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Location of a source of main acceleration of relativistic particles during the flare on 14 July 2000

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Abstract. We determine a location of a source of a main acceleration of relativistic particles during the flare on July 14, 2000, adopting that the time of acceleration coincides with a burst of the hard linear and continuum gamma-radiation. The process of this effective acceleration starts when one of flare ribbons reaches the large spot of the group, as it follows from the TRACE data. An estimation shows that the source of acceleration locates on the height of 15–20 thousands of km above the photosphere. Comparison these results with those for other large flares allows us to conclude that during almost 30 powerful events in the last three cycles an additional effective "accelerator" of a moderate scale turns on in diluted regions with large magnetic fields and their gradients.

The problem of particle acceleration is one of the most difficult in the physics of solar flares. It is known that the electrons are accelerated to energies exceeding a few tens of keV in numerous flares that are sources of hard X-ray bursts. As follows from studies conducted over the last several decades, particles with energies of 10–80 MeV can probably accelerated by shocks formed by coronal mass ejections (CMEs) or in a vertical current sheet. Physically, we must answer the question of whether there is an additional source of very efficient particle acceleration in some phenomena (other than "impulsive or posteruptive acceleration") and, if so, what are its properties.

Modern observational data make it possible in some cases to localize the source of acceleration of the relativistic protons ($E \geqslant 100$ MeV). By way of illustration we carried out morphological study of the July 14, 2000 flare using both data on emission at different spectral ranges and on the direct detection of accelerated particles. These observations unambiguously fixed the time of powerful particle acceleration in the flare of July 14, 2000. The most efficient acceleration of relativistic particles in this flare took place in a time interval that coincided with the hard γ-ray burst, from 10:19 to 10:30 UT (Share *et al.* 2001). From the other side, Belov *et al.* 2001 and Bieber *et al.* 2002 concluded that all or most of the energetic particles arriving at the Earth were accelerated during the some time interval.

On the Sun the situation changed dramatically at approximately 10:19 UT, when one of the ribbons of the flare began to develop, and luminous plasma crossed the large spot from west to east. Starting from 10:25 UT, the emission at 195 Å began to propagate to the northeast part of the group (figures 1, the right corner).

The result of the analysis for the flare of July 14, 2000 is very simple: the location of the acceleration coincides with the source at $h\nu = 33{-}53$ keV at the maximum of the γ-ray burst. Within an accuracy of $3''$, the same location is associated with the emission of an excess number of photons in short-wavelength lines of ions with ionization temperatures of 1.2–1.5 MK. Using the calculated magnetic fields Yan *et al.* 2001, this height can be estimated to be 15 ± 5 thousands of km. This corresponds to a mean scale between

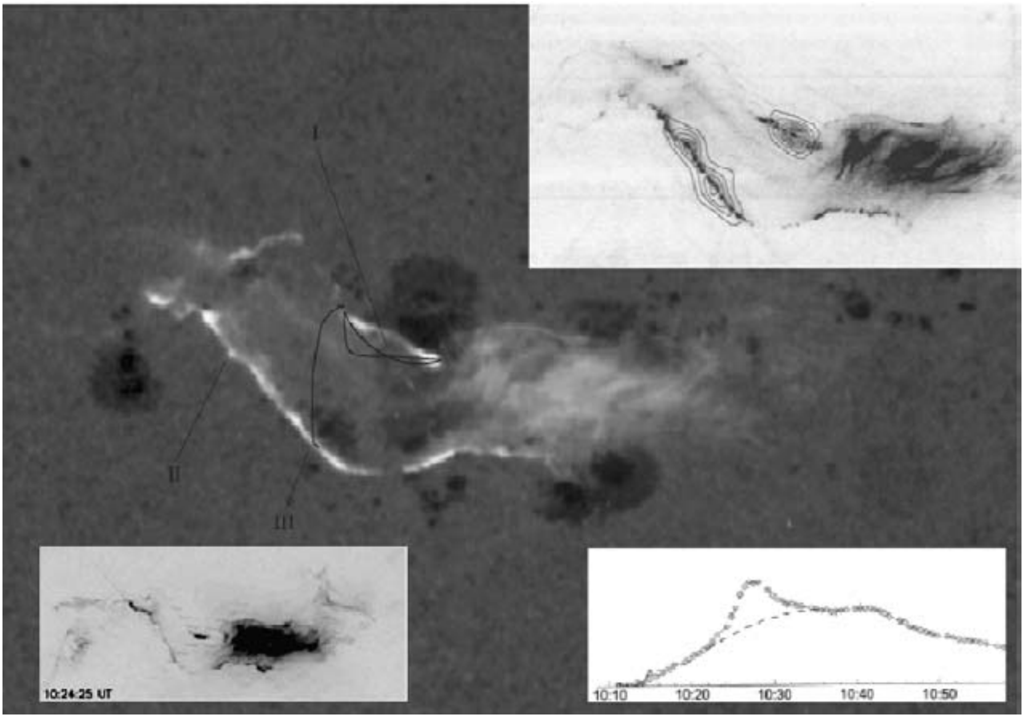

Figure 1. Schematic comparison of effects near the maximum of the γ-ray burst of July 14, 2000. The 195 Å TRACE image of the flare are superimposed onto the picture of the spots. At the left corner, such image at 195 Å is shown separately for 10:24:25 UT. The positions of sources of the hard X-ray emission are marked by the Roman numbers I, II, and III; contours of equal brightness are presented in the top, the right corner (in accordance with Fig. 8 in Fletcher & Hudson (2001)). The position of the loops satisfying the calculations Yan *et al.* 2001 of the behavior of the magnetic field lines in the region of the hard emission is shown schematically. The brightness variations at 171 Å above the entire flare region are presented in the bottom, the right corner, in accordance with Aschwanden & Alexander (2001); the dashed curve denotes the brightness of the same region without the area covered by the hard source I.

the characteristic sizes of the chromospheric and coronal loops. Therefore, in reality the acceleration can be more efficient in a more extended source that remains in a region of strong magnetic fields and field gradients. The detail consideration and comparison of our results with those for other large flares is published in Livshits & Belov(2004).

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