Spectral dynamics and spatial structure of microwave emission during the flare of 28 August 1999.

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So far the study of spectral evolution of optically thin radio emission of solar flares was carried out for the full Sun observations without any spatial resolution. The specific task of this work is an analysis of particular flare the spatial structure of which was resolved with the Nobeyama Radio Heliograph (NoRH) at 17 and 34 GHz. For detailed study of the spatial/spectral dynamics of microwave emission from a flare loop we have chosen a flare of 28 August 1999. The radio source of this flare had a well developed loop-like structure at both frequencies. The sizes of the source considerably exceeded the beam sizes both at 17 GHz and 34 GHz. The data from the Nobeyama Radio Polarimeter (NoRP) for this flare were available too. The flare was detected as well with the BATSE/CGRO hard X-ray spectrometer. Shortly, the main results are as follows:

1. Brightness distribution. The maximum of the radio brightness distribution during the main peak of emission is located at the top of the loop-like structure at both frequencies. Evidently, this indicates an important role of the trapping effect.
2. Intensity temporal profiles from different parts of the radio source. From comparative analysis of the time profiles of microwaves at 17 and 34 GHz and HXR-emission (BATSE: 25-50 keV, 50-100 keV, and 100-300 keV) for the main peak of the burst we have found that the emission at 34 GHz is delayed (some seconds) against that at 17 GHz, and both of them are delayed against HXR-time profiles. This is valid for the full Sun NoRP data as well as for the high sensitivity NoRH data that relate to the large area (100"x100") around the flaring region. As well the characteristic decay times after the intensity peak is larger at 34 GHz then at 17 GHz, and both are larger then the HXR decay time at 50-100 keV, and 100-300 keV. The same relations between time profiles are noticed for the loop-top radio source. Along with this, the corresponding characteristic times are noticeably larger then for the integrated fluxes, especially for 17 GHz emission. On the contrary, the temporal profiles of emission coming from the areas closed to foot points of the loop display very fast decay and almost no delays against the HXR time profiles.
3. Dynamics of spectral indices. The temporal evolution of the microwave spectral index derived from the emission at 17 and 34 GHz demonstrates the very common behavior: decrease of its value starting in the rise phase, continuing in the decay phase, and then stabilizing near 0. This is valid for the total flux of the Sun (NoRP) as well as for the flux from the small part of the Sun covering the entire source region (NoRH). And what is important, this is also valid for separate parts of a flare loop independently on their positions: loop top (see Fig. 1), loop legs, foot points.

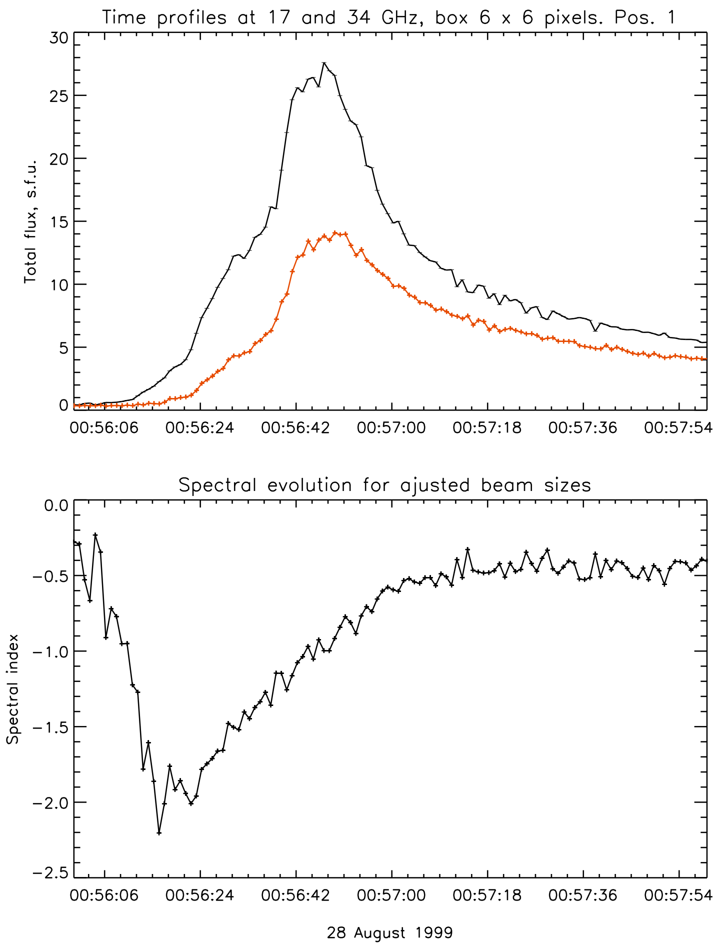

Fig.1.Intensity time profiles at 17 GHz (black line) and 34 GHz (grey line) and the spectral index evolution of microwave emission from the top of the loop.

For the latter analysis we use NoRH data being adjusted to the same beam size.
It is worth to note, that, on the contrary to microwaves, the HXR spectral index (BATSE, channels 50-100 keV and 100-300 keV) increases during the decay phase, manifesting well-known "soft-hard-soft" behavior.
4. Values of spectral indices in different parts of the loop. The value of the radio spectral index is noticeably higher (by ~ 1) in a foot point than in a loop top. It is valid all the time during the main emission peak.

As it can be seen from the results, the temporal and spectral relationships obtained for the total radio and HXR emission of the flare 28 Aug 1999 confirm very well the previous empirical results and model simulations (Melnikov and Magun, 1998; Melnikov and Silva, 1999, 2000). To reconcile the faster decay and higher spectral indices for radio emission coming from sites close to footpoints, we consider in detail two physical reasons which are able (each one or in some combination) to explain the peculiarities found: a) influence of the magnetic field strength, and b) different relative contributions to microwave emission from trapped and precipitating electrons in different sites of a flare loop.

References

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