The Solar Flare on April 20, 1998 by Aboard ”Interball-2” Measurements

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Abstract

We present measurements of the solar energetic particle spectrum for solar flare event on April 20, 1998 observed with the Institute of Cosmophysical Research and Aeronomy installation 10K-80 aboard ”Interball-2” spacecraft. A space-borne installation 10K-80 consists of electronic and detection units with the wide-angular scintillation detector of 100 mkm in thickness with an area of 1 cm^2. The geometric factor of a telescope is 4 cm$^2\cdot$ sr. The instrument registers the protons in five differential channels in the energy intervals of $27-41, 41-58, 58-88, 88-180, 180-300$ MeV and in the integral energy channel with $E_p > 7$ MeV.

1 Introduction:

For recent years, a new class of observations has revealed two distinct populations of solar energetic particles (SEPs) with completely different origins based upon the abundances, time profiles of the particles as well as the longitudinal distribution and the radio, optical, X-ray and γ-ray associations of the events (Reames 1993, 1994, 1995).

It has become clear that the most powerful SEP events on the Earth are associated with shock waves ejected into interplanetary space by coronal mass ejections (CMEs). They are classified as gradual events. The other class of SEP events has strong associations with impulsive H_α and X-ray flares and type III radio bursts.

2 Solar Activity in April 1998:

Strong heliospheric storms at the end of April and at the beginning of May 1998 were associated with the flare events in two groups of sunspots, separated in longitude by almost 200° in the southern hemisphere of the Sun: (S27L138), (S16L330). The relatively large proton event generated by the duration M1 X-ray flare of April 20 was a surprise for all forecasters (McIntosh, 1998).

3 Observations and Data Analysis:

The event on April 20, 1998 is associated with the active region NOAA 8194 where the flare M1/EPL (S43W90) with a maximum H_α at 1021 UT is followed by the coronal mass ejection with a velosity $V \sim 1000$ km/s took place (McIntosh, 1998).

It should be noted that the spacecraft ”Interball-2” crosses regularly the Van Allen belts, therefore, there are the gaps data in Fig. 1.

The propagation time (without a scattering) of SEP from the generation place on the Sun to the observation point (”Interball-2”) is not more than 40 min. One of the features of this event is that in about 40 hours the temporal profiles (Fig. 1) of SEP intensities have been essentially modulated, thereby both the character and the time are the same for all energetic channels. Interplanetary disturbance propageted from the Sun to the Earth’s orbit at average spped about 500 km/s (corresponding SSC were odserved on the Earth on April 23, 1998 at 1825 UT). It led to the appearance of the second maximum. It appears to be connected with the interplanetary disturbance from the CME. The temporary evolution of a index (γ) of a differential energetic spectrum of SEP in a point of observation monotonously grows (Fig. 2). This testifies that a spectrum becomes gradually steeper, the maximum of which coincides with the second maximum of SEP intensity.

This modulation appears to be also connected with an additional acceleration of SEP in interplanetary medium. A steep spectrum in the region of SEP intensity modulation is also indicative of it.

The event on April 20, 1998 is of characteristic features, such as the gradual X-ray event, CME and interplanetary disturbance that led to the SEP intensity modulation. The modulation appears to be associated with the additional acceleration of SEP in interplanetary space. A steep spectrum in the modulation region of the SEP intensity testifies about it.

4 Conclusion:

The event on April 20, 1998 has pecularities of a gradual character.

It seems likely that the differential energy spectrum index γ in the observation point should be taken into account when the class of a SEP event is classified.

The event on April 20, 1998 is of the steepest spectrum of all events observed on the rise phase of the 23-rd solar activity cycle.

A rapid arrival of the first SEPs into the observation point is a characteristic feature of this period and it is probably associated with peculiarities of the magnetic fields on the Sun and interplanetary medium in that period.

5 Acknowledgments:

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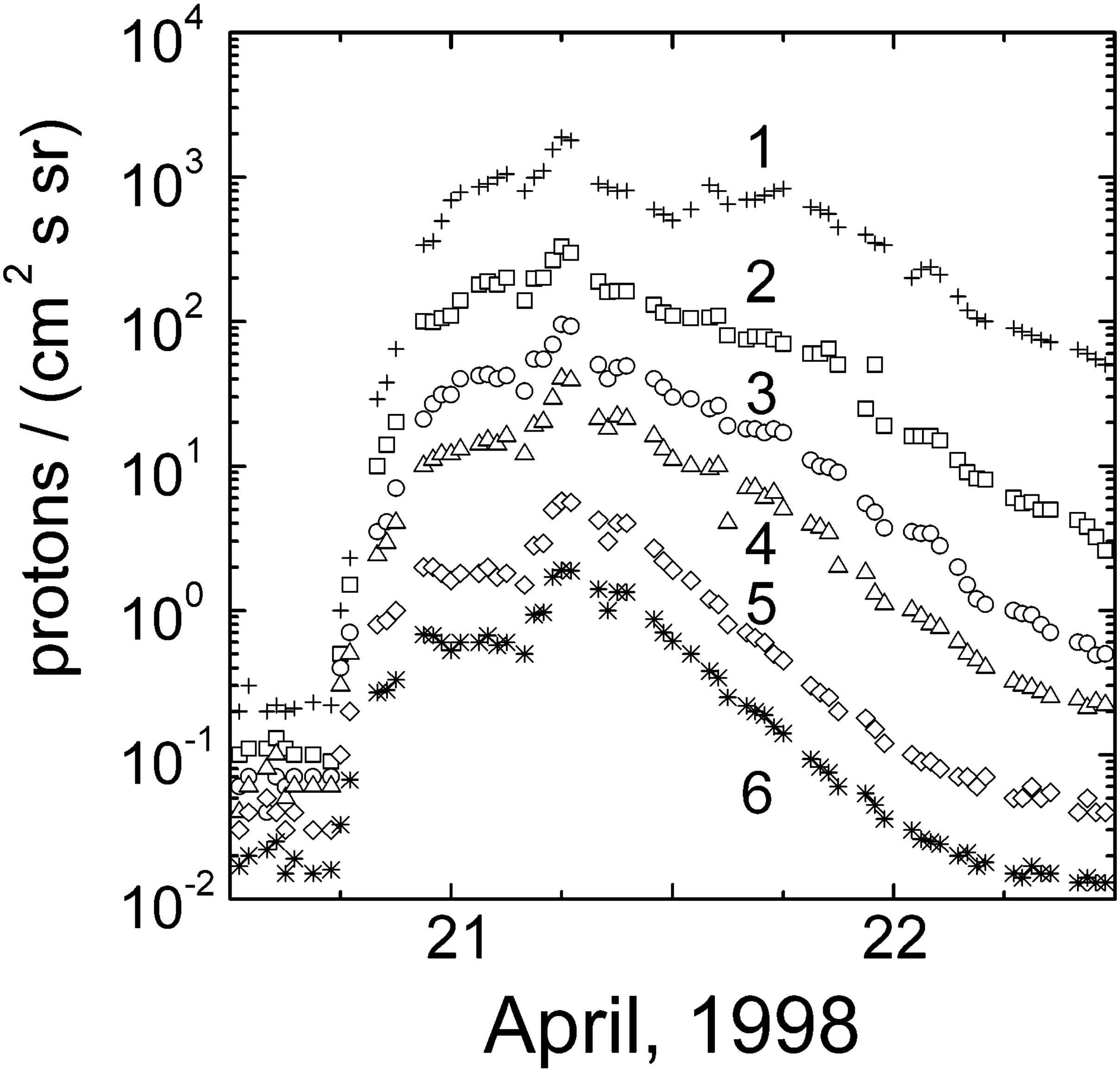

Figure 1: Temporal profiles of SEP increases from the solar flare on April 20, 1998 registered with the installation 10k-80. The digitals show the energetic channels: 1 - $E_p > 7$ MeV, 2 - $E_p = 27 - 41$ MeV, 3 - $E_p = 41 - 58$ MeV, 4 - $E_p = 58 - 88$ MeV, 5 - $E_p = 88 - 180$ MeV, 6 - $E_p = 180 - 300$ MeV.

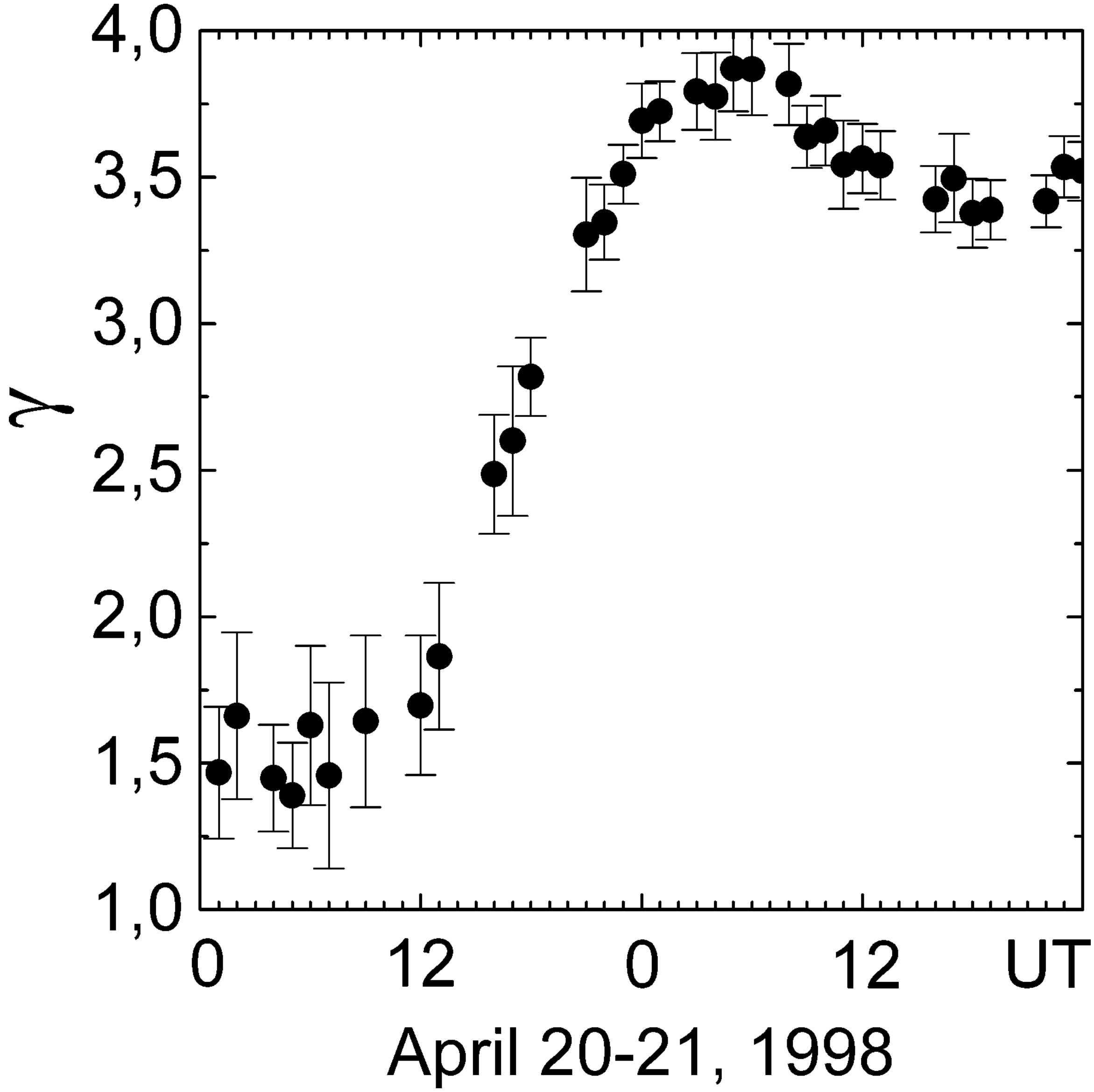

Figure 2: Temporal evolution of the energy spectrum index (γ) for the SEP event on April 20, 1998. Standard deviations are shown.