II-3. Solar Radiation

II-3A. Electromagnetic Waves

Chairman: R. G. Athay
Co-chairman: T. Hatanaka

Date	Time	Paper Numbers
Sept. 4	11 : 30 – 13 : 30	from II–3A–1 to II–3A–5
Sept. 4	15 : 30 – 17 : 30	from II–3A–6 to II–3A–11
Sept. 8	09 : 00 – 10 : 30	
	plenary session	from II–3A–P1 to II–3A–P3

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

II-3A-1. Some Features of the Type IV Radiobursts*

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1. Some features of the type IV radiobursts, interesting for the solution of the problem on generation of geoeffective corpuscular streams on the Sun, are briefly reported. Observations of the solar radio emission by radiotelescopes (frequencies of 209 and 545 Mc) and the materials of patrol observations of chromospheric flares (IZMIRAN-Moscow) and a number of published IGY data of radioburst observations at frequencies of 167, 450 Mc (USA), 2800 Mc (Canada); 200, 1000, 2000, 3750, 9400 Mc (Japan) and radiospectral data of Fort Davis observatory (range 100–580 Mc) are used.

2. The type IV radiobursts are usually associated with the type II radiobursts.** However, their distinguishing is very difficult. A statistical function of radioburst amplitudes can serve as one of the objective radioburst characteristics during an observation at a fixed frequency[1]. Fig. 1 gives averaged-curves of amplitude distribution for the types II and IV radiobursts which can be used (alongside with the analysis of other radioburst properties for distinguishing the types II and IV radiobursts following each other).

3. The type IV radiobursts are closely associated with major chromospheric flares. The comparison of radioburst records with the patrol film tapes of chromospheric flares has shown the following:

The moment of the type II radioburst commencement is close to the period of hydrogen plage radiation maximum (maximum of chromospheric flare). The moment of the type

* This paper was read by A. I. Lebedinsky.

** In future only those type II radiobursts which are directly associated with the type IV radiobursts will be considered.

IV radioburst commencement occurs at the second part of a flare after the maximum and coincides with the commencement of eruptive prominence of filament.

4. The correlation of the moments of the types II and IV radioburst commencements is determined by the location of a chromospheric flare connected with them. If a flare took place within 30° of the central zone, then the moments of the types II and IV radioburst commencements differ within $\leq 15^{m}$. For limb flares this difference increases to some decades of minutes (sometimes up to an hour or more).

5. While the type II radioburst intensity does not almost depend on the flare location on the disk, the type IV radioburst intensity essentially decreases for the limb-flares (Fig. 2). The decrease of intensity at decimeter wavelengths is particularly essential, so the energy spectrum of the type IV radioburst may be strongly reduced due to a flare location on the disk.

In analysing the energy spectrum of radio burst, only central flares are used.

6. The type IV radioburst duration essentially surpasses that of the type II radioburst. The spectrum of the type IV radiobursts is continuous and wider than that of the type II radiobursts. Therefore, the total energy flux of the type IV radiobursts is approximately three times as large as the energy flux of the type II radiobursts.

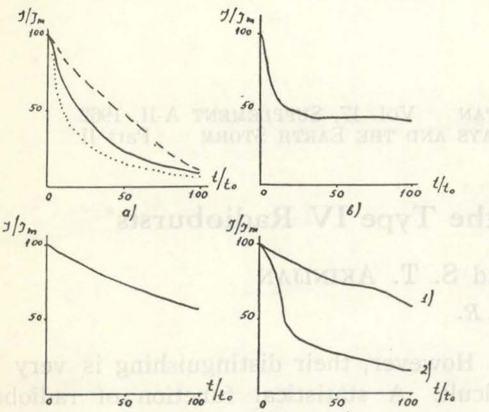

Fig. 1. a) A general average-statistical curve of amplitude distribution for 8 radiobursts of the type IV; ---- for burst increase; .... for burst decrease.

b) A curve of amplitude distribution for the type II radiobursts.

c) Average-statistical curves of amplitude distribution of the type IV radioburst elements (averaging is made in 100 elements, whose duration is 1-7 minutes).

d) Average-statistical curves of amplitude distribution of noise-storm elements: 1) for the elements similar to the elements of the type IV radiobursts; 2) for complex elements, consisted of 1) and of the type I radioburst.

The abscissae show the relation of radioburst period at a given level in % to the full radioburst period. The ordinates—the amplitude at a given level in % to the maximum.

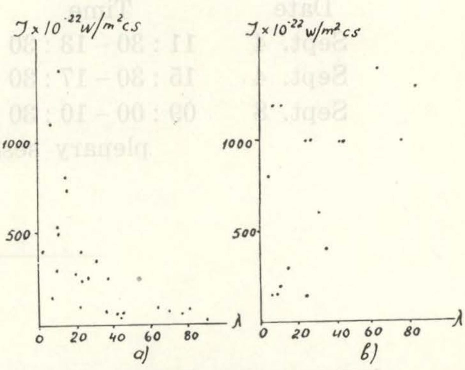

Fig. 2. a) Maximum values of the type IV radio burst intensity versus the flare location on the disk;

b) the same for the type II radiobursts.

7. A close association of the type IV radiobursts with geomagnetic-ionospheric disturbance becomes clear for central flares, while the type IV radiobursts, associated with chromospheric limb-flares, are not geoeffective.

8. A number of properties of the type IV radiobursts imply that they are due to magneto-bremsstrahlung-radiation of electrons which have the energy of order of $\sim 10^{6}-10^{7}$ eV and mean density $\sim 10^{2}$ cm^{-3}; magnetic field has magnitude of order of $10-10^{2}$ oersted[8]. Such a magnetic field may appear as a result of a large-scale plasma cloud passage into the solar corona, while moving, in the active region of the cloud, its own force-free magnetic field is generated[2]. A paper[3] showed that the energy spectrum of the type IV radioburst is confined by the region of high frequencies ($\geq 10^{3}$ Mc). This does not agree with a number of observations[4,5,6], which show that the type IV radiobursts are mainly observed within the decimeter and meter ranges. The result of the paper[3] is

probably connected with the difficulty to distinguish the types IV and II radiobursts, which have different energy spectra.

9. A typical energy spectrum of the type IV radiobursts either has the maximum in the decimeter range (Fig. 3) or decreases monotonically with increasing frequency (Fig. 4).

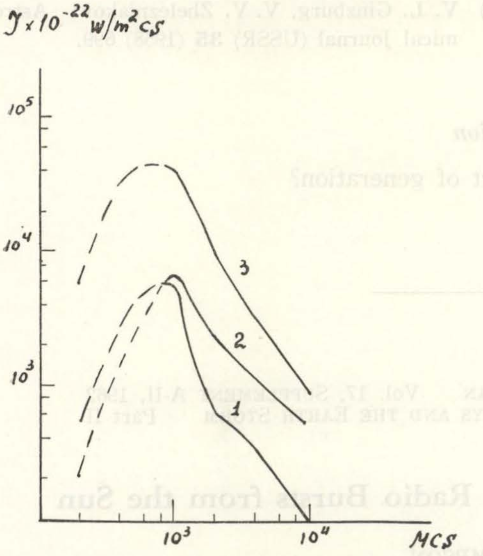

Fig. 3. Distribution of the type IV radioburst intensity versus the spectrum (maximum in the decimeter range).

1) 11.IX.57, flare 02^h45^m; N17, W05; $J=3$.
2) 16.XII.59, flare 21^h15^m; N8, E26; $J=3+$.
3) 11.XI.60, flare 03^h05^m; N25, W05; $J=2+$.

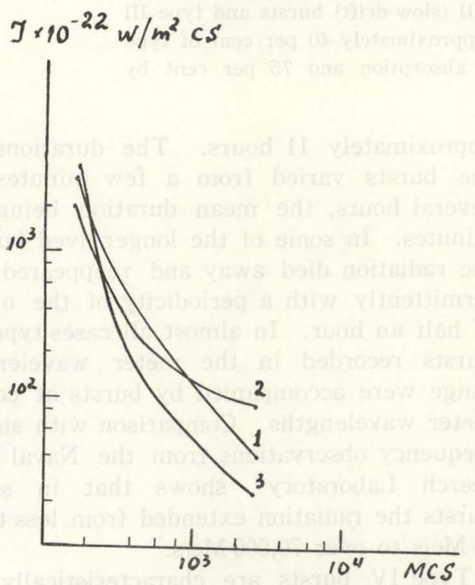

Fig. 4. The type IV radioburst intensity distribution versus the spectrum (maximum in the meter range).

1) 2.IX.57, flare 13^h13^m; S32, W36; $J=3$.
2) 18.IX.57, flare 18^h18^m; N21, W03; $J=3$.
3) 21.IX.57, flare 13^h32^m; N20, E10; $J=2$.

Such kind of the type IV radioburst spectrum is described by the function[7]

$$I_\nu \simeq A\,(H_\perp,\ N_e)\frac{\nu^{0,3}}{\nu+\bar{\nu}}, \tag{1}$$

which is characteristic for the spectrum of magneto-bremsstrahlung-radiation of relativistic electrons, having the energy spectrum of the following type

$$f\,(\varepsilon)\simeq\varepsilon^{-2,4}\,\exp\,(-\bar{\nu}g/\varepsilon^2)\,. \tag{2}$$

The location and the value of radiation energy spectrum maximum depend on the magnetic field strength $H_\perp$ and radiating electron density N_e.

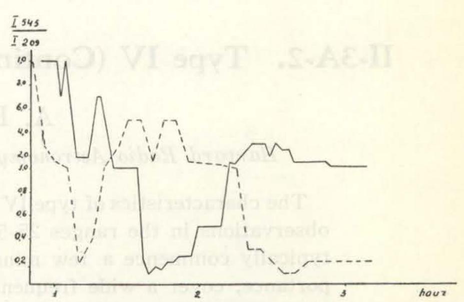

Fig. 5. The correlation of the type IV radioburst intensity variation at 2 frequencies I_{545}/I_{209}:
A solid curve: for the flare 25.VI.60; 11^h36^m; N22; $J=2+$.
A dotted curve: for the flare 1.IV.60; 08^h40^m; N13, E11; $J=3$.

The correlation of the type IV radioburst intensity variations at two frequencies (209 and 545 Mc, Fig. 5) allows, according to expression (1), to judge about the conditions of radioburst generation. The change of the value $I_{\nu 1}/I_{\nu 2}\sim\phi(H_\perp,\ N_e)$ during a radioburst shows that the electron generation, responsible for the type IV radioburst, takes place continuously during the passage of the corpuscular stream with its own magnetic field through the corona. The assumption about a single act of generation during a chromospheric flare is incompatible with the main properties of the type IV radiobursts.

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Discussion

Waddington, C. J.: What is duration of act of generation?
Lebedinsky, A. I.: About 2-3 hours.

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II-3A-2. Type IV (Continuum) Radio Bursts from the Sun

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The characteristics of type IV bursts are described from sweep frequency observations in the ranges 25-580 Mc/s and 2100-3900 Mc/s. The bursts typically commence a few minutes after the start of a flare of high importance, cover a wide frequency range, and may last for several hours. The association of the bursts with type II (slow-drift) bursts and type III (fast-drift) bursts is also discussed. Approximately 40 per cent of type IV bursts are followed by polar cap absorption and 75 per cent by magnetic storms.

This paper gives a brief description of type IV solar bursts, as observed at the Harvard Station, Fort Davis, on sweep frequency equipment covering the ranges 25—580 Mc/s and 2100—3900 Mc/s[1]. The bursts are believed to be produced by synchrotron radiation from electrons accelerated or released during the early stage of a solar flare, and are associated with the emission of solar cosmic rays.

On the sweep frequency records type IV bursts are characterized as a broad band continuum, as shown in the example in Fig. 1. The intensity of the radiation does not vary sharply in frequency or time, in contrast to the records of type II (slow-drift) and type III (fast-drift) bursts. During the period October 1956 through December 1960, an average of 20 type IV bursts per year was recorded with a daily observing period of approximately 11 hours. The durations of the bursts varied from a few minutes to several hours, the mean duration being 90 minutes. In some of the longer lived bursts the radiation died away and reappeared intermittently with a periodicity of the order of half an hour. In almost all cases type IV bursts recorded in the meter wavelength range were accompanied by bursts at centimeter wavelengths. Comparison with single frequency observations from the Naval Research Laboratory[2] shows that in some bursts the radiation extended from less than 25 Mc/s to over 70,000 Mc/s.

Type IV bursts are characteristically associated with flares of high importance; of the bursts recorded at Fort Davis, 24 were associated with flares of importance 3+ or 3, 18 with flares of importance 2+ or 2, and 17 with flares of importance 1+ or 1. In