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II-3A-5. Some Comments on Type IV Bursts

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It has become clear that a large continuum burst is composed of 4 distinctive types, CM_1, CM_2, DM and IV, which originate from different altitudes over the photosphere. The observational characters of each type are given. CM_1 is the main phase of centimeter-wave burst originating from about 0.02-0.05 $R_\odot$ in height. DM burst is polarized in ordinary sense, which is the cause of reversal of polarization with frequency. Its center frequency lies between about 1000 and 200 Mc/s, and is often misunderstood as the original Type IV burst. The movement of magnetic field during a burst is suggested. CM_2 may be considered as an enhancement of the upper part of the source of S-component caused by this movement of the field.

A large continuum burst is often generally called as Type IV. However, recent observations show that the continuum is composed of several groups of emission originating from different altitudes over the photosphere.

Fig. 1 is a simplified spectral diagram[1),2)] of a typical burst, where we propose to separate the continuum into 4 distinctive types. The observational characters of the respective types are shown in Table I. Here we shall explain several new topics in some detail.

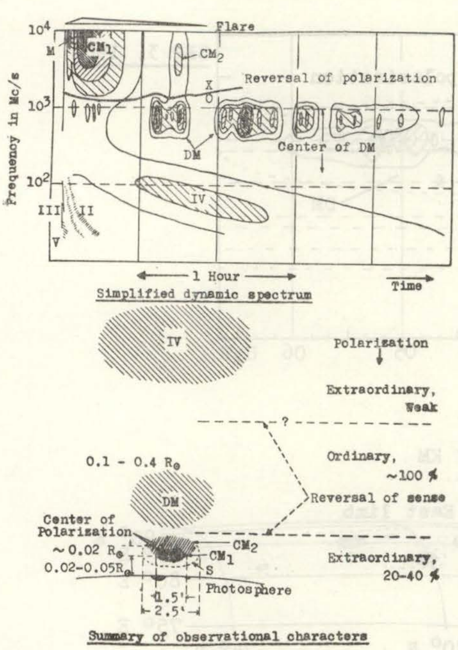

Fig. 1. Simplified dynamic spectrum and summary of observations.

(*1*) *The sense of polarization at CM_1 and CM_2 corresponds definitely to the sense of extraordinary wave.* It was confirmed at 3.2 centimeter wavelength by 16-element interferometer[3)] which can take two series of drift curves of both intensity and polarization. We have selected 26 bursts of intensity more than 800 units during the period from May 1959 to December 1960, where the sense at CM_1 and CM_2 was perfectly the same with that of *S*-component, the latter is in turn always equal to the sense of extraordinary wave[4)]. This relation is not clear statistically, though suggestion was made by Kakinuma[5)] a few years ago.

(*2*) *Type DM is circularly polarized in ordinary sense. The reversal of the sense of polarization[6)] takes place between CM and DM bursts.* The ordinary sense and moderate variability are the characteristics of DM bursts. The reversal of sense may take place also between low frequency end of DM and original Type IV, but this is not clear due to the insufficiency of observations.

(*3*) *The center frequency of Type DM lies between 1000 and 200 Mc/s. Many of the so-called Type IV bursts observed around 200 Mc/s may be DM bursts,* except the initial phase of the cintinuum. This statement is supported by two observational facts at 200 Mc/s that the origin is low and seldom moves and that the sense of polarization is ordinary in general[7)]. It must be noted that DM burst may be the same with 'orage continuum' by

Table I. Observational characteristics of 4 distinctive types.

Type	Frequency	Duration	Position of the source	Size	Apparent temperature	Polarization	Remarks
CM_1 The main phase of centimeter-wave burst	Centimeter waves down to about 10^3 Mc/s. Maximum intensity is at around 10^4 Mc/s.	Tens of minutes	Coincide with flare, about 0.05 $R_\odot$ over the photosphere	About 1.5′ or less, expands up to 4′.	Up to about 10^9°K	10–40% X-wave. Weak at initial phase in general.	Position and size of initial phase (Type M by Takakura) are not measured. Associated with flare.
CM_2 The 2nd phase of centimeter-wave burst	Centimeter waves down to about 10^3 Mc/s. Maximum intensity is at around 3000 Mc/s.	Tens of minutes	A little higher than CM_1	About 2.5′ up to 4′	Up to about 5×10^7°K	10–40% X-wave. Max. pol. is at around 3000 Mc/s	Superposed on the decay part of CM_1. Source of polarization is different from CM_1. Similar to S-component except the spectrum of polarization.
DM Decimeter-wave burst	Decimeter waves 200–2000 Mc/s. Half-power width is about octave.	Tens of minutes to hours	0.1–0.4$R_\odot$ over the photosphere	Several minutes	Up to 10^{11}°K assuming size 4′ at 1000 Mc/s	Near 100%. The sense is opposite to CM_1 and CM_2. O-wave.	Storm-like appearance. Probably the same with 'orage continuum' by French group.
IV	Meter waves up to about 300 Mc/s.	Tens of minutes to hours	0.5–5$R_\odot$ over the photosphere	6′–12′	Up to about 10^{11}°K	Weak. X-wave.	By J. F. Denisse and others.

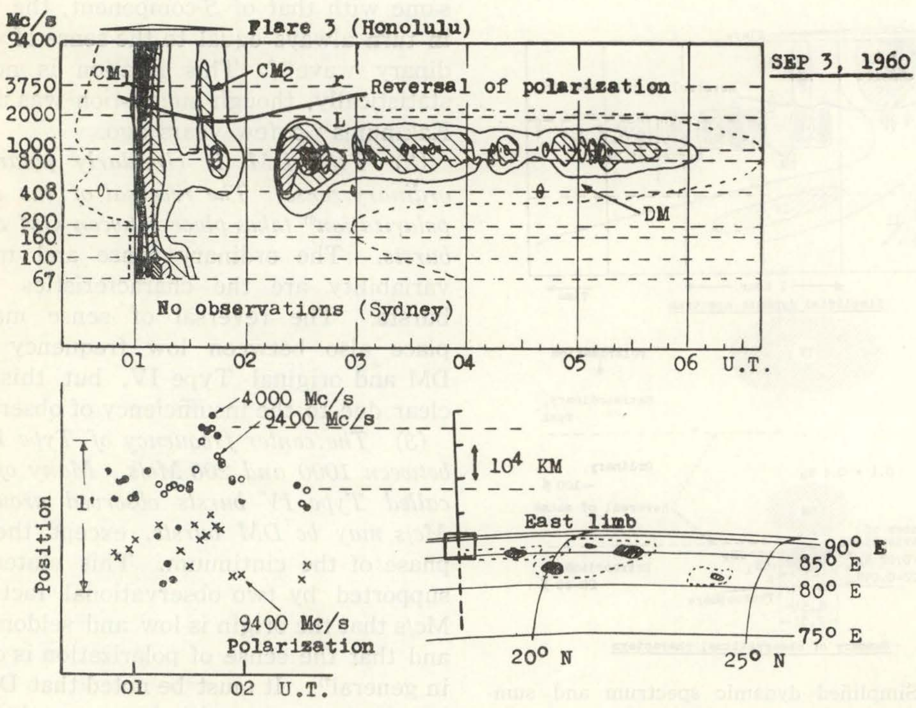

Fig. 2. An example of the movement of position at CM_2 burst.

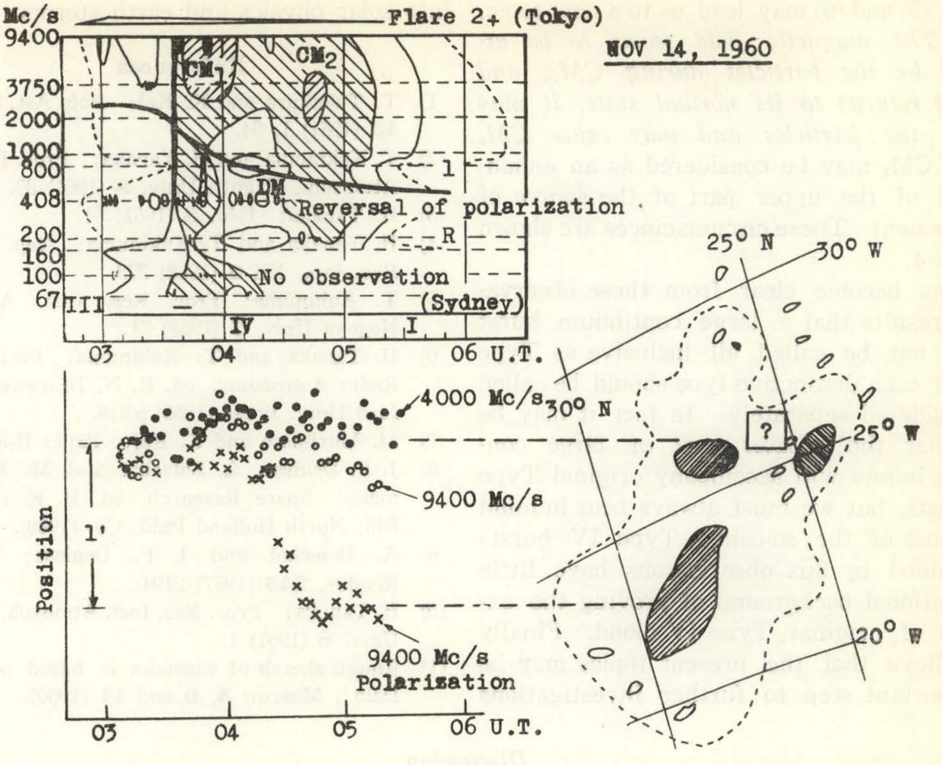

Fig. 3. An example of the movement of the center of polarization at the rising phase of CM_2 burst.

French group[8]. By taking also their results into consideration, the altitude of the origin may be 0.1—0.4 $R_\odot$ over the photosphere which will vary according to center frequency.

(4) *The Type IV burst in the original meaning initiated by Boischot and Denisse*[9] *can be observed only on meter-wave range* below about 200 Mc/s. Usually there seems to be a clear gap between DM and IV, though sometimes the gap is not so clear. Interferometric observations or at least spectral observations of polarization would be necessary to identify the original Type IV burst.

(5) *Origin of CM_2 may be a little higher than CM_1 or S-component.* This is presumable from the frequency spectrum, which is confirmed directly by a limb flare as shown in Fig. 2. We have another less clear example on April 5, 1960.

(6) *Center of polarization moves at the rising phase of CM_2*[10] towards the position corresponding to *S*-component. An example is shown in Fig. 3. We have also two other examples on 11th and 15th November 1960[10].

A noticeable difference between CM_2 burst and *S*-component is that the degree of polarization at 3750 Mc/s is usually larger or equal to the degree of polarization at 9400 Mc/s, probably due to the difference in height.

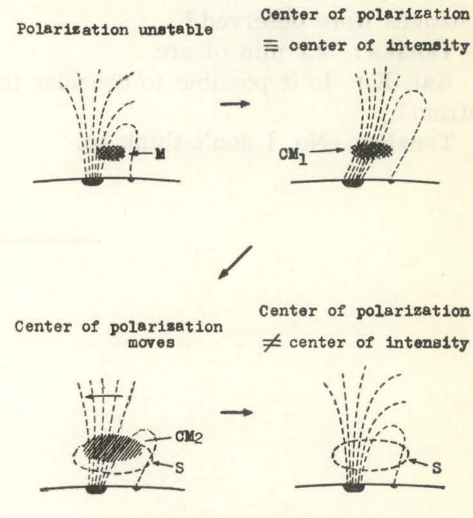

Fig. 4. Presumable evolution of CM bursts in connection with the movement of magnetic field.

Topics (5) and (6) may lead us to a new topic.

(7) *The magnetic field seems to be attracted by the particles during CM_1, and when it returns to its normal state, it may agitate the particles and may cause CM_2 burst.* CM_2 may be considered as an enhancement of the upper part of the source of *S*-component. These circumstances are shown in Fig. 4.

It has become clear from these observational results that a large continuum burst should not be called all inclusive as Type IV, but each distinctive type should be called or considered separately. In fact it may be true that the greater part of large continuum bursts will accompany original Type IV bursts, but we must always bear in mind that most of the so-called Type IV bursts determined by flux observations have little observational background of proving the existence of original Type IV cloud. Finally we believe that the present topics may be an important step to further investigations into solar physics and earth storms.

References

1) T. Takakura and K. Kai: Pub. Ast. Soc. Jap. **13** (1961) 1, 94.
2) T. Kakinuma and H. Tanaka: Proc. Res. Inst. Atmosph., Nagoya Univ. **8** (1961) 39.
3) H. Tanaka: ibid. **8** (1961) 51.
4) H. Tanaka and T. Kakinuma: Rep. Ionosph. Res. Jap., XII **3** (1958) 273.
5) T. Kakinuma: Proc. Res. Inst. Atmosph., Nogoya Univ. **5** (1958) 71.
6) H. Tanaka and T. Kakinuma: Paris Symp. Radio Astronomy, ed. R. N. Bracewell, Stanford Univ. Press (1959) p 215.
7) M. Morimoto and K. Kai: Paper II-3A-7.
8) J. F. Denisse, A. Boischot and M. Pick-Gutmann: Space Research, ed. H. K. Kallmann Bijl, North Holland Publ. Co. (1960).
9) A. Boischot and J. F. Denisse: Comptes Rendus, **245** (1957) 2194.
10) H. Tanaka: Proc. Res. Inst. Atmosph., Nagoya Univ. **8** (1961) 1.
11) Rough sketch of sunspots is based on 'Solar Data', Moscow **4**, **9** and **11** (1960).

Discussion

Kundu, M.R.: What is the velocity you deduce for the CM_2 burst? And what is the error of measurement? Could it be ± 50 km/s?

Tanaka, H.: The mean velocity is about 50 km/s, the error being say 30 per cent. This figure is deduced from the data on November 14th, 1960.

Ogilvie, K.W.: Is there any direct evidence for the movement of the magnetic fields?

Tanaka: Movement of the field is supposed from interferometric observations which are composed of two series of drift curves both for intensity and polarization. Two peaks on the respective records begin to separate at the beginning of CM_2 burst.

Thompson, A.R.: What is the beamwidth of the interferometer with which the position changes were observed?

Tanaka: 2.2 min of arc.

Kai, K.: Is it possible to consider that DM burst may be an extension of type I strom?

Tanaka: No, I don't think so.