The Analysis of Solar Data at 2.84 GHz on May 16,1991

Zheng Le-ping and Liu Yu-ying

Beijing Astronomical Observatory, Chinese Academy of Sciences,
Beijing 100080, China

I. The Results of Observation.

A great solar burst was observed by the radio telescope of Beijing Astronomical Observatory at 2.84 GHz on May 16,1991. It started at 0641UT, peaked at 0646.8 UT and endured for 156 minutes. Its peak flux was 3041 sfu, and it was classified as 47GB radio burst [1]. The above equipment was made in 1990. Except the analogue S-resolution records, there are three kinds of dataout processed by computer softwaves: digital S-resolution records, time constant τ=10 ms records and τ=1ms records (if some condition is satisfied). On May 16, there were two τ=1ms disk files in our hands, and their time spans add up to 16s.To make further data processing easier, we have combined the two successive disk files of τ= 1ms into a new one, ignoring the finite time interval which actually separated them. Figure 1 is the digital S-resolution record.

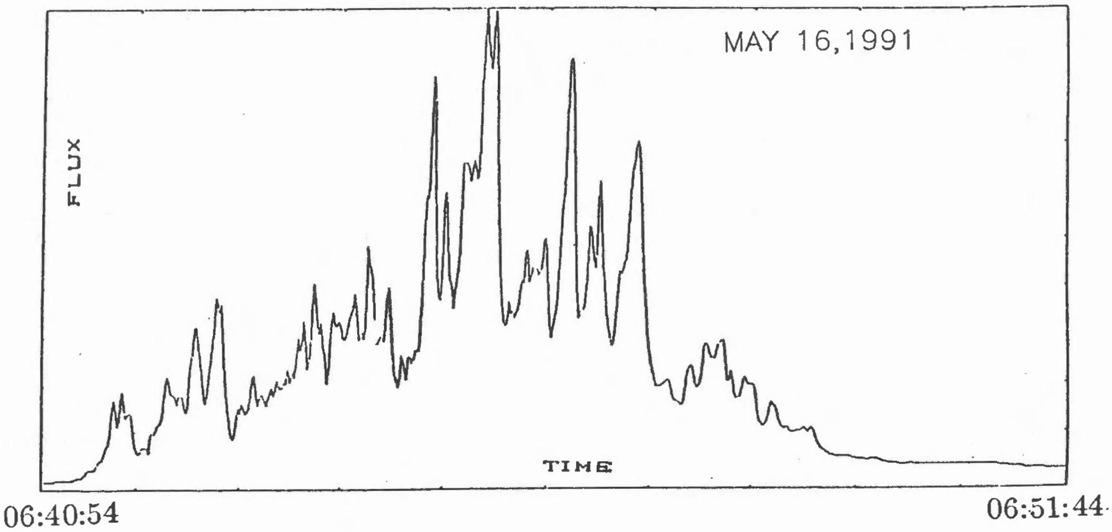

Fig. 1. The solar radio burst curve of Beijing Observatory at 2.84 GHz on May 16, 1991.

II. The Data Processing.

1. Smoothed averaging of data (or low filter).

In order to analyse data with different time constants, they must be returned to ones with a common time constant. So the data with time constant of 1ms were averaged and smoothed per 1000 points,

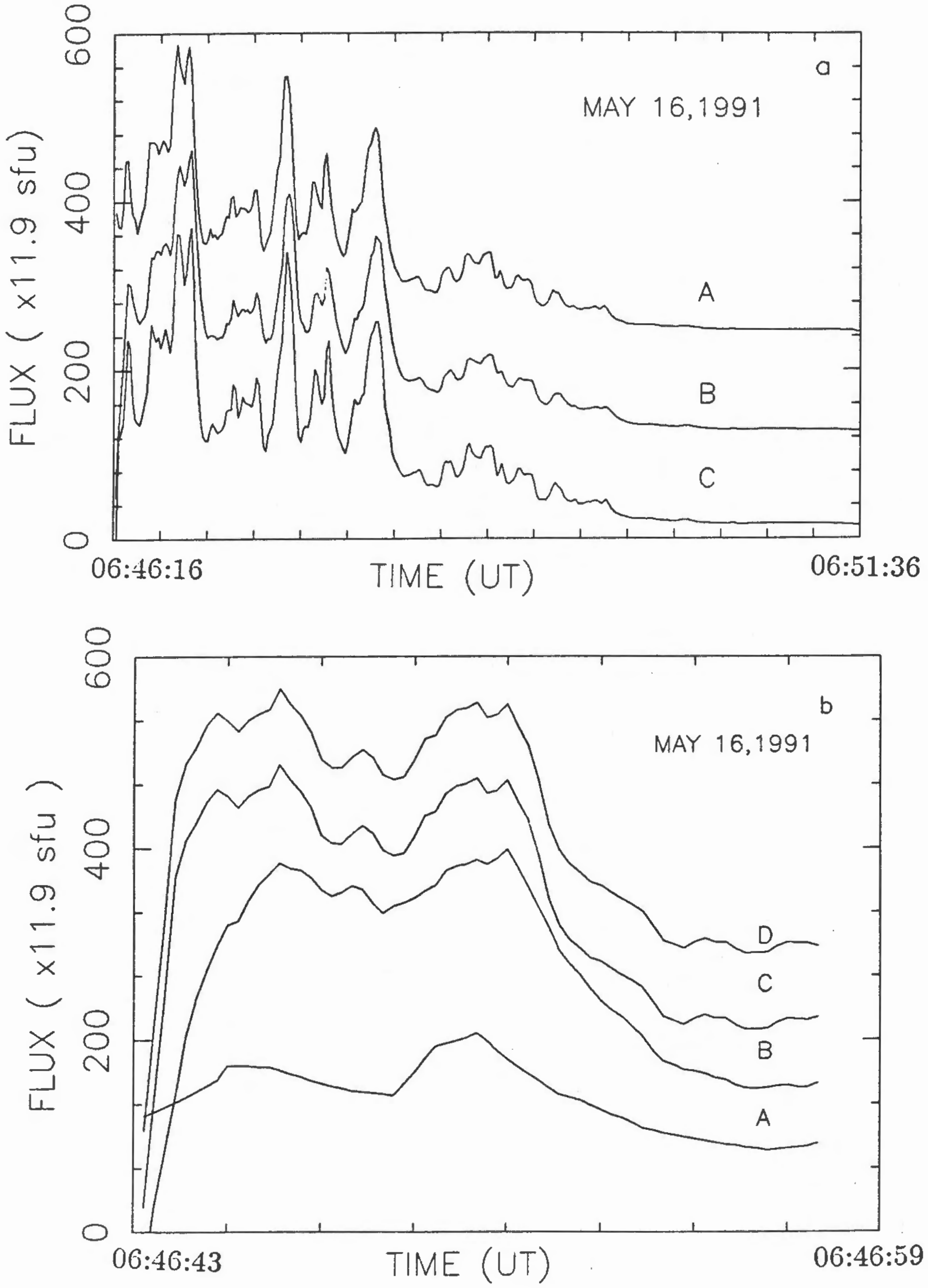

Fig. 2. The solar s-resolution records on May 16,1991 at 2.84 GHz obtained with different methods.

A: digital s-resolution record
B: RC filter of τ =10ms data
C: smoothed averaging of τ =10ms data
D: smoothed averaging of τ =1ms data

and the data with time constant of 10 ms were averaged and smoothed per 100 points. This method, by which ms-resolution data are reduced to s-resolution data, is called ‘ the simplest smoothed averaging ’[2]. It is easy to understand this kind of method processing data by considering the concept of time constants of telescopes [3]. In 1988 using this method we processed the ms-resolution data on May 16,1981 [4][5], and somebody raised a query for it [6]. So we processed new ms-resolution records by the same method as above once again to examine whether the record may be reduced to s-resolution ones or not. The result of processing is shown in Figure 2.

In Figure 2 we can see that the four (or three) s-resolution curves from observational data processed by the different methods are alike. We also compared these curves with analogue s-resolution record curves and found that they are essentially in agreement, and there is no difference in order of magnitudes. It means that the observational data with different time constants from the new receiver at 2.84 GHz are self-consistent.

2. The band-pass filter of data.

It is known that solar rapid fluctuation phenomena and s-resolution radio bursts possess different physical mechanisms; so observational record curves ought to show us that ms-resolution rapid fluctuation is superposed on the background of second-resolution solar radio bursts. Making the high-pass filter of solar ms-resolution observational data, i.e. low frequency signals were filtered out, or the signals of the s-resolution (or sub-s-resolution) background of solar bursts were deducted from the data, the rest of signals is belong to solar rapid fluctuation phenomena and noises. So we have a relation as follows:

$$\text{the original ms-resolution record}=A+B+C+D,$$

(see Figure 3.)

From the analytic result we found there is sub-second fluctuation in the data and no rapid fluctuation with the time scale lower than 100ms.

3. Comparision with the white noise

We also made a probability distribution analysis of the fluctuating flux density for A in Figure 3. The result is shown in Figure 4. From Figure 4, we see that curve A is very similar to the normal distribution curve B with r.m.s. error $\sigma = 1.8$ (i.e. the flux density is about 65 sfu).

We also made a Fourier spectrum analysis of a total of 8192 data covering 06:46:43–06:46:51 UT (see Figure 5), and found several outstanding peaks below 10 Hz in the power spectrum for $\tau = 1$ ms (curve A), indicating the existence of sub- second time scale fluctuations in the data. Furthermore, we found that a 100-1000 Hz after band-pass fliter the same dataset yield a relatively smooth power spectrum (curve B), approximating a white noise with an r.m.s. error eguivalent to a flux density of some 65 s.f.u.

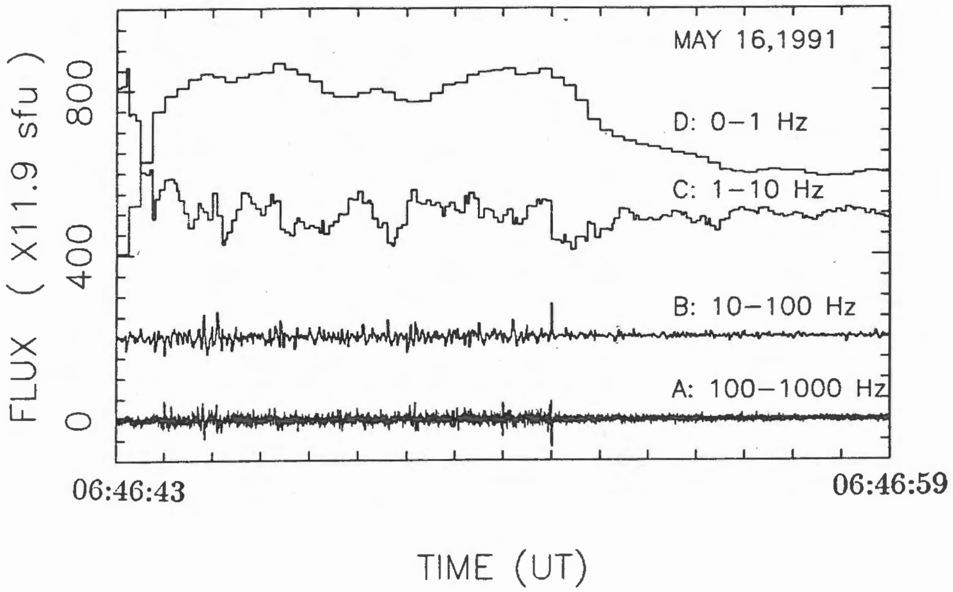

Fig. 3. The solar radio burst curves filtered with band-pass in different frequencies on May 16,1991.

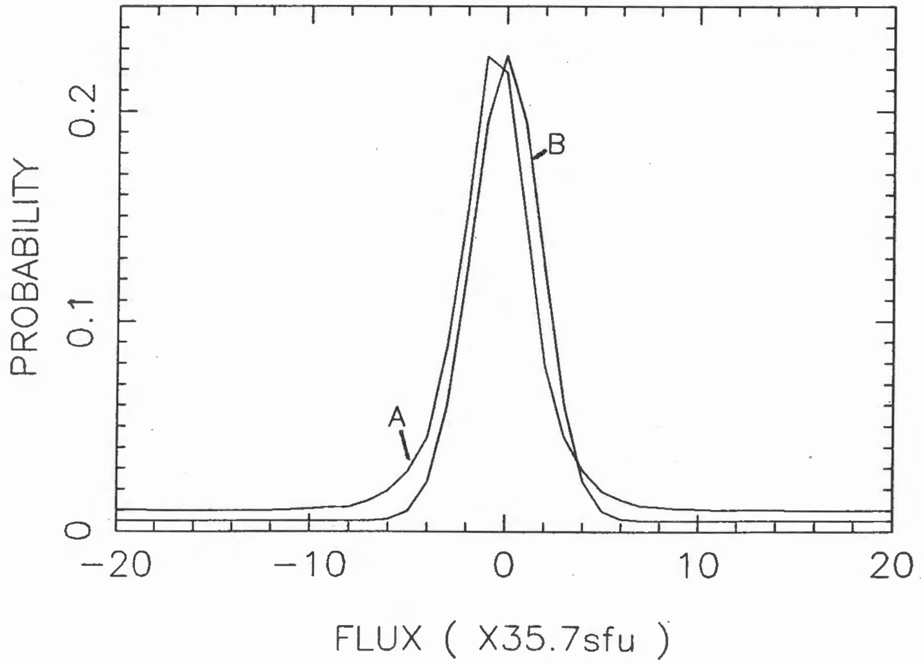

Fig. 4. The comparison between the probability distribution of various fluxes of with band-pass in 100–1000Hz on May 16,1991 (curve A) and normal distribution $P(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp[-\frac{x^2}{2\sigma^2}]$ (curve B).

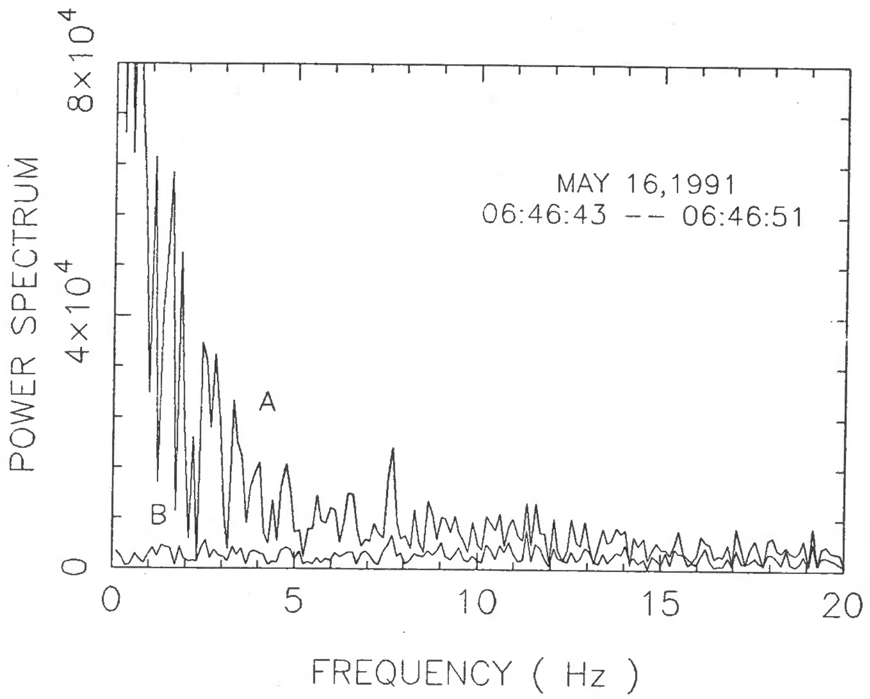

Fig. 5. Fourier spectrum curves.

III.Conclusion.

We had compared the smoothed averages of solar ms-resolution data with s-resolution data of the burst at 2.84GHz on May 16,1981 and found that the two kinds of data obtained from above equipment are not self-consistent, whether in calibration or trend of burst fluxex. But using above method , we have processed the data of May 16,1991 and found the ms-resolution record can be reduced to the s-resolution record. This fact makes clear that the data with various time constants from the receiver improved in 1990 are self-consistent.

In this paper, it is introduced that band-pass filter separates the components of rapid fluctuation with various time scales from ms-resolution data of solar bursts. Alough the components of rapid fluctuation with the time scale lower than 0.1s have not been found in data of May 16,1991; above method is very useful to examine and receive data from now on.

Reference

Liu Yuying, Chen Zhijun and Zhao Bing: CSGD February-March 1992.

Cheng Qian-sheng ' The mathematical principle of signal digital processing ', Petroleum Publishing House (1979).

Zheng Le-ping and Liu Yu-ying: 1991, Acta Astronomical Sinica No.32, 56.

Zheng Le-ping and Liu Yu-ying: 1988, Acta Astronomical Sinica No.29, 175.

Zheng Le-ping and Liu Yu-ying: 1990, Solar Phys. 129,127.

Jin S-Z, Zhao R-y and Fu Q-j: 1989, Acta Astronomical Sinica No.30,70.

Ding Yue-rong and Zheng Da-wei ' The handling method of Astronomical measurement data', 1990, Nanjing University Press.