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Nature of Crochet Associated Solar Microwave Bursts

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Using crochet data at Kodaikanal and solar microwave burst data at Toyokawa, Japan, a study is made of the nature of crochet associated solar microwave bursts. A consideration of the results in the light of earlier work indicates that the nature of crochet associated solar microwave bursts depends on the monitoring frequency of the bursts.

1. Introduction

Energetic electrons resulting from the eruption of a solar flare are considered to be responsible for microwave bursts and enhancement of ultraviolet (uv) and X-ray emission of solar origin.[1] The interaction of the flare produced uv and X-ray emissions with the earth's upper atmosphere results in an immediate enhancement of the ionospheric electron density, the magnitude and height characteristics of which are governed by the intensity and spectral characteristics of the uv and X-ray bursts as well as the zenith angle of the sun.[2] This enhancement of electron density manifests in the well known phenomenon of sudden ionospheric disturbances (SIDs), one of which is the geomagnetic crochet (SFE) which manifests as a sudden short-lived perturbation in the components of the earth's magnetic field, monitored in the sunlit hemisphere.

The close association between the occurrence of solar microwave bursts and the various SIDs is well documented.[3-7] Das Gupta and Sarkar[8] studied the nature of crochet associated solar radio bursts at 4995 MHz and found the bursts at this frequency to be mostly of impulsive and complex type. They reported the percentage occurrence of crochet associated bursts according to type as follows : 41·7% impulsive; 31·5% complex; 11·3% gradual rise and fall (GRF) and 15·5% other types. Our recent study showed that the association between crochets and solar microwave bursts is dependent on the monitoring frequency of the bursts in the range 1000-17000 MHz and is a flat maximum in the frequency range 2000-3000 MHz.[9] In view of this we have now re-examined the nature of crochet associated solar microwave bursts monitored at 2000 MHz.

2. Data

As in our earlier study,[9] we made use of crochets observed at Kodaikanal (10°14'N; 77° 28'E) during the period 1966-70 and solar microwave bursts (2000 MHz) monitored at Toyokawa, Japan (Research Institute of Astrophysics, Nagoya University, Japan, and published in the *I.A.U. Quarterly Bulletin* on *Solar Activity*). The Japanese observations have been used as they give the best possible coverage to our crochet data among the existing sources of radio burst data. The coverage of Nagoya University is from 23 to 06 hrs UT in the 1st and 4th quarters and from 22 to 07 hrs UT in the 2nd and 3rd quarters of the year. We feel that our selection of the Japanese radio burst data is justified for the following reason. The occurrence of crochets is known to be a maximum around local noon and is more or less symmetrical around the maximum.[9] Since the Japanese observations cover the period up to the maximum, whatever features are noticed for the period up to noontime may also be expected to represent the latter half of the day.

3. Analysis

During the five year above period from 1966 to 1970, 72 crochets were observed at Kodaikanal out of which 44 were associated with microwave bursts at 2000 MHz, giving a percentage association of 66·1 for microwave bursts at this frequency with crochets. The statistical figures of the composition of these 44 crochet microwave bursts are given in Table 1. It can be seen the crochet associated microwave bursts at 2000 MHz are mostly of complex (54·5%) and simple (40·9%) types. Since the simple bursts comprise both impulsive and gradual rise and fall (GRF) types, we have further examined the composition of these crochet associated simple bursts in the following way. For each of these bursts, the total duration and peak flux density are noted. Bursts for which the total duration is greater than 10 min and peak flux less than 50 S units [1S unit = 10^{-22} W m^{-2} (c/s)$^{-1}$] are taken as "gradual rise and fall" (GRF) type; for

Table 1—Association between Geomagnetic Crochets and Solar Microwave Bursts at 2000 MHz

Total No. of crochets	Total No. of associated bursts	Type of bursts* *s*				*c*	*C*+
		18 (40·9%)				24 (54·5%)	2 (4·5%)
72	44	GRF	Impl.	Spike	*s***		
		2 (4·5%)	5 (11·4%)	1 (2·3%)	10 (22·7%)		

*Notes : *s* —Simple rise and fall of intensity
c —Complex variation of intensity
C+ —Prolonged broad band enhancement of radiation
GRF —Gradual rise and fall burst
Impl. —Impulsive burst
*s*** —Simple burst that does not fall into impulsive, spike and GRF categories

which the total duration is less than 10 min and peak flux above 50 *S* units as "impulsive" type; and for which the total duration is less than 1 min as "spike" type. Using this classification procedure, it is found that only 5 out of the 18 crochet associated simple bursts are of impulsive type (see Table 1 for details).

4. Results

The present study thus showed that a majority (54·5%) of the crochet associated microwave bursts at 2000 MHz are of complex type. A consideration of the above finding in the light of earlier work of Das Gupta and Sarkar[6] mentioned earlier indicates that the nature of the crochet associated solar microwave bursts depends on the monitoring frequency of the bursts. We have examined the possibility whether the noticed difference in the nature of the crochet associated microwave bursts at 2000 MHz and 4995 MHz is due to a difference in the percentage occurrence of impulsive bursts at these two frequencies. It is considered that the finding of the present study is proper as the earlier work of Das Gupta and Sarkar[10] (Table 2 of their work) show the relative occurrence of impulsive bursts at 1415 MHz (close to the frequency of 2000 MHz used in this study) and 4995 MHz, to be more or less the same.

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