF 164 kHz RADIO-WAVES RECEIVED AT AHMEDABAD FROM TASHKENT IN 1960-65 AND EFFECT OF SOLAR X-RAY EMISSIONS

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Abstract

The paper summarises the results of observations on the field strength of 164 kHz radio-waves received at Ahmedabad from Tashkent during the period 1960–65. There is a general increase in field strength with decrease in solar activity. From the end of 1965 when we began to receive X-ray data from N.R.L. satellites, it has been noticed that increases in the intensity of 0–8 Å at satellite level, are associated with daytime decreases in the field strength of 164 kHz waves received at Ahmedabad. As may be expected, the enhancement of 0–8 Å X-rays is also associated in a general way with an increased emission from the sun of 10·7 cm. radio-waves. Examples are given.

Introduction

The paper presents the results of observations on long-term changes in the field strength of 164 kHz radio-waves received at Ahmedabad (23° 01′ N, 72° 36′ E) from Tashkent (42° N, 69° E) over a great circle distance of 2150 km. during the period March 1960 to July 1965. There was a break in the recording from August 1964 to April 1965, when the receiver used for this work was modified for use in a radio polarimeter. A new receiver of the tuned radio-frequency type was constructed and put into commission in April 1965. Since then, the recording has continued without interruption.

Daytime Variation of the Signal Strength

An account of the diurnal and seasonal changes in the daytime field strength of the Tashkent 164 kHz radio-waves received at Ahmedabad has been given by S. K. Alurkar.[1] Briefly, the signal strength variations are significantly different in the two seasons, June to October, corresponding to local summer, and November to May, corresponding to winter and spring, In the summer months, the field strength varies regularly with the position of the sun, attaining a maximum around noon. In the non-summer months, the field strength shows oscillations in the morning and afternoon hours.

Diurnal Variation in the Field Strength from 1960–65

The diurnal changes in field strength for the period 1960–65 are shown in Figs. 1 and 2, where the monthly mean field strengths for July, September and January, April are shown for each year. The change in noon absorption between July 1960 and July 1964 was about 10 decibels, with nearly the same difference in September. The most interesting feature in the diagrams is the steady increase in field strength from 1960 or 1961 to 1964, the nature of the diurnal variation remaining practically the same in each of these months.

Figure 2 shows the field strength curves for the two non-summer months, January and April. A similar increase in field strength with

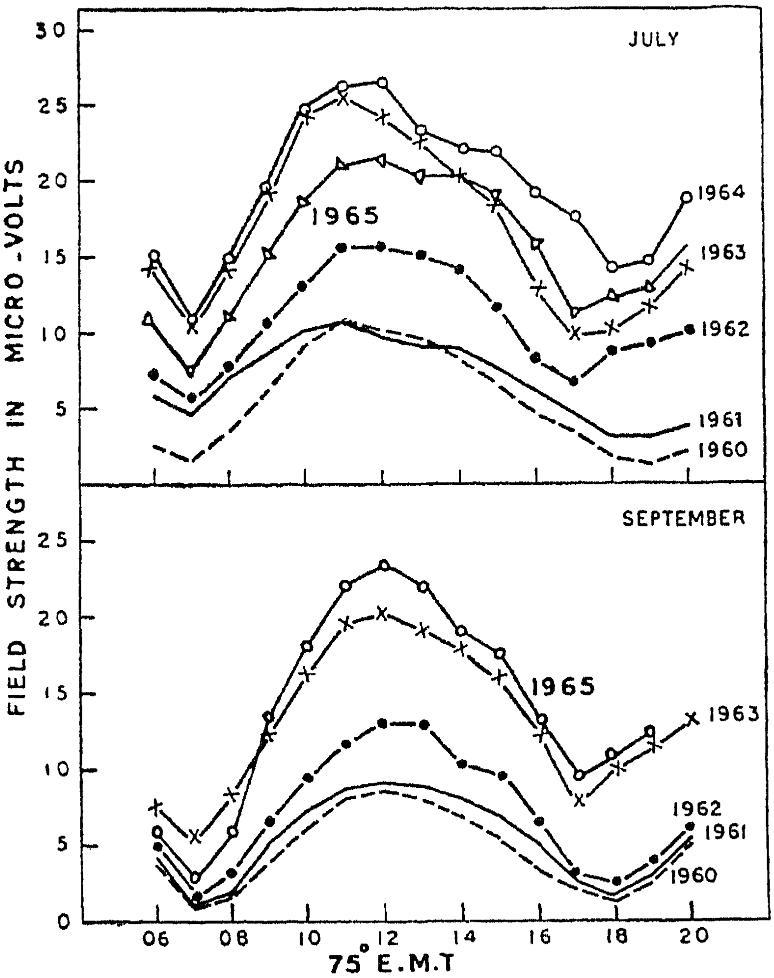

Fig. 1

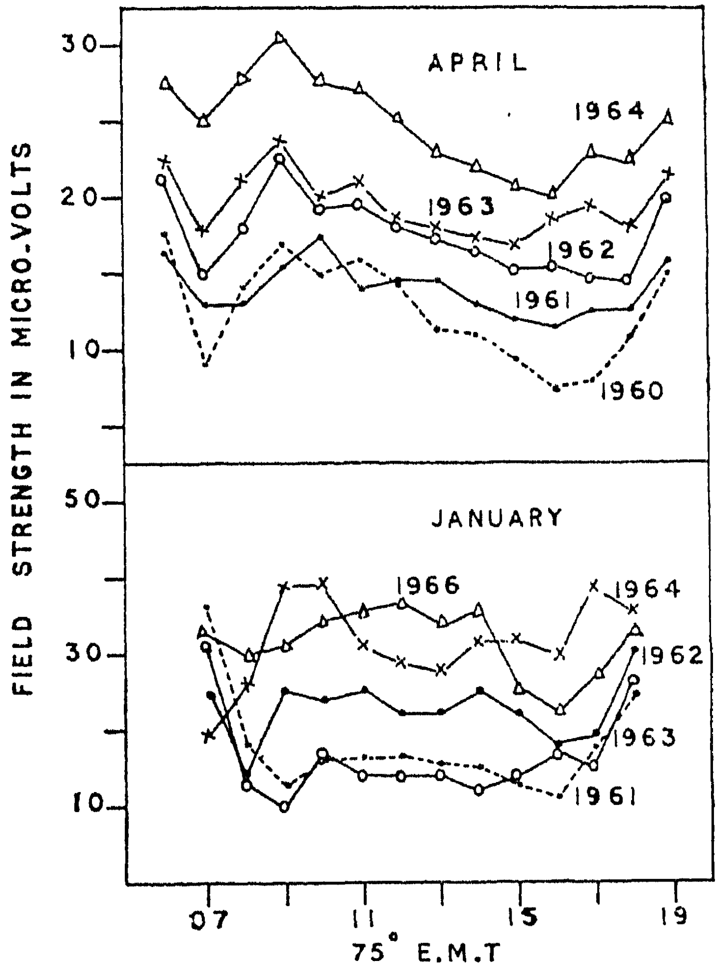

Fig. 2

Fig. 1. Mean daily variation of field strength of 164 kHz waves transmitted from Tashkent and received at Ahmedabad—July and September 1960–65.

Fig. 2. Mean daily variation of field strength of 164 kHz waves from Tashkent and received at Ahmedabad—January and April 1960–64.

decreasing solar activity is also evident here. There is however no pronounced increase in noon field strength in these months.

ANNUAL CHANGE IN THE DAYTIME FIELD STRENGTH AT AHMEDABAD

The seasonal and yearly variations of the observed noon signal strength from March 1960 to January 1966 are shown in Fig. 3. The changes are given in terms of the absorption loss in decibels (*db*). The method of calculation was as follows:

In the A–3 method of calculating absorption at low frequencies, the ratio of sky to ground wave is used to estimate the reflection coefficient. The absorption can then be determined using a simple relation. Since the great circle distance between Tashkent and Ahmedabad is large, the ground-wave signal would be very small, rendering the use of this method impracticable. An alternative approach to the problem was by making use of the night-time signal strength, since there is an insignificant amount of absorption below the E-region at night. A careful study of the night-time signal strength between 1960 and 1964 brought out two features clearly: (*a*) The field strength in any month reaches a maximum at about *midnight*; (*b*) the field strength increased with decreasing solar activity reaching its maximum value in 1963–64. The mean *midnight* field strength for this period (E_m) on nights undisturbed by atmospherics was taken to be a measure of the unabsorbed sky-wave field strength. The ratio E_n/E_m where E_n is the mean noon-day signal strength was then used to calculate the absorption loss using the relation

$$L\,(db) = -20 \log E_n/E_m.$$

The noon absorption determined in this way is shown by the broken line in Fig. 3. In the same figure is shown the absorption loss corrected for the variation of the noon-zenith angle of the sun with season. For this purpose the relation

$$L_\chi = L_0 \cos^n \chi$$

where χ is the solar-zenith distance at noon, was used. The value of the index n was found by measuring the slope of the straight line obtained by plotting the absorption loss in decibels against the zenith angle of the sun on logarithmic paper. The mean value came out to be $n = 0 \cdot 6$.

It is evident from Fig. 3 that the 164 kHz signal strength between Tashkent and Ahmedabad is correlated in a general way with sunspot activity but there is no detailed correlation.

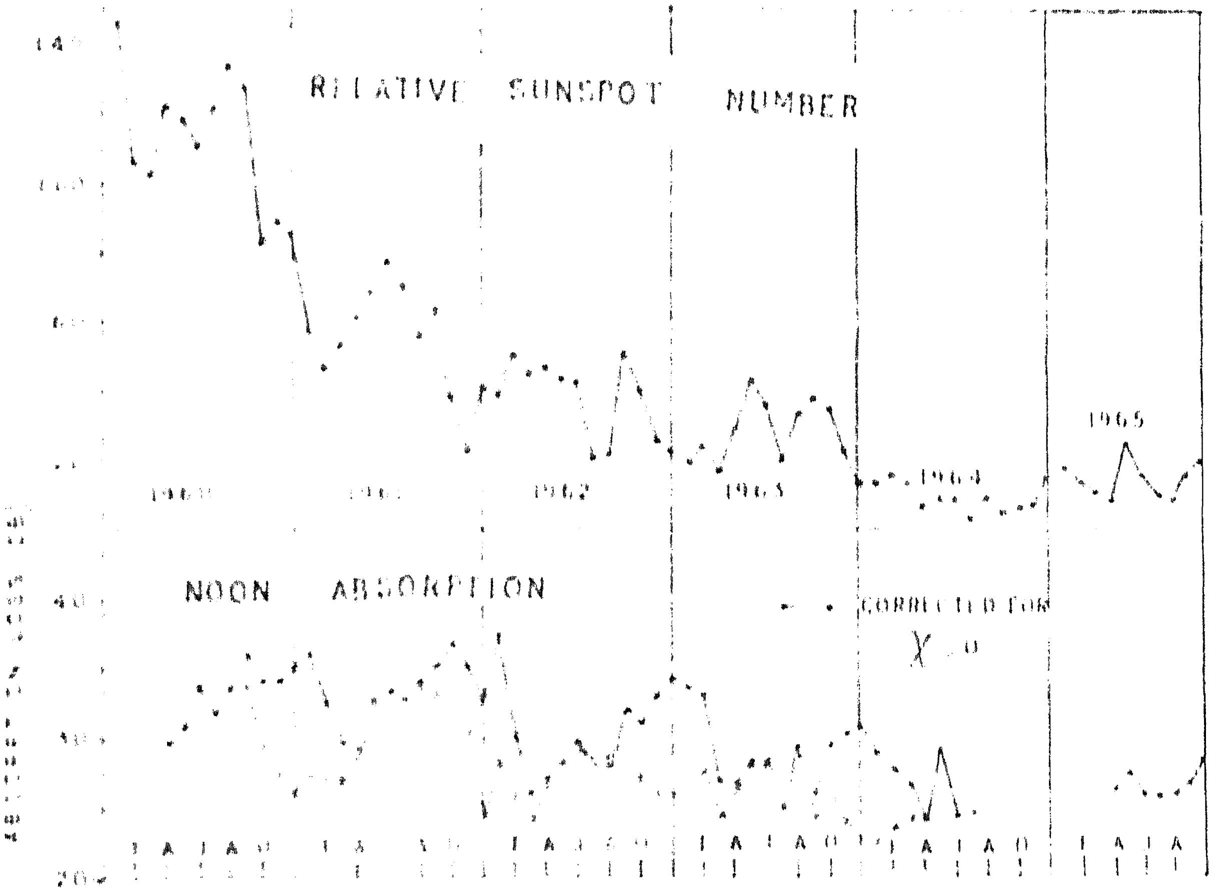

FIG. 3. Variation of monthly *noon* absorption of 164 kHz radio-waves (1960–65) with sunspot number.

SOLAR X-RAY EMISSIONS AND THEIR EFFECT ON SIGNAL STRENGTHS OF REFLECTED LONG RADIO-WAVES

The immediate effect of solar flares on the reflection of long radio-waves is well known. It has been established that the effect is due to the ionization of the lower part of the D-layer by solar X-rays in the kev region. Three examples of the effect are shown in Fig. 4 where the changes in signal strength of Tashkent 164 kHz waves received at Ahmedabad are shown against the times of reception of solar X-rays in Oso I and Ariel Satellites on 21 April and 1 and 3 May 1962.

In a previous paper,[3] we had pointed out that in addition to the general increase in field strength (decrease in absorption) with the gradual decrease in solar activity from 1960 to 1965, there were groups of two to six days of high daytime intensity which were sometimes preceded by a solar flare.

Early in 1966, on comparing the day-to-day signal strengths of 164 kHz received at Ahmedabad with the X-ray fluxes (0–8 Å and 8–20 Å) from N.R.L. satellites recorded at the satellite telemetry station at Ahmedabad, the interesting fact was noticed that on a number of occasions when the

0–8 Å X-ray flux increased in intensity, the signal strength fell down and *vice versa*. This effect, unlike the well-known solar flare effect, persisted during day hours for a number of days at a time.

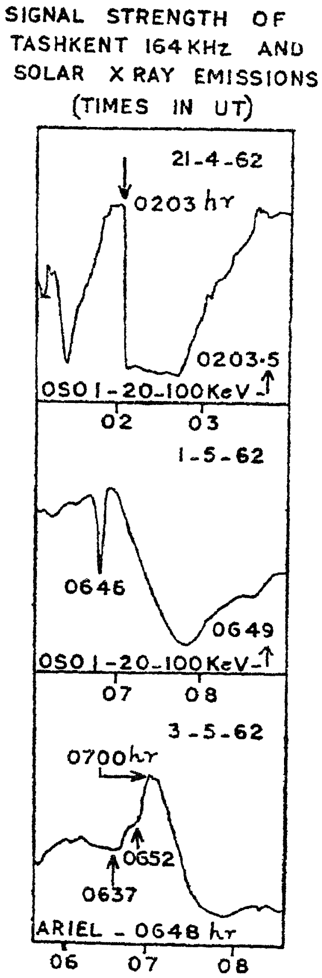

FIG. 4. Signal strengths of Tashkent 164 kHz received at Ahmedabad and solar X-rays from flares, telemetered from OSO I and ARIEL satellites.

Figures 5 and 6 show a comparison of the field strengths at Ahmedabad and solar X-ray fluxes in the two bands 0–8 Å and 8–20 Å in March, April and July, August 1966. The field strengths relate to the *noon* hours 11–13 hrs. local time and the X-ray fluxes are the average values during the day according to the data published from World Data Centre A. The high field strength on 2–12 March and the corresponding low X-ray fluxes are very striking; similarly, the low field strengths from 14–22 March and the corresponding high X-ray fluxes. There are similar changes in other months also. In July (Fig. 7) the low field strengths from the 23rd to 29th were associated with comparatively high X-ray fluxes in 0–8 Å band. In the period 7–12

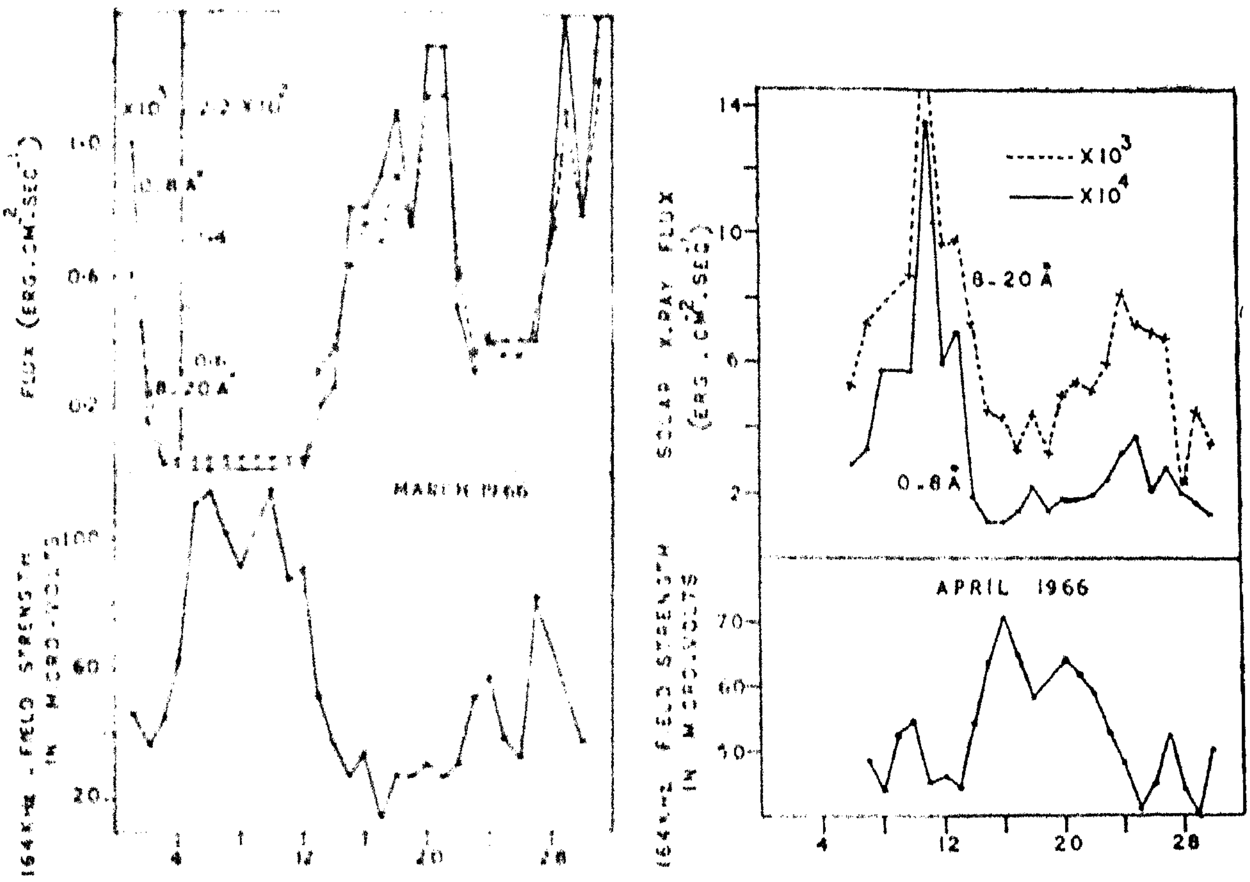

FIG. 5. Solar X-ray flux, 0–8 Å and 8–20 Å and Tashkent 164 kHz field strength at Ahmedabad—March and April 1966.

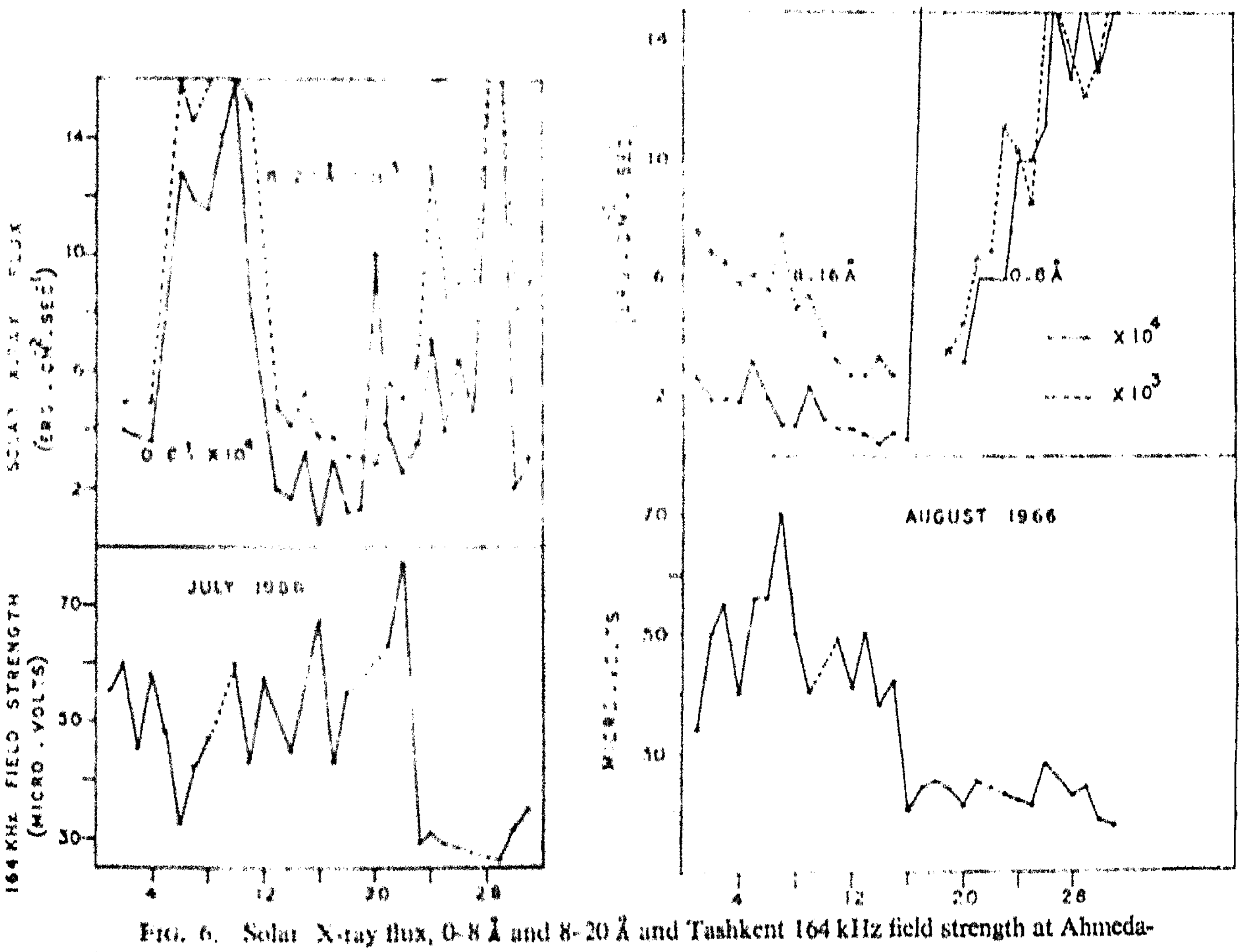

FIG. 6. Solar X-ray flux, 0–8 Å and 8–20 Å and Tashkent 164 kHz field strength at Ahmedabad—July and August 1966.

July there were high fluxes in both bands, but the signal strengths were not markedly low. This and a few other similar occurrences suggest that while the 0–8 Å band causes a decrease in signal strength, the 8–16 Å band has perhaps an opposite influence. The resultant effect will therefore depend on the relative strengths of the radiation in the two bands.

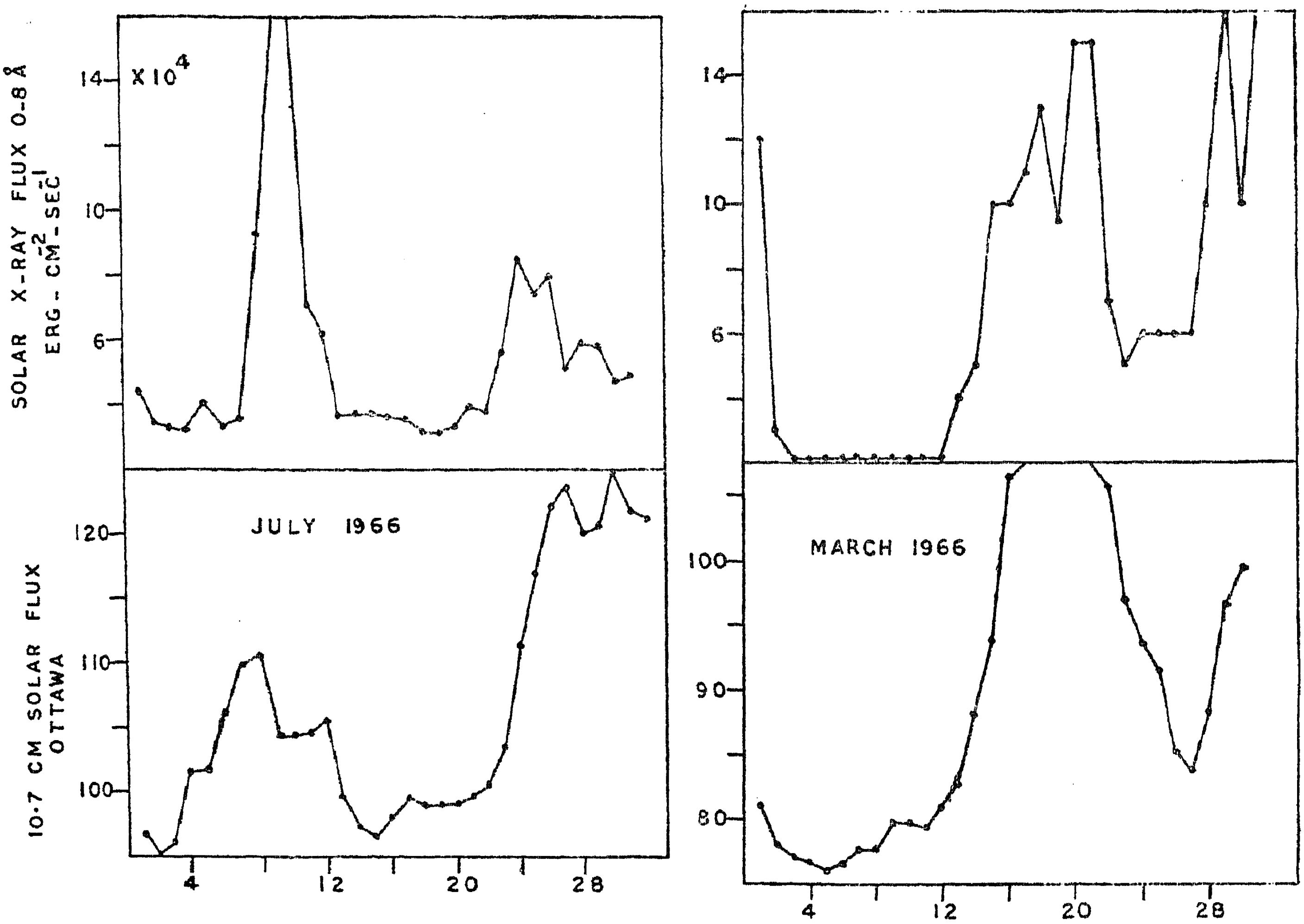

FIG. 7. Intensity of solar X-rays (0–8 Å) and of 10·7 cm. radio-waves in March and July 1966.

The persistence of low values of L.F. signal strengths for many days during a period of enhancement of non-flare solar X-rays and their absence at night suggests that the ionization produced by these X-rays exists in the form of negative ions, and that electrons are liberated from the negative ions during daytime by photo-dissociation. Various molecular ions have been suggested as being responsible for this, NO_2^-, O_2^- and recently CO_3^-. More laboratory and mass spectrometry work is required to elucidate this.

It may be mentioned that as may be expected, the enhancement of solar X-rays in the 0–8 Å band is associated in a general way with an increased emission from the sun of 10·7 cm. radio-waves. An example is given in Fig. 7.

Acknowledgements

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References

1. Alurkar, S. K. .. *Ind. Jour. Pure and Appl. Phys.*, 1965, 3(2), 58.
2. Ananthakrishnan, S. and Ramanathan, K. R. .. *Proc. Ind. Acad. Sci.*, 1966, **55**, 38.
3. Branscomb, L. M. .. *Ann. Geophys.*, 1964, **20**, 88.
4. Hultqvist, B. .. *Ibid.*, 1966, **22**, 245.
5. Reid, G. C. .. *Rev. in Geophys.*, 1964, **2**, 311.
6. Willmore, A. P., Pounds, K. A. and Sanford, P. W. .. *Space Research IV*, 1964, p. 741.
7. White, W. A. .. *Ibid.*, 1964, p. 771.

352–67. Printed at The Bangalore Press, Bangalore City, by M. S. Narayanamurthy, Secretary, and Published by B. S. Venkatachar, Editor, "Proceedings of the Indian Academy of Sciences," Bangalore