THE OBSERVED SPECTRUM OF SOLAR BURST CONTINUUM EMISSION IN THE SUBMILLIMETER SPECTRAL RANGE

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Abstract. Observations of solar flares at high frequencies suggest that a considerable fraction of the events present flat or even increasing flux spectra at frequencies above 35 GHz. This imposes restrictions on the gyrosynchrotron emission mechanism and source parameters. We analysed a sample of 115 microwave events in order to investigate their spectra at peak flux. The analysis shows that about 50% of the sample exhibits a flat and 25% an increasing spectrum between 19 and 35 GHz. This class of events is significant and must be considered in the models. In order to better define the characteristics of this class of events it is necessary to carry out observations at frequencies well above 50 GHz with high time resolution and high sensitivity.

Key words: infrared: stars – Sun: radio radiation – Sun: flares

1. Introduction

Solar flare observations above 80 GHz are very rare and therefore only little is known about the spectrum above this frequency. It was believed that flares produce only negligible gyrosynchrotron emission at frequencies above 30 GHz. In the past two decades there were only a few solar patrol observations at frequencies up to 100 GHz. Occasional observations with high spatial resolution and high sensitivity were carried out only to measure the limb darkening and brightness temperature of quiet Sun. Most flare observations were made with low sensitivity and a time resolution not better than 100 milliseconds. During some of those observations strong events were detected suggesting an increasing flux towards higher frequencies (summarized in Kaufmann *et al.*, 1986). Of a sample of 40 strong events (observed at Bern) which were correlated with gamma-ray emission above 300 keV (observed from SMM), 19 microwave spectra showed a constant or monotonically rising flux and very broadband spectral peaks up to 35 GHz (Crannell and Magun *et al.*, 1984). It has also been noted that the hardest X-ray spectra are associated with a very low Microwave Richness Index (MRI) at 9 GHz (Bai and Dennis, 1985). In 1984, using the large antenna of Itapetinga Radio Observatory in Saõ Paulo (for the first time), an event with an increasing spectrum up to 100 GHz was observed (Kaufmann *et al.*, 1985, Correia and Kaufmann, 1987). It suggests that the spectral maximum was well above 100 GHz.The time characteristics of this event impose severe restrictions to the gyrosynchrotron interpretation, especially when the turnover frequency of the spectra is above 120 GHz (Kaufmann *et al.*, 1986; de Jager *et al.*, 1987).

The question is: Are these events a rare phenonemon on the Sun?

D. M. Rabin et al. (eds.), Infrared Solar Physics, 125–129.

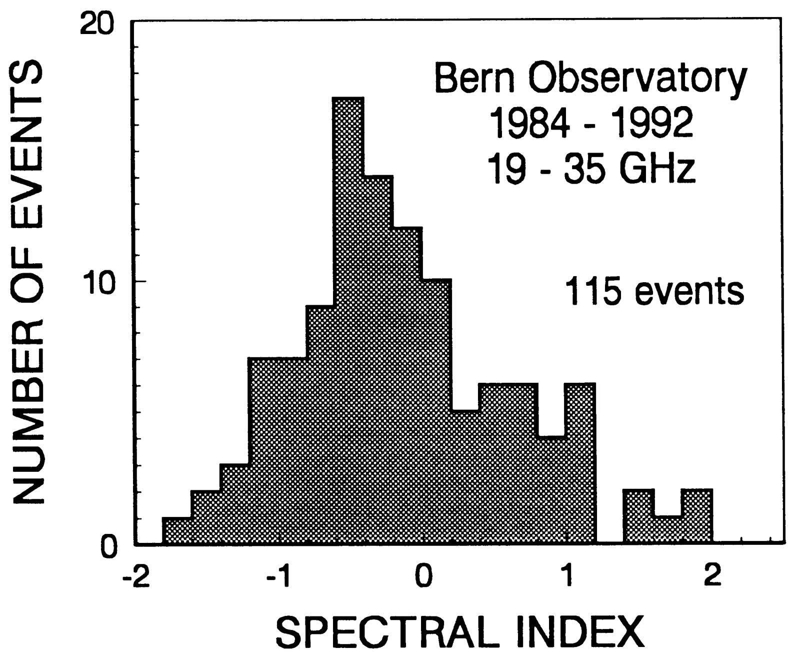

Fig. 1. Histogram showing the distribution of the spectral index, at frequencies between 19 and 35 GHz for the 115 events that had fluxes above 100 sfu.

2. Statistical Analysis

This analysis is based on a sample of bursts that were observed from 1984 to 1992 by patrol telescopes at the Solar Radio Observatory of the University of Bern, Switzerland. By selecting only those events with fluxes above 100 s.f.u. at 19 and 35 GHz a sample of 115 events resulted, whose spectral indices are shown in the Figure 1. The spectral indices were obtained from the linear slope between 19 and 35 GHz. Approximately 50% of the events exhibit a spectrum with a spectral index around zero and 25% above zero indicating a flat or increasing spectrum respectively.

The scatter diagram of the spectral index versus the heliographic longitude (Figure 2) indicates that no directivity is associated with the spectral characteristics of the events.

https://doi.org/10.1017/S0074180900124349 Published online by Cambridge University Press

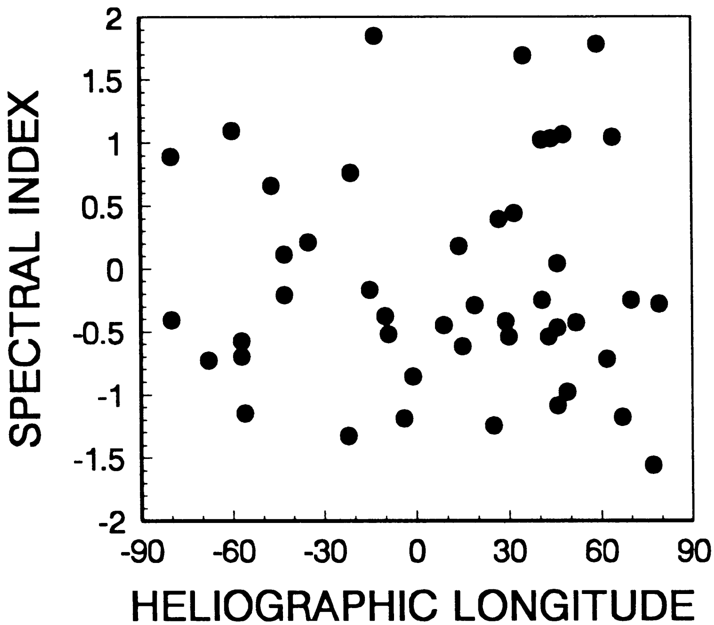

Fig. 2. Scatter diagram of Spectral Index and Heliographic longitude. Only events occurring during the years 1990 through 1992, the most significant part of the sample, have been included.

3. Discussion

Little information exists about the characteristics of events at frequencies above 30 GHz. This is especially true for weak events where the sensitivity of patrol instruments is insufficient for the observation of fluxes at higher frequencies. One of the earliest examples of flat spectra in the range 2-20 GHz (Hachenberg and Wallis, 1961), was interpreted as caused by free-free absorption of gyrosynchrotron emission of nonthermal electrons (Ramaty and Petrosian, 1972). The earlier data, however, were very poor in sensitivity and time resolution. The best event observed so far, with spectral coverage up to 100 GHz, occurred on May 21th, 1984. It was observed by the Itapetinga Radio Telescope with 1 ms time resolution and 0.01 sfu sensitivity and showed a spectrum increasing to frequencies above 100 GHz. The most notable characteristics of this event were flux variations with a relative amplitude of about 50% with unusually short durations of only 50 milliseconds. From the increasing spectrum a turnover frequency above 100 GHz was derived (Correia and Kaufmann,

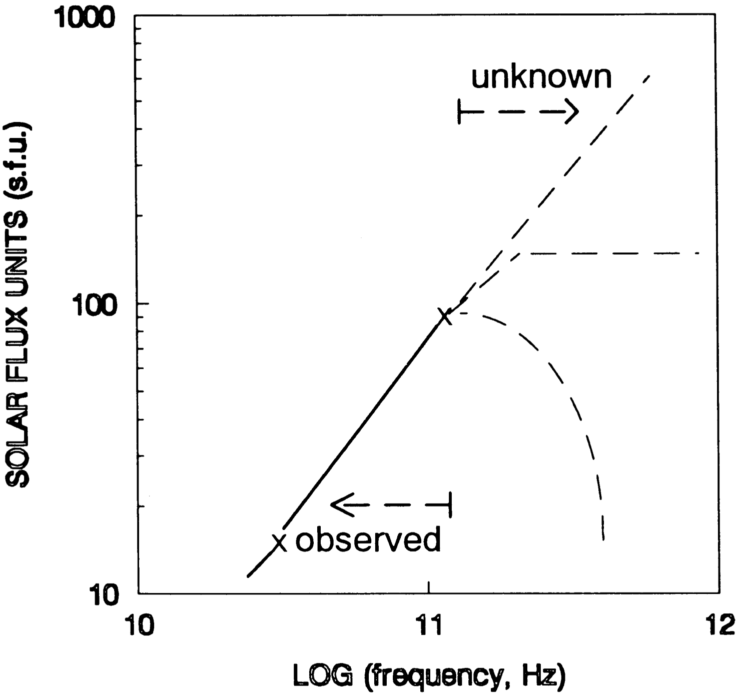

Fig. 3. Possible spectral behavior ar frequencies above 100 GHz.

1987). The combination of these two features is difficult to interpret as arising in gyrosynchrotron emission. Depending on the spectral features at frequencies above 100 GHz, *i.e.*, whether the spectrum is flat or increasing (Figure 3), it may be necessary to invoke another emissiom mechanism or to specify the plasma conditions better.

Thus we conclude from our analysis of more than 100 microwave spectra that there is a significant class of events with spectral peaks at frequencies well above 30 GHz. Furthermore it is worth noting that , according to Bai and Dennis (1985), the hardest X-ray spectra show a very low MRI that could mean that during the most energetic events the spectral maximum is shifted towards higher frequencies. In order to study this class of events and the relevant radiation mechanisms it is important to perform burst observations, especially at frequencies above 100 GHz, with high time resolution and high sensitivity.

Acknowledgements

CRAAE is jointly operated by the Universities of São Paulo, Campinas, and Mackenzie, and by the National Institute for Space Research. One of the authors (E.C.) received partial support from IAU and CNPQ to attend this meeting.

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