GROUND INCREASE OF COSMIC RAY INTENSITY ON FEBRUARY I6, I984

Belov A.V., Blokh Ya.L., Eroshenko E.A., Ishkov V.N., Yanke V.G.
Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, USSR Academy of Sciences, I42092 Troitsk, Moscow Region, USSR

The event of February I6, I984 is one of the two largest ground increases of solar cosmic rays (CR) in the last two cycles of solar activity. This event happened at a decrease of the 2I-st cycle against a quiet background. Although at the beginning of I984 the observed indices of solar activity /I/ were higher than those at the end of I983, the day of February I6 may be characterized as very quiet. On that day the geomagnetic perturbance ($\sum K_p$=I4, A_p=7) was the lowest in February. After a small Forbush decrease due to the magnetic storm of February I2-I3, the CR intensity almost completely recovered by February I6. Thus, the solar particles that came to the Earth on February I6 got into a practically unperturbed magnetosphere, and the variations of secondary CR induced by these particles were nor superimposed on any other substantial variations of extraterrestrial or magnetospheric origin.

In the first half of February I984 the solar flare activity was determined mainly by two active regions and was at a rather low level. This activity was somewhat hightened beginning from February 9, when the two active regions, AR 4408 (CD 25: S I2 L 340) and AR 44I3 (CD 30: S I4 L 264) increased sharply in size and within 3 days each gave two flares of medium force. The second of the active regions rapidly lowered its activity and went beyond the western disk on February I9, I984 and practically died away. The region AR 4408 went behind the disk increasing its area, it was in the phase of increasing activity. The activity of the region AR 442I on the eastern disk did not give noticeable effects in CR observed on the Earth.

The solar flare responsible for the ground increase of solar CR on February I6 occurred most probably in the region AR 4408 three days after it went behind the western disk. That the flare occurred far beyond the disk is probably the most important specific feature of this event. Due to this, besides the CR from the indicated flare, it was only radio emission that reached the Earth, no emission at all being observed in the optical, UV, X-ray and γ-ranges.

According to radio data, the flare of February I6 occurred not later than 0858 T and was accompanied by intensive bursts of types IV, III, and II. For this event the western disk is a screen for all emissions that occur below ~I50 IO^3km. The microwave burst was therefore small, whereas in the metric wave band, for which the radiation source is high in the corona, the event was rather powerful.

Figure I presents ground increases of February I6 for a number of neutron monitors of the world-wide net (five-minute data). The time of the beginning of the increase differs strongly for different stations. But within the second five-minute interval of the tenth hour (0905-09IO UT) a large effect was observed already for several stations. Analizing the time variation of the counting rate for different monitors, one can obtain the following estimate of the time of arrival of first solar particles to the Earth: t_i=(0906 ± 0I) UT. Thus, if one does not assume the existence of an essential delay of radio bursts relative to the time of CR generation, one may state that having rapidly overcome the 60-degree's difference between the heliolongitude of the flare and IMF lines passing near the Earth, the first flare protons came to the Earth, in fact, without any delay.

Figure 2 presents the data of the neutrino monitor on the ship "Academician Kurchatov" which was at that time in the Atlantic Ocean at the point with coordinates (at 0900 UT) 46° II'N, 53°02'W. By means of interpolation of the calculations made by Shea and Smart /2/, we estimated the vertical cutoff rigidity for this point to be R_c = I.62 GV.

By many characteristics the flare of February I6, I984 turned out close to the largest ground increase of the last cycle, to the event of May 7, I978. In both cases one should note a rapid arrival of particles from the Sun, a small duration of the increase, a fast rise (< IO min. for stations with a large cutoff rigidity) and a sharp decrease of intensity. The decrease of intensity on the ship "Academician Kurchatov" can be represented in the period 09I5-I0I5 UT in the form exp $(-t/\tau)$, where τ = I5 m (Fig.2).

The increase of February I6, I984, the same as the increase of May 7, I978 is characterized by a large (close to IOO %) degree of anisotropy. The anisotropic phase of the flare was positive and occupied almost the whole period when the increase was large. The largest effect was observed in the stations, which at 9 h UT "looked" along the IMF lines towards the Sun. North-American stations and the research ship "Academician Kurchatov" appeared to be in an advantageous position for recording the ground increase. The dependence on the longitude and latitude of the point of observation turned out to be even stronger than the dependence on the cutoff rigidity, and the value of the increase (57.4 %) on the research ship "Academician Kurchatov" (R_c = I.62 GV) exceeded, in particular, the value of the increase in high-latitudinal stations Alert and Thule (R_c = 0.00 GV) situated in the same longitudinal zone /I/.

The large anisotropy of the effect and the large duration of its anisotropic phase do not allow us in this case to determine the form of the energy spectrum of the solar CR which came to the Earth by analyzing the dependence of the increase on the cutoff rigidity. In this case the analysis of the distribution of the effect on neutrons of different multiplicity /4/ may prove to be the most effective means for determining the slope of the energy spectrum. The observations of multiple neutrons were carried out in an expedition on the research ship "Academician Kurchatov".

It seems to us that the arrival to the Earth of charged particles from a flare beyond the disk can be explained by a particle drift in the neutral layer of heliomagnetosphere. By the indirect magnetospheric data /I/, on February I6 the Earth was in the positive sector of IMF, and the neutral layer was crossing the helioequator plane 40-50^{o} to the west. The line of force which goes out of the flare region of heliolatitude $\sim$s IO can come closer to the neutral layer, which at this heliolongitude must be projected onto the southern hemisphere of the Sun. Having drifted about 60^{o} eastward (the drift of protons in I984 in the neutral layer near the Sun must have just this direction), the protons could get (already in the northern hemisphere) onto the IMF line which was coming to the Earth. The hypothetic way of charged particles from the flare of February I6 to the Earth is shown in Fig.3.

REFERENCES

I. Solar Geophysical Data, 476, Part I, I984, Boulder, Colorado, USA 80303.

2. Shea M.A., Smart D.F., Proc. I8-th ICRC, v.3, 4I5 , I983.

3. Belov A.V., Blokh Ya.L., Gushchina R.T., Dorman L.I., Eroshenko E.A., Inozemtseva O.I., Kaminer N.S. Libin I.Ya. Izv.AN SSSR, ser.fiz., 43, I2, 25I2, I979.

4. Dorman L.I. Experimental and Theoretical Bases of Cosmic Ray Astrophysics. Moscow, Nauka, I975.

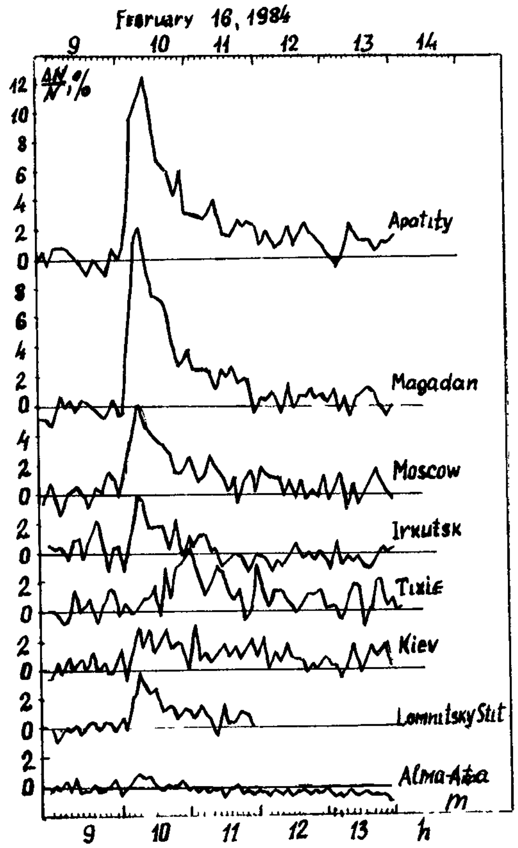

Fig. 1

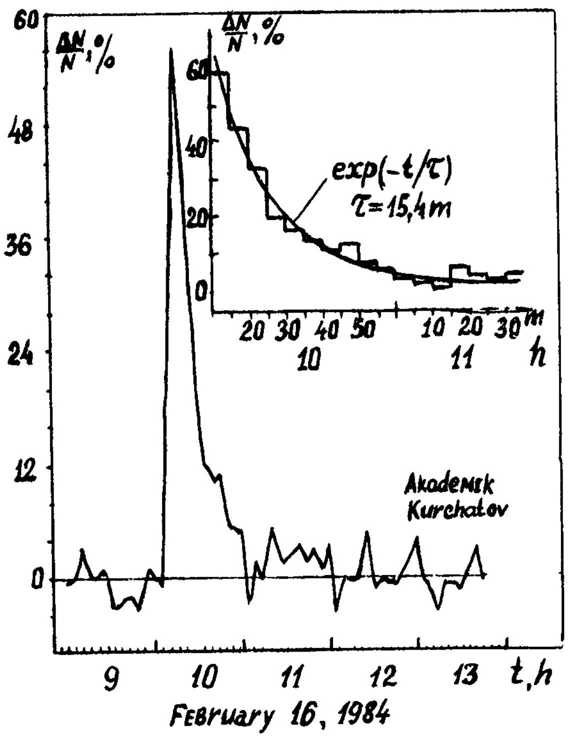

Fig. 2

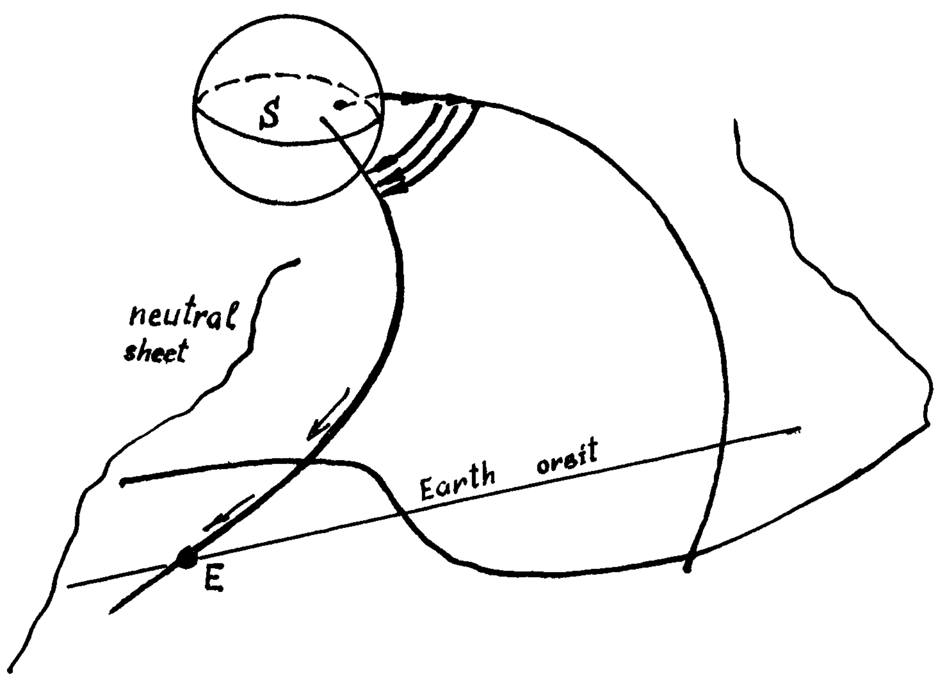

Fig. 3