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Relativistic Protons in a Solar Flare

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It is shown that the spectra of relativistic protons measured by development of data of solar monitors in the energy range up to 20 GeV reveal two components of solar cosmic rays. The prompt cosmic ray component is generated during main flare energy release. A part of these protons hits solar surface producing nuclear reaction and γ-ray radiation. Other part of the prompt component moves along interplanetary magnetic field and reaches the Earth magnetosphere. The prompt component brings information about the most energetic phenomena in the flare. The exponential spectrum of these protons is in agreement with particle acceleration by Lorenz electric field along the X-type magnetic singular line in a current sheet that appears in the corona above an active region before the flare. Current sheet creation in the corona is shown by numerical MHD simulation. The calculation of particle acceleration in such a current sheet also demonstrates the exponential spectrum. The similar mechanism of particle acceleration has been discovered in the thermonuclear laboratory experiments with high power linear discharge - pinch discharge. Such experiments permit to measure the plasma velocity, the magnetic field, and energy of charged particles that accelerated in the Lorenz electric field up to several kV/cm. The acceleration in the laboratory takes place along a O-type singular line that coincides with the discharge axis. The similarity and difference of particle acceleration in a linear pinch effect and in the current sheet is discussed. The flares produce also a delayed component that arrives to the Earth 20 -30 min later. This component reveals the power spectrum $W^{-\alpha}$, where $\alpha \sim 5$. This high α spectrum can not be explained acceleration in a shock wave. Apparently, the prompt component spectrum is created during fast particle diffusion in the turbulent magnetic field.