MULTIPLE FREQUENCY SPIKE EMISSION DURING SOLAR FLARES

S. KRUCKER and A.O. BENZ
Institute of Astronomy, ETH-Zentrum, CH-8092 Zurich, Switzerland

Key words: Sun: bursts – Sun: flares – Sun: radio radiation – millisecond spikes

1. Observations

Events of narrowband spikes have been selected from broadband (survey-type) spectral observations at ETH Zürich covering the past 15 years. Only events with at least two bands of spikes well resolved in frequency have been taken into consideration. The total number of selected spike events amounts to 17, whereof three events have three and one has four bands. The selected recordings were done with a time resolution of 0.1 s or 0.25 s and a frequency resolution of 1 MHz, 3 MHz or 14 MHz. Relevant for this work is the accuracy of the observed frequency. It is better then ±2 MHz.

2. Analysis

The separation of two bands \( \Delta \nu \equiv \nu_2 - \nu_1 \) was calculated with the aid of the auto-correlation in frequency. A local maximum at non-zero lag in the auto-correlation indicates the frequency separation. If the band separation and one of the two center frequencies of the bands is known, it is possible to calculate the frequency ratio \( h \equiv \frac{\nu_2}{\nu_1} = 1 + \frac{\Delta \nu}{\nu_1} \).

Because of the frequency-agile receivers, simultaneous emission at two frequencies appears often in only one of the two frequency bands in a single spectral scan (Güdel 1990). Therefore, several scans were integrated in time before correlation. For both the separation and the frequency ratio, the scatter within one event usually gets smaller for longer time intervals of integration. The values of the separation and the frequency ratio converge! Thus, integration improves the results. A mean value, \( \bar{\Delta \nu} \) respectively \( \bar{h} \), can be calculated by averaging over all time intervals. The error of this mean value is the standard deviation of the distribution of single spectra divided by the square root of the total number of time intervals.

The maximum of the cross-correlation of different bands is found at zero time lag. It suggests a one-to-one correspondence of single spikes in these two bands.

Space Science Reviews 68, 247–248.
Fig. 1. Frequency ratios of all events vs. mean center frequency of the lower band. Error bars are given only for the frequency ratio. The solid and dashed lines indicate ratios of integers and half integers. There is no good agreement of these ratios with the observed values.

3. Conclusion

In addition to the short duration (less than 100 ms), the small bandwidth (1-2% of the center frequency) and the high brightness temperature (up to $10^{15}$ K) (Benz 1986), the following new characteristics result from this study on multiple frequency spike emission and their frequency ratios:

- The observed frequency ratios are contained in the range between 1.17 and 1.52.
- Ratios composed of two integers are not favored
- The bands have comparable intensities
- The ratios are independent of frequency
- The emission of the harmonics is simultaneous

Until now, none of the proposed spikes mechanism can explain the observation satisfactory. A completely new idea seems to be necessary to describe the observed multiple frequency radio spikes.

References