Study of Cosmic-Ray Energy Spectrum during Solar Weather Disturbance

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Abstract: This work presents comparative analysis of cosmic rays intensity results got at different heights. Evaluation of cosmic-ray energy spectrum during solar weather disturbance (GLE) was made based on the data of neutron monitors located at the heights of 3340 m, 1700 m, and 800 m above the sea level.

Keywords: 'ATHLET', neutron monitors, solar cosmic rays.

1 Introduction

For the last years, it is said in increasing frequency about influence of solar activity upon the Earth. Since solar activity has grown for the last years, the issue of influence of this phenomenon becomes of current concern to a sufficient degree. The Earth gets from the Sun not only light and warmth, providing necessary level of illumination and the medium temperature of its surface, but also is exposed to the combined influence of ultraviolet and roentgen irradiation, solar wind, solar cosmic rays. Variations of power of these factors in case of any change of solar activity level excite a chain of coherent phenomena in the inner space, in magnetosphere, ionosphere, neutral atmosphere, biosphere, hydrosphere, and, possibly, in lithosphere of the Earth. Study of these phenomena becomes of paramount importance, since the state of 'cosmic weather' determines not only the climate, but also the state of health of people and work of communication systems.

Experimental determination of neutron flows at the height of 3340, 1700, and 800 meters above the sea level was performed with the help of neutron monitors included in a multi-level complex installation "ATHLET" (Almaty Three Level Experiment Technique) [1,2] located in the mountains of Zailisky Alatau close to the city of Almaty.

In most cases, GLE (Global Level Enhancement) events have complicated enough profile and their description, including receipt of energy specters, requires knowledge of many parameters of interplanetary atmosphere and geomagnetic field, calculation of the trajectory of cosmic rays in the magnetosphere of the Earth, according to models with different perturbed energy levels as well as big volume of complicated numerical calculations [3]. This circumstance makes very difficult study of GLE events with the help of ground-based measurements. In this work, we used the method of evaluation of absolute flow and, consequently, of specter of solar cosmic rays (SCR) according to the data of measurements of separate neutron monitors [4]. The essence of the method consists of determination of the efficient impulse or energy that does not change the flow of particles, calculated by the neutron monitor reading rate, with small changes of the solar cosmic rays' power law spectrum index.

For comparison of cosmic rays intensity results got at different heights, Fig. 1 shows neutron flow intensity, where letter a stands for neutron flow at the height of 3340 meters, "b" - the neutron flux at the height of 1700 meters, "c" - the neutron flux at the height of 800 meters.

2 Results

Based on the experimental data, evaluation of energy spectrum of cosmic rays was made at the time of solar activity disturbance got according to the data of neutron monitors located at the heights of 3340 m, 1700 m, and 800 m above the sea level. In most cases of land increase of solar cosmic rays, the land network of neutron monitors permits to determine energy specter only up to energies of 4-5 GeV. With big energies, neutron monitors usually do not show increases - because of lack of sensitivity and statistical
Fig. 2: The event (GLE42), associated with the flare of 29 September 1989, according to the neutron monitor data (at the height of 1700 m above sea level).

Fig. 3: The SCR energy spectrum caused by the flare of 29 September 1989, according to the data of the GOES cosmic apparatuses (1), the data of the ground neutron monitors (2) and the data of the three-level installation (3).

accuracy. Only such giant events as the solar flare of 29 September 1989 are exclusions. The GLE event of 29 September 1989 was as powerful, as unusual. A large-scale heliosphere disturbance, which was fixed according to cosmic rays fluctuations, continued long enough, up to the end of October 1989.

Land SCR increase was reliably registered by neutron monitors located at the heights of 3340 m, 1700 m, and 800 m above the sea level after the flare of 26 September 1989. Detectors fixed increase of \((150 \pm 0.05)\%\) in the single component reading rate.

The spatial and temporal characteristics of all discovered increases of neutron flow intensity statistically significantly differ from corresponding characteristics of background increases.

The event of 29 September 1989 was caused by a solar flare of X9.8 class. The temporal profile of the event got according to 1-minute data of HM-64 installation is shown in Fig. 2.

Using the profiles of SCR increase on neutron monitors, one can get the energy spectrum of SCR flow.

Fig. 3 presents the SCR energy spectrum caused by the flare of 29 September 1989 measured at GOES cosmic apparatuses and the data of the global network of neutron monitors, including the three-level system of neutron monitors located at the heights of 3340 m, 1700 m, and 800 m above the sea level.

Thus, the SCR particle specter with big enough energy has a form close to the power law spectrum \((J \sim E^{-1})\), where \(J\) is particles flow, \(E\) - energy with an exponent \(\sim 2-3\). With smaller energies, the steepness of the SCR specter is decreased.

References


