

AD-A104 305

CALIFORNIA UNIV BERKELEY SPACE SCIENCES LAB

F/G 3/2

DOWNWARD SHIFT OF THE ACCELERATION/INJECTION REGION DURING SOLA--ETC(U)

APR 81 S R KANE, A RAOULT

F19628-80-C-0208

UNCLASSIFIED

SCIENTIFIC-1

AFGL-TR-81-0214

NL

1 OF 1

40 A
104305

END

DATE

FILED

10-81

DTIC

AD A104305

AFGL-TR-81-0214

LEVEL II

12

DOWNWARD SHIFT OF THE ACCELERATION/INJECTION
REGION DURING SOLAR FLARES

S. R. Kane
A. Raoult

Space Sciences Laboratory
University of California, Berkeley
Berkeley, California 94720

Scientific Report No. 1

April 1981

Approved for public release; distribution unlimited

DTIC FILE COPY

AIR FORCE GEOPHYSICS LABORATORY
AIR FORCE SYSTEMS COMMAND
UNITED STATES AIR FORCE
HANSCOM AFB, MASSACHUSETTS 01731

DTIC
ELECTE
SEP 17 1981
S D
E

81 9 17 026

Qualified requestors may obtain additional copies from the Defense Technical Information Center. All others should apply to the National Technical Information Service.

17) SCIENTIFIC-1

11 REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM	
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER	
1) AFGL-TR-81-0214	AD A104 305		
4. TITLE (and Subtitle)		5. TYPE OF REPORT & PERIOD COVERED	
6) Downward Shift of the Acceleration/Injection Region During Solar Flares		Scientific Report No. 1	
7. AUTHOR(s)		6. PERFORMING ORG. REPORT NUMBER	
10) S.R. Kane and A. Raoult			
9. PERFORMING ORGANIZATION NAME AND ADDRESS		8. CONTRACT OR GRANT NUMBER(s)	
Space Sciences Laboratory University of California, Berkeley Berkeley, CA 94720		15) F19628-80-C-0208	
11. CONTROLLING OFFICE NAME AND ADDRESS		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
Air Force Geophysics Laboratory Hanscom AFB, MA 01731 Monitor: Dr. D.A. Guidice, PHG		61102F 16) 231161AQ	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		12. REPORT DATE	
12) 18		11) 31 Apr 1981	
		13. NUMBER OF PAGES	
		16	
		15. SECURITY CLASS. (of this report)	
		Unclassified	
		15a. DECLASSIFICATION DOWNGRADING SCHEDULE	
16. DISTRIBUTION STATEMENT (of this Report)			
Approved for public release; distribution unlimited.			
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)			
18. SUPPLEMENTARY NOTES			
*D.A.S.O.P., Observatoire de Paris, 92190 Meudon, France Accepted for publication in <u>The Astrophysical Journal Letters</u> , 1981			
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)			
Solar hard x-ray Simultaneous observations Type III radio bursts Electron acceleration region Impulsive phase Injection region			
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)			
Simultaneous observations of impulsive hard x-rays and type III radio bursts associated with two recent solar flares have been analyzed in order to study the characteristic increase in the starting frequency of fast-drift type III bursts during the impulsive phase. The time variation of the starting frequency has been found to be similar to that of the 35 KeV x-rays, especially during the increasing phase. A similar variation has been observed for the low frequency cut-off of these bursts. The observations are consistent with a systematic downward shift of the electron acceleration/injection region during the impulsive			

328/50

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

Item 20(cont.)

phase of solar flares.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

DOWNWARD SHIFT OF THE ACCELERATION/INJECTION REGION DURING SOLAR FLARES

S. R. Kane*

*Space Sciences Laboratory, University of California,
Berkeley, CA 94720, USA*

A. Raoult

D.A.S.O.P., Observatoire de Paris, 92190 Meudon, France

Accession For	
NTIS GRA&I	☒
DTIC TAB	☐
Unannounced	☐
Justification	☐
By _____	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A	

ABSTRACT

Simultaneous observations of impulsive hard x-rays and type III radio bursts associated with two recent solar flares have been analyzed in order to study the characteristic increase in the starting frequency of fast-drift type III bursts during the impulsive phase. The time variation of the starting frequency has been found to be similar to that of the ~ 35 keV x-rays, especially during the increasing phase. A similar variation has been observed for the low frequency cut-off of these bursts. The observations are consistent with a systematic downward shift of the electron acceleration/injection region during the impulsive phase of a solar flare.

I. INTRODUCTION

Although electrons are known to be accelerated in solar flares, very little information is presently available about the acceleration process itself, its location in the solar atmosphere and its evolution during the course of a flare. In view of the important role energetic electrons seem to play in solar flares, any new information on the characteristic of the electron acceleration process is of vital importance for an understanding of the flare process itself.

Simultaneous observations of impulsive hard x-rays and type III radio bursts provide an important means for studying the acceleration and propagation of energetic electrons in solar flares. In the earlier studies [Kane, 1972, 1981; Kane and Lin, 1972] the relationship between the impulsive x-ray and type III radio burst groups was found to have several important charac-

*Most of this work was completed while the author was a Visiting Astronomer at the Observatoire de Paris, Meudon, France

teristics. The overall statistical correlation between these two types of bursts is $\sim 20\%$. The overall correlation improves with the increase in the hardness of the x-ray spectrum, intensity and starting frequency of the type III radio burst groups, this correlation being often evident even during a single flare. The correlation also improves with the hardness and emission measure of ≥ 20 keV electron spectrum inside the impulsive x-ray source [Kane, 1981]. In flares where both the impulsive x-ray and type III radio emission occur, the temporal relationship between them is very close, indicating a common origin of the energetic electrons responsible for the two types of emissions. The deduced ion density in the region of electron acceleration seems to vary from event to event and lies in the range $10^9 - 10^{11} \text{ cm}^{-3}$. In a later study, [Kane, Pick and Raoult, 1980] it was found that the electron acceleration region covers a wide range of magnetic field lines. Moreover, inside the acceleration region, the acceleration efficiency seemed to undergo both spatial and temporal variations.

In this paper, we present new substantially improved high time resolution observations of impulsive x-ray and type III radio bursts associated with two flares. Simultaneous spatially resolved measurements at 169 MHz help in reducing possible ambiguity in the interpretation. The present observations indicate that the electron acceleration region undergoes a systematic downward shift during the impulsive phase.

II. INSTRUMENTATION

The observations presented in this paper were made with three different instruments: x-ray spectrometer, radiospectrograph, and radioheliograph. The x-ray spectrometer aboard the International Sun Earth Explorer-3 (ISEE-3) has been described earlier [Anderson *et al.*, 1978; Kane *et al.*, 1979, 1981]. It measures the whole-sun (global) x-ray emission from 5 - 2630 keV in 18 energy channels. In this paper we are concerned primarily with 7 channels which cover approximately 26 - 350 keV range and have a time resolution of 0.5 sec.

Unlike the more common swept-frequency instruments, the radiospectrograph at Nancay, France consists of a large number of "single" frequency filters, the output of which is continu-

ously recorded on a 35 mm photographic film. The instrument analyzes 115 channels of 1 MHz bandwidth chosen in the frequency range of 150 - 470 MHz. More information concerning this instrument can be found in Internal Report no. 203/Sectro 44 Despa-Meudon.

The spatially resolved radio observations were obtained with the radioheliograph at Nancy, France. The instrument has also been described before [*Radioheliograph Group*, 1977]. At the time of the present observations it provided one dimensional (East-West) images at 169 MHz with an optimum spatial resolution of 1.15' and time resolution of 0.04 sec per image.

III. OBSERVATIONS

The general optical and radio characteristic of the flares on 11 April 1979 ($\sim$ 1345 UT) and 13 April 1979 ($\sim$ 1050 UT) are summarized in Table I. Both the flares were located in the Eastern hemisphere, the flare on 11 April being more intense than that on 13 April by about one order of magnitude.

(a) 13 April 1979 flare

Details of the x-ray and radio emission associated with the 13 April 1979 flare are shown in Figure 1. In this flare, significant increase in the hard x-ray flux was detected only in the 26 - 42 keV range. The observed x-ray enhancement consisted of four quasi-periodic pulses lasting $\sim$ 10 sec, with possible sub-structure in each.

The radio spectrum show that the starting frequency of type III emission evolved during the event: initially the starting frequency was low ($\approx$ 340 MHz), then increased to about 400 MHz, and reached 470 MHz at the end of the event. It can be noted that the low cut-off frequency followed roughly a similar evolution towards higher frequencies during the event.

The type III emission appears to be organized into subgroups: one subgroup with starting frequency $\sim$ 340 MHz, followed by three subgroups whose starting frequency is $\sim$ 400 MHz, then one with starting frequency $\sim$ 470 MHz. It is important to note that the frequency drifts are not homogenous within subgroups; while some drifts exhibit changes in their slope, others are reversed.

At the 169 MHz level, the type III activity occurred at three stable and distinct E-W locations (7 arcmin E, 4 arcmin E, and 1 arcmin W) having essentially simultaneous emissions. The relative radiation intensities at the three locations varied during the event. The extreme separation of the locations (8 arcmin) and the variety of frequency drifts suggest that the event is occurring in a region of complex diverging field lines.

The first subgroup of type III bursts starting at ~ 360 MHz is not associated with any detectable x-ray emission. Later, however, each x-ray major maximum correlates in time with a subgroup of type III bursts having a high starting frequency.

Inside each subgroup there is some indication of even finer peak-to-peak correlation with the x-ray emission. The temporal resolution and statistical accuracy of the x-ray data, however, are not sufficient to establish this firmly. In this connection, it is interesting to note that the first subgroup that correlates with x-rays has only one burst starting at 400 MHz, and is associated with the sharpest x-ray maximum. The width of the three following x-ray maxima is roughly proportional to the number of bursts starting at high frequencies in the corresponding type III burst subgroup.

Another aspect of the correlation with the 169 MHz activity is that the type III components that reach the 169 MHz activity from higher frequencies and maintain rapid frequency drift during the passage of the electron beam through the corona do have a good temporal correlation with the x-ray structures. But many of the type III components that start at high frequencies either vanish before the 169 MHz level, or endure such frequency drifts that they are delayed by several seconds with respect to the relevant x-ray emission.

(b) 11 April 1979 flare

Figure 2 shows the hard X-ray and radio measurements during the 11 April 1979 flare. In microwave, hard X-ray, as well as optical emission, this flare was more intense than the 13 April 1979 flare by almost one order of magnitude. The 26 - 42 keV x-ray enhancement consisted of two principal maxima separated in time by ~ 40 sec, the first maximum being larger than the second maxima by a factor of ~ 2 . Those two successive x-ray pulses are part of a

much larger event. In the pre-heating phase, (not shown in the figure) only a few faint type III bursts could be observed.

All the observed type III bursts have starting frequencies higher than 470 MHz (except the first one that starts around 460 MHz) and exhibit very fast frequency drifts. The temporal evolution of the starting frequency of this type III group could not be studied from the Nancay radiospectrograph data because it lies beyond the range of the spectrograph. Complementary spectral data from Zurich [Benz, private communication] show, however, that the starting frequency exhibits increase towards higher frequencies during the rise of the first x-ray pulse. The systematic increase of the low frequency cut-off from 150 MHz to 360 MHz can be very clearly seen in this event.

The spectrum shows a broadband continuum emission, lasting about 10 sec, that starts during the decay of the first x-ray pulse and reaches a maximum at the time of the minimum between the two major x-ray maxima.

From radioheliograph observations, we know that the type III activity occurred in a unique source position located at 7 arcmin E and remained stable during the event. The polarization of this type III burst was $\sim 30\%$. At 169 MHz, the continuum emission is more intense than the type III emission and is located much higher in the corona (19 arcmin E).

In summary, all the type III bursts in this event had a starting frequency ≥ 470 MHz. The x-ray-radio correlation was good right from the onset to the maximum of the first x-ray pulse. A single type III burst was associated with the onset of the second x-ray pulse. This was followed by a group of type III bursts at the time of the second x-ray maximum. The last group of type III bursts was associated with a relatively small third maximum in the x-ray flux.

As in the case of the 13 April 1979 event, there was a good correlation between x-ray intensity structures lasting more than 10 sec and subgroups of type III bursts. It is tempting to look for peak-to-peak correlations between the quasi-periodic type III activity and the x-ray spikes superimposed on the first slowly varying x-ray pulse. While both the rise and decay portions of this x-ray pulse exhibit many fluctuations, type III bursts were observed during the rise

portion only. Therefore any finer peak-to-peak correlation in this event could be fortuitous.

IV. DISCUSSION

The most significant result of the present study is the observed systematic increase in the starting frequency (f_s) of the type III emission during the impulsive phase. The time variation of f_s seems to follow closely the variation of the ~ 35 keV x-ray flux, especially during the increasing phase. In addition, the low-frequency limit f_l of the fast-drift type III bursts also seems to increase during the impulsive phase.

Earlier studies indicated that the electron acceleration/injection region is located in the lower corona [Kane, 1981]. In models similar to that proposed by *de Jager and Kundu* [1961] electrons moving downwards towards the chromosphere enter the higher ion density regions and produce x-rays through the bremsstrahlung process. Those electrons which move outwards through the corona produce type III emission through a plasma process (cf. *Sturrock*, 1964).

In general, the x-ray emission from a given region depends on the ambient ion density and the spectrum of the accelerated electrons. If the increase of the x-ray emission is due to an increase in the number of associated electrons, it is likely that the intensity of the successive type III bursts will also be enhanced, at least in the case of "small turbulence." Due to the detection limit of the radiospectrograph, the emission could be detected at higher and higher frequencies, as the intensity of type III emission increases. As a consequence, one should see a systematic increase in the intensity of successive type III bursts seen at a fixed frequency, which is not observed in the present events. Therefore this explanation, as well as any other process which can systematically enhance the type III emission during the impulsive phase, does not seem adequate to explain the present observations.

A more likely explanation would involve a dynamical process related to the temporal evolution of the acceleration/injection of electrons and/or the magnetic field structure in which electrons can escape. In a simple interpretation, the starting frequency $f_s \approx f_{pe}$, where f_{pe} is the electron plasma frequency at the level just above the region where energetic electrons are

accelerated/injected. If n_e be the number density of the ambient electrons, then $f_p \approx 9 \times 10^{-3} n_e^{1/2}$ MHz. Hence, if N_{eo} be the ambient electron density just above the region of electron injection, then $f_i \approx 9 \times 10^{-3} n_{eo}^{1/2}$ MHz.

The present observations indicate that f_i increased by a factor of ~ 1.4 during a period of ~ 45 sec. This corresponds to an increase of n_{eo} by a factor of ~ 2 . We now consider two relatively simple explanations of this increase in n_{eo} .

1. The region of acceleration/injection was located at a constant altitude h_o , where the ambient electron density is n_{eo} . During the impulsive phase, the ambient electron density n_e at heights $h > h_o$ increased by a factor of 2.
2. Initially the region of acceleration/injection was located at an altitude h_o , where the ambient electron density is n_{eo} . During the impulsive phase, the effective region of acceleration/injection moved gradually to altitudes $h < h_o$ where the ambient electron density is $n_e > n_{eo}$.

Explanation 1 requires a rather rapid increase in the ambient electron density n_e . The relatively smooth appearance of the type III bursts requires that the increase in n_e should occur over an extended region in the corona. Such a rapid "coronal condensation" could, in principle, result from a compression of the surrounding magnetic field. This would inhibit, however, the escape of the energetic electron beam, which requires a relatively open field structure. Another way the ambient electron density, n_e , could increase at coronal altitudes is if the additional plasma is obtained from the chromosphere. In "thick target" models of impulsive phase (cf. *Brown, 1979, Hudson, 1972*), energetic electrons moving downward towards the chromosphere deposit a large amount of energy, which results in "chromospheric evaporation." It is possible that some of this evaporated material reaches coronal altitudes and increases the ambient electron density [*Somov et al., 1980*]. In order to produce significant effects at coronal altitudes within a few seconds, however, chromospheric material must move upwards with a speed of $\sim 10^4$ km/sec, a speed much greater than the Alfvén velocity. In addition, a rapid increase in coronal density would induce a shift of the 169 MHz plasma level. No source

movement has been detected in the present observations. Therefore, density enhancement, if present, must have been restricted to altitudes much smaller than that for the 169 MHz level.

Explanation 2 requires that the region where conditions are favorable to electron acceleration/injection varies with time. During the impulsive phase, the required conditions are satisfied at lower altitudes, and, hence, the acceleration/injection region effectively moves to lower altitudes. Since the time variation effect results from variations in the inter-relationship between magnetic field and plasma parameters rather than the bulk motion of material itself, speeds of the order of the Alfvén velocity can be invoked. Consider, for example, the motion of the acceleration/injection region from 360 MHz level to 470 MHz level during a period of 45 s. Those levels correspond, respectively, to $n_e \approx 1.4 \times 10^9 \text{ cm}^{-3}$ and $n_e \approx 2.7 \times 10^9 \text{ cm}^{-3}$ if the emission is produced at the fundamental level, and to $n_e \approx 3.6 \times 10^8 \text{ cm}^{-3}$ and $n_e \approx 6.8 \times 10^8 \text{ cm}^{-3}$ respectively, if the emission is assumed to be produced at the second harmonic. The spatial separation between these two levels has been estimated from the Saito model for the mean quiet corona [Saito, 1972] multiplied by factors from 5 to 10 which are generally accepted for coronal structures in which type III bursts are produced (cf. Pick *et al.*, 1979). This leads to speeds ranging from 850 km/sec to 1050 km/sec in the fundamental emission hypothesis and from 1300 km/sec to 1700 km/sec in the harmonic emission hypothesis. Computing the Alfvén velocity in the corresponding density structures in order to be consistent with the Alfvén speed, it is found that the above propagation speeds need magnetic fields from 18 G to 21 G in the fundamental hypothesis and from 13 G to 18 G in the harmonic hypothesis. The generally accepted values of B in the corona range from 1 G to 10 G, but values twice as large cannot be excluded in narrow structures. In addition, if the type III emission is not produced just above the acceleration/injection region, the required values for the magnetic field would be smaller.

Thus, although explanation 1 cannot be completely ruled out, explanation 2 seems to be more plausible. As far as the low frequency cut-off of the fast drift type III burst is concerned, it is probably related to the region in the corona where the outward moving electron beam

becomes relatively diffused and ceases to excite significant plasma emission. The present observations indicate that this "scattering" region is also shifted downward during the impulsive phase.

In large flares, shocks may be produced very early in the event as suggested, for example, by the open coronal MHD model of *Wu et al.* [1978]. Such shocks may give rise to density enhancements in the corona. In the above discussion it has been assumed that no such shock waves were produced. The relatively small magnitudes of the present optical flares and hard X-ray bursts as well as the absence of detectable type II radio bursts support that assumption. It is possible, however, that non-linear high amplitude MHD waves were produced during the impulsive energy release at the flare site $\sim 0.1R_{\odot}$ above the photosphere (*M. Dryer*, private communication). The upward, downward or bidirectional propagation of these waves could produce alternate density compressions and rarefactions. It may be argued that such an alternating pattern of density compressions and rarefactions is suggested by the quasi-periodic nature of the x-ray response in Figures 1 and 2. If, however, the impulsive x-rays are produced in a thick-target source, as is generally assumed, the variations in the x-ray emission are caused primarily by the variations in the electron injection spectrum. Any changes in the ambient density alone are not expected to produce significant variations in the observed hard x-ray emission. Thus, although the presence of non-linear large amplitude MHD waves in the present flares cannot be ruled out, there is no direct observational evidence to support the density enhancements caused by these waves.

To summarize, the present observations of hard x-ray and type III radio bursts show that the acceleration/injection of particles in solar flares is a dynamical process where the characteristic plasma and magnetic field parameters most favourable for acceleration/injection vary with time. Specifically, the observations indicate that the region of electron acceleration/injection undergoes a systematic downward shift during the impulsive phase with an apparent velocity of $\sim 10^3 \text{ km sec}^{-1}$.

ACKNOWLEDGMENTS

We are grateful to Drs. Jean Louis Bougeret and Michel Poquerusse of the Observatoire de Paris for providing the Radiospectrograph observations made at Nancy. We are also grateful to Dr. A. O. Benz of the Radio Astronomy Group at Zurich for complementary information. One of the authors (S. R. K) wishes to express his thanks to the Radio Astronomy Group at Meudon, France for their hospitality during his visit there. He would also like to acknowledge discussions with Drs. R. P. Lin and M. Dryer. At Berkeley the ISEE-3 x-ray data processing was supported by the National Aeronautics and Space Administration under contract NAS5-25980 and the analysis was supported by the U. S. Air Force Systems Command (AF Geophysics Lab.) under contract F19628-80-C-0208.

REFERENCES

- Anderson, K. A., Kane, S. R., Primbsch, J. H., Weitzman, R. H., Evans, W. D., Klebesadel, R. W., and Aiello, W. P., 1978, *IEEE Trans.*, GE-16, 157.
- Brown, J. C., 1972, *Solar Phys.*, 26, 441.
- Hudson, H. S., 1972, *Solar Phys.*, 24, 414.
- Jager, D. de. and Kundu, M. R., *Space Research 3*, North Holland Publ. Co., Amsterdam, p. 836.
- Kane, S. R., 1972, *Solar Phys.*, 27, 174.
- Kane, S. R., 1981, *Ap. J.*, in press.
- Kane, S. R. and Lin, R. P., 1972, *Solar Phys.*, 23, 457.
- Kane, S. R., Anderson, K. A., Evans, W. D., Klebesadel, R. W., and Laros, J., 1979, *Ap. J.*, 233, L151.
- Kane, S. R., Anderson, K. A., Evans, W. D., Klebesadel, R. W., and Laros, J., 1981 (in preparation).
- Kane, S. R., Pick, M., and Raoult, A., 1980, *Ap. J.*, 241, L113.
- Pick, M., Trottet, G., and MacQueen, R. M., 1979, *Solar Phys.*, 63, 369.
- Radiohelograph Group, 1977, *Solar Phys.*, 55, 251.
- Saito, K., 1972, *Ann. Tokyo Astron. Soc.*, 13, 93.
- Somov, B. V., Syrovatskii, S. I., and Spector, A. R., 1980, *Solar Phys.*, in press.
- Sturrock, P. A., *AAS-NASA Symp. on Solar Phys.*, edited by W. N. Hess, NASA SP-50, p. 357.
- Wu, S. T., Dryer, M., Nakagawa, Y., and Han, S. M., 1978, *Ap. J.*, 219, 324.

FIGURE CAPTIONS

Figure 1. X-ray and radio measurements during the 13 April 1979 flare made with the Nancay Radiospectrograph (top), ISEE-3 x-ray Spectrometer (center), and Nancay Radioheliograph (bottom). The three curves (solid, dashed and dotted lines) in the radioheliograph observations refer to emissions from three spatially-resolved components of the radio source. The groups of fast-drift type III bursts are in good time coincidence with the x-ray maxima. Note that the starting frequency of the type III bursts increased systematically with time.

Figure 2. Similar to Fig. 1, but for the 11 April 1979 flare. The two curves (solid and dashed lines) in the radioheliograph observations refer to two spatially-resolved component sources. The starting frequency of the type III bursts was mostly above 450 MHz and hence outside the range of the Nancay Radiospectrograph. The low frequency cut-off, however, was very evident. It increased from the onset to the maximum of the x-ray flux. The source of the type V emission ($\sim 1339:25$ UT) was quite distinct from the source of the type III emission.

Table 1. Optical and microwave characteristics of the two flares

DATE (1979)	11 April	13 April
Hα EMISSION		
START (UT)	1344	< 1050
MAX. (UT)	~ 1345	1050
END (UT)	1356	1100
IMPORTANCE	1B	SB
LOCATION	N04, E53	N04, E16
McMATH REGION	15937	
MICROWAVE EMISSION		
MAX (UT)	~ 1339.2	~ 1050.3
PEAK FLUX (SFU)		
15.4 GHz	180	
10.7 GHz	170	14
8.8 GHz	347	17
5.0 GHz	299	
2.7 GHz	234	7

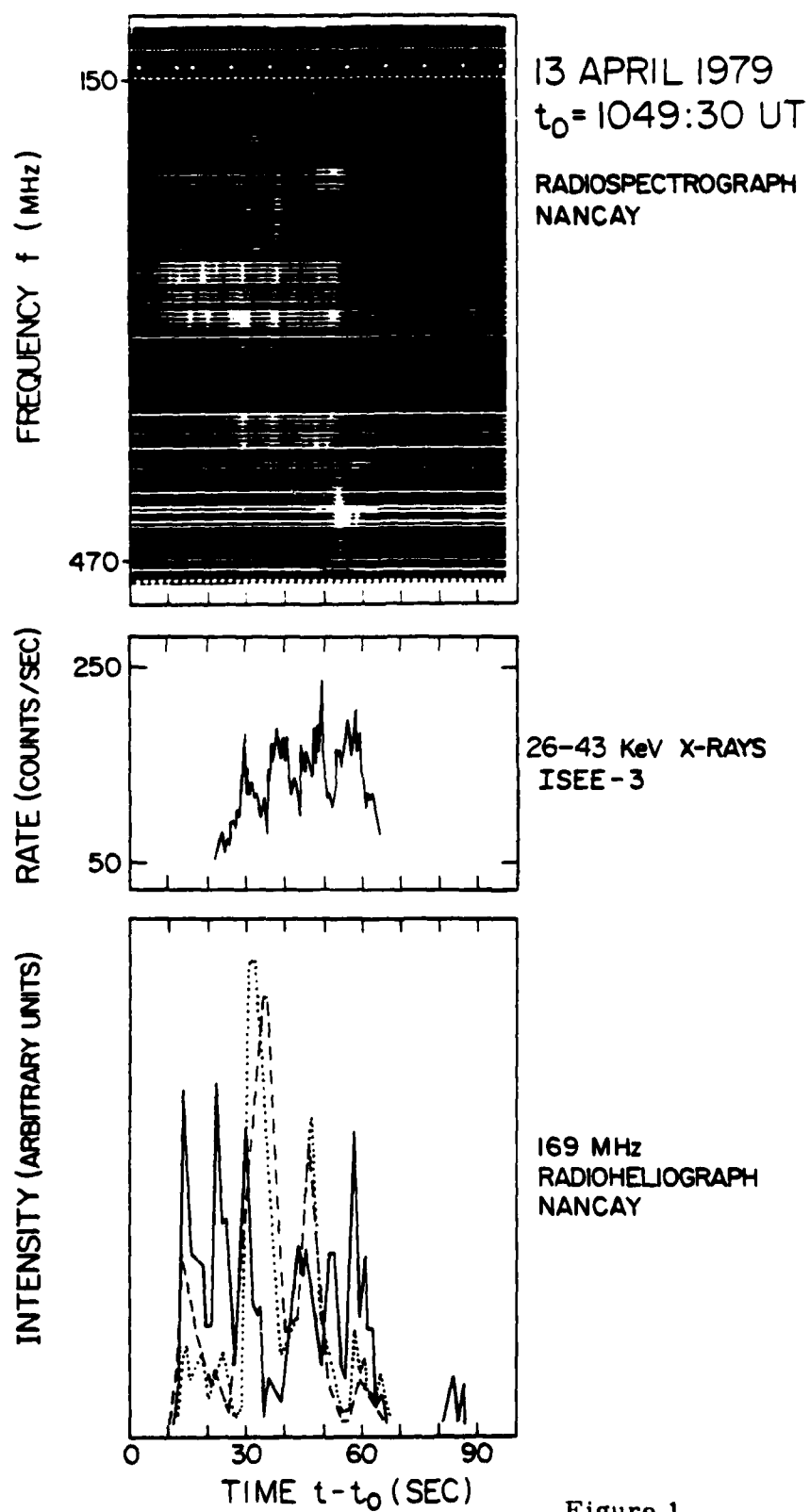


Figure 1

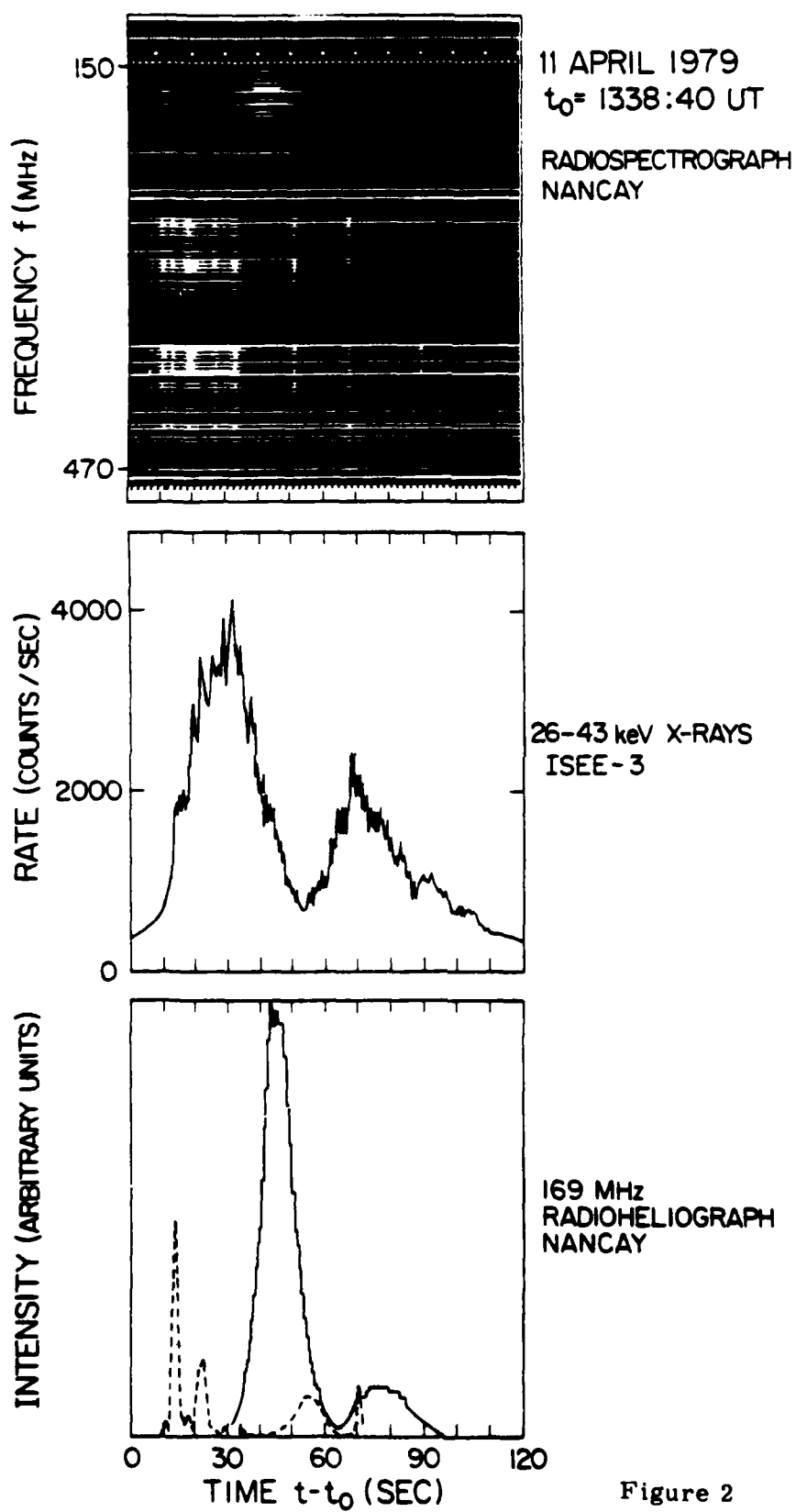


Figure 2