THE ASTROPHYSICAL JOURNAL, 325:901–904, 1988 February 15

SOME STATISTICS OF SOLAR RADIO BURSTS OF SPECTRAL TYPES II AND IV

H. V. CANE[1] AND D. V. REAMES
Laboratory for High Energy Astrophysics, NASA/GSFC
Received 1987 February 17; accepted 1987 July 31

ABSTRACT

Using the sample of all type II and type IV radio bursts detected by the Culgoora radio observatory during the years 1968–1983, we examine some of the properties of meter wavelength solar emissions.

Subject heading: Sun: radio radiation

I. INTRODUCTION

In a previous paper (Cane and Reames 1988) we examined the relationship between metric radio bursts and soft X-rays in order to further our understanding of solar phenomena and particularly particle acceleration. Since such a comprehensive, uniform data set may not soon be available we document the general statistics of the events. Although not all the results are new, the much larger sample enhances their statistical significance. The major early works reporting on the statistics of type II bursts are those of Roberts (1959) and Maxwell and Thompson (1962).

II. DATA ANALYSIS

The data consisted of all type II and type IV radio events detected by the Culgoora observatory in the years 1968–1983 inclusive. Except for the years 1982 and 1983 the events have been compiled into a catalog (Robinson *et al.* 1983). This catalog consists of all "major meter-wavelength solar events recorded by the Dapto and Culgoora solar radio observatories (1961–1981)." Nearly all the events (97%) in the catalog include type II or type IV bursts. The remaining events were "the stronger" shortwave fadeout events. Our study continued beyond the extent of this catalog by using type II and type IV events reported by the Culgoora Observatory in *Solar Geophysical Data* (*SGD*). The total number of radio events studied was 685, of which 458 were type II only, 28 were type IV only and the remainder included both. The Culgoora catalog includes Hα associations for the radio events. These were used and supplemented with data from *SGD* for the years 1982 and 1983. The fraction of the radio events associated with Hα flares was 74% for type II and 84% for type IV. Three type II events were associated with regions beyond the west limb based on the presence of soft X-ray (1–8 Å) flares and the recent rotation of known active regions.

III. RESULTS

Table 1 shows the distribution of type IV emission as a function of intensity classes. Type IV emission occurs generally in conjunction with type II bursts, and the intensity class of the associated type II bursts are shown in the table. Only 12% of the type IV bursts do not have an associated type II burst. Most of the intensity class 3 type IV events are associated with intensity class 3 type II events. However, only 57% of intensity class 3 type II bursts are associated with type IV emission and only 30% of all type II bursts are associated with type IV emission. Table 1 also shows that very intense type IV emission is quite rare; 16 cases in 17 years.

We looked for correlations between durations and intensities of type II and of type IV bursts. The correlation was slightly stronger for type II bursts. The correlation coefficient for 657 type II bursts was 0.35, and for 227 type IV bursts it was 0.29.

Sixty-three percent of all type II bursts are preceded by type III bursts. The mean delay between the start of type III emission and the start of associated type II bursts was found to be 6.5 minutes with a distribution as shown in Figure 1*a*. The starting frequencies of the type II bursts tend to decrease as the delay became longer, as shown in Figure 1*b*. For the 270 events with start frequencies we find a correlation coefficient of 0.41. The probability of getting this coefficient if the data were uncorrelated is less than 0.001. This relationship was discussed by Maxwell and Thompson (1962).

The distribution of flares associated with type II bursts, has been shown to be fairly uniform as a function of heliolongitude (Maxwell and Thompson 1962; Wright 1980; Kosugi 1985). The distribution for type IV bursts shows a decrease toward the limbs (Maxwell and Thompson 1962; Svestka 1976; Kosugi 1985). Using the larger data sample available to us these results are supported. Figures 2*a*–2*b* show the distribution of flares associated with type IV and type II bursts, respectively. The black sections indicate the fractions of the events

TABLE 1

DISTRIBUTION OF TYPE II INTENSITY CLASSES AS A FUNCTION OF TYPE IV INTENSITY CLASSES

TYPE II	TYPE IV None	TYPE IV 0	TYPE IV 1	TYPE IV 2	TYPE IV 3	Sum Type II	Sum All Events
None	0	0	11	13	4		28
0	37	1	0	1	0	39	
1	221	10	30	10	1	272	
2	144	11	44	18	1	218	657
3	56	6	30	26	10	128	
Sum Type IV		28	115	68	16		
Sum All Events	458		227				

[1] Also Department of Physics and Astronomy, University of Maryland, College Park, MD.

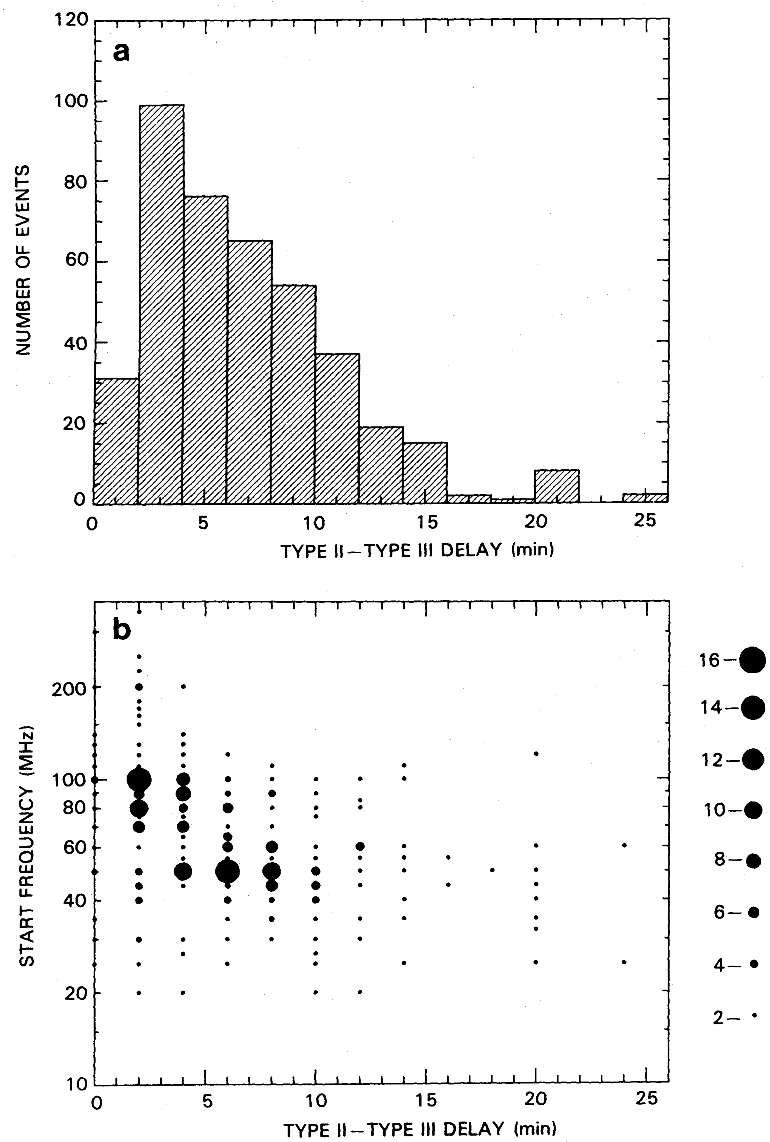

FIG. 1.—(*a*) The distribution of the delays between the onset of type III activity and the onset of type II bursts. (*b*) Starting frequencies as a function of the delays between the onset of type III activity and the onset of type II bursts. The size of the circle indicates the number of events with the same properties.

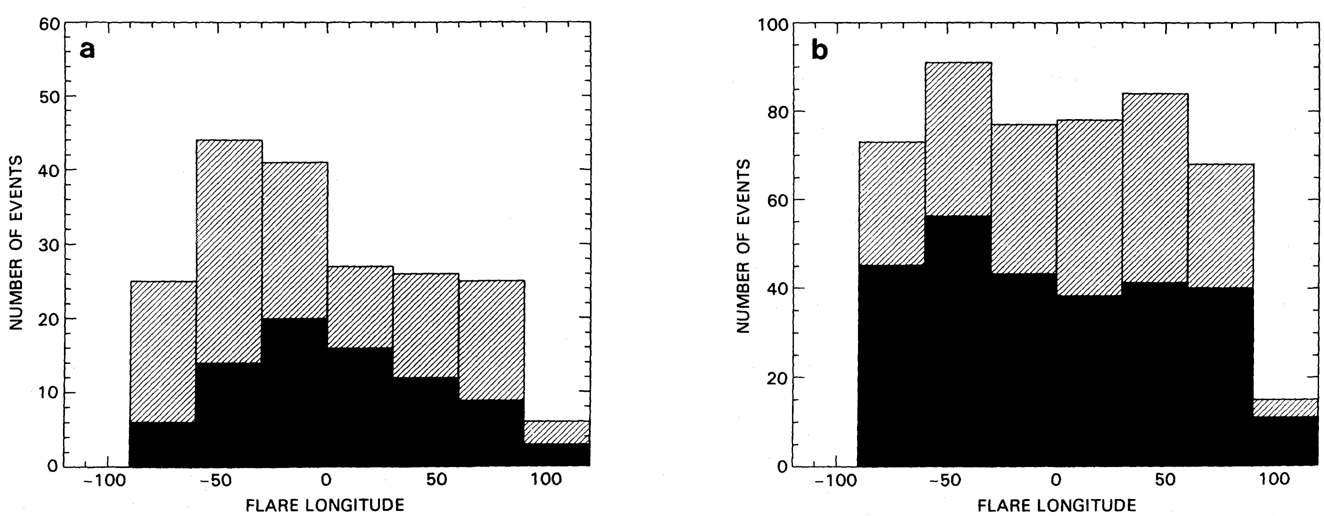

FIG. 2.—Distributions of (*a*) all type IV bursts and (*b*) all type II bursts as a function of the heliolongitude of the associated flare. Black sections indicate the fraction of the events that have intensities of class 2 or 3.

which have intensity classes 2 and 3. There are 193 type IV events and 486 type II events represented in these figures. These numbers are considerably larger than the study of Kosugi (1985), for example, in which there were less than 80 events of either type.

The decrease of observability of type IV emission as events occur closer to the limbs is further suggested by the distributions shown in Figure 3. The duration of the emission in each event is shown as a function of the longitude of the associated flare. The upper panel shows type IV. Clearly the events that last the longest occur near central meridian. The lower panel shows the durations of type II bursts. These durations do not appear to be dependent on heliolongitude of the source.

IV. SUMMARY

1. Type IV emission occurs generally in conjunction with type II emission. Only 12% of type IV bursts do not have an associated type II burst. However, only 30% of type II bursts are accompanied by type IV emission.

2. For type III bursts preceding type II bursts, the delay to type II onset is on average 6.5 minutes. The starting frequency of the type II burst decreases as the delay becomes longer.

3. The intensities and durations of type II bursts do not depend on the heliolongitude of the associated flares. In contrast, intensities are less and durations shorter for type IV events associated with flares far from central meridian.

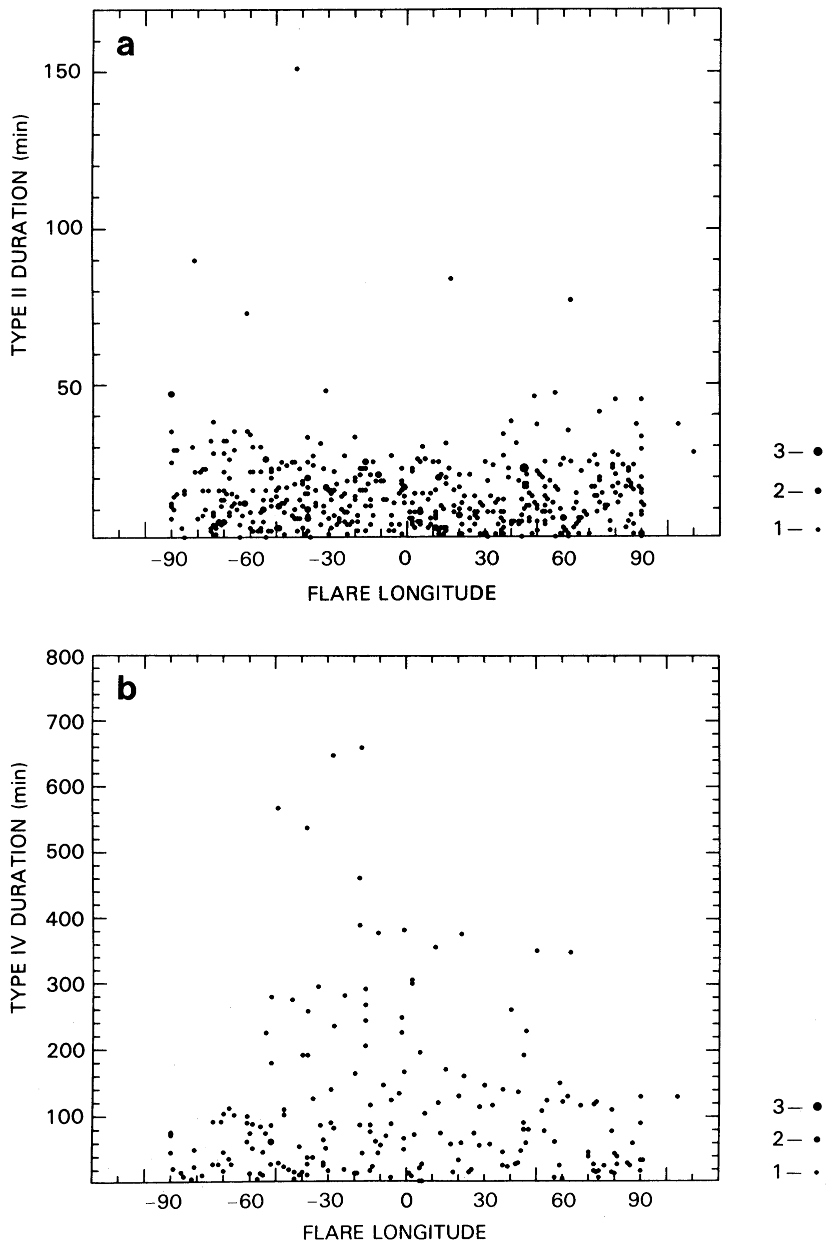

FIG. 3.—Distributions of durations of (*a*) all type IV events and (*b*) all type II events, as a function of the heliolongitude of the associated flare. Size of the circle indicates the number of events with the same properties.

REFERENCES

Cane, H. V., and Reames, D. V. 1988, *Ap. J.*, **325**, 150.
Kosugi, T. 1985, *Pub. Astr. Soc. Japan*, **37**, 575.
Maxwell, A., and Thompson, A. R. 1962, *Ap. J.*, **135**, 138.
Roberts, J. A. 1959, *Australian J. Phys.*, **12**, 327.
Robinson, R. D., Tuxford, J. M., Sheridan, K. V., and Stewart, R. T. 1983, *Proc. Astr. Soc. Australia*, **5**, 84.
Solar Geophysical Data. 1982–1983, (Boulder, Colo.: US Department of Commerce).
Svestka, Z. 1976, *Solar Flares*, (Dordrecht: Reidel).
Wright, C. S. 1980 *Proc. Astr. Soc. Australia*, **4**, 59.

H. V. Cane and D. V. Reames: NASA/Goddard Space Flight Center, Laboratory for High Energy Astrophysics, Code 661, Greenbelt, MD 20771