

RADIATION ASPECTS of INVESTIGATION of COSMIC RAY IN THE EARTH ATMOSPHERE and NEAR-EARTH SPACE

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Abstract

In the paper the results of investigation of radiational situation in the space near the Earth at the different altitudes of the Earth atmosphere and at the ground level in dependence on geocoordinates and solar activity during 1957 - 1997 are presented. Radiation is due to the Galactic Cosmic Rays flux for different periods of the Solar activity and cosmic rays produced during flares on the Sun..

Introduction

Now different components of the primary cosmic rays on a large scales of cosmos, in the cosmic space near the Earth and on the boundary of the Earth's atmosphere have studied [1-3]. There are the results of measurements and theoretical calculations of the energy spectra, the angular distribution of different components of the secondary cosmic rays from the ground level of the Earth up to the atmospheric boundary, and also the fluxes of direct and reverse albedo on the atmosphere boundary [4-8]. Total radiational doses at different levels of the Earth atmosphere and in the cosmic space near the Earth were calculated on the base of data of primary and secondary Galactic and solar radiation. It is shown that the maximum doses of radiation are at the altitudes of 16-19 km from the ground level of the Earth ($60 \div 50 \text{ g/sm}^2$). The secondary cosmic radiation maximum is at these altitudes as a function of geolatitude. It is also emphasized that when appearing to aviation flights at altitudes more than 12 km flight during the 6-7 and more hours is undesirable [9-10].

It is necessary to point out that the contribution of the nuclei with $Z > 2$ at energies $E < 1 \text{ GeV}$ into the secondary fluxes of the different components of CR is relatively small. Therefore it is possible that the nuclei with $Z > 2$ and $E > 10^9 \text{ eV}$ relatively are not taken into consideration as a rule when determining the doses what, seems to us, is unjustified [9, 11, 12]. The radiational doses from different nuclei types are shown in table 1.

Table 1.

Nuclei	p	He	C	O	Ne	Mg	Si	Fe	S
particle sm²year2p	4 ×10⁷	5,4×10⁶	1,6 ×10⁵	1,5×10⁵	2,6 ×10⁴	3,0×10⁴	2,2×10⁴	1,7×10⁴	
Dose rad/year	1,3	0,8	0,2	0,3	0,09	0,14	0,14	0,14	3,37

Equivalent dose rate is calculated in the case of biological object radiation. Its spectral composition is known from the formula:

$$P_i(x, R) = \sum_i \iint D_i(E) N_i[E, \Omega, x] dE d\Omega \quad (1)$$

where $D_i(E)$ - is conventional specific equivalent dose $Zv/\text{sm}^2/\text{particle}$;

E - is the energy of i -sort particle radiation; $N(E, \Omega)$ - is the differential density of this radiation flux at depth x .

It is noted that the dose rate may be calculated also from:

$$P_i(x, R) = \sum_i \int_{E_R}^{\infty} N_0(E') \mathfrak{K}(E', x) dE' \quad (2)$$

where E_R - is the correspondent to the cut off rigidity energy R . For the simplicity one can introduce the transition coefficient for dose rate:

$$W_p(R, \mathbf{e}, x) = P_i(x, R) / N_0(0, \mathbf{e}_m) \quad (3)$$

where the numerator is given by (1) and denominator - is the primary spectrum at the pole from single particle.

The coefficient (3) has dimension ber·sm²/particle and it is the standardized rate of equivalent dose.

The CR spectrum for the Earth's orbit have been taken for the calculations in the form:

$$N(\mathbf{e}) = 1,32 \cdot 10^4 e^{-2,65 \left(1 - \frac{0,6}{\sqrt{E}}\right)} \cdot \exp - \int_r^{r_0} \frac{U}{c} dr \quad (4)$$

where E- is the total energy, U - the solar wind velocity, χ - the diffusion coefficient, r_0 - width of the modulation region.

The calculations shows that the modulation coefficient $K = \int_r^{r_0} \frac{U}{c} dr$ varies from the minima to the maxima of solar activity in range 0,3÷2,5.

Results

The calculated doses of irradiation by GCR a SCR's at different altitudes of the earth's atmosphere and their change in time presented below.

Figure 1. shows the doses, calculated on the basis, of the experimental data of measurements total ionization component of cosmic radiation at the different Earth atmospheric levels, for the solar activity minimum (fig.1.a.) and for solar activity maximum (fig.1.b.) and also for 4 stations of the Earth with geomagnetic cut off rigidity 6,61 GV (Almaty, $\lambda=43^\circ$ N, $\varphi \approx 76^\circ$ E), 2,39 GV (Moscow, $\lambda \approx 55^\circ$ N, $\varphi \approx 37^\circ$ E), 0,5 GV (Murmansk, $\lambda \approx 69^\circ$ N, $\varphi \approx 33^\circ$ E), 0,03 GV (Mirny, Antarctica, $\lambda \approx 66^\circ$ S, $\varphi \approx 93^\circ$ E).

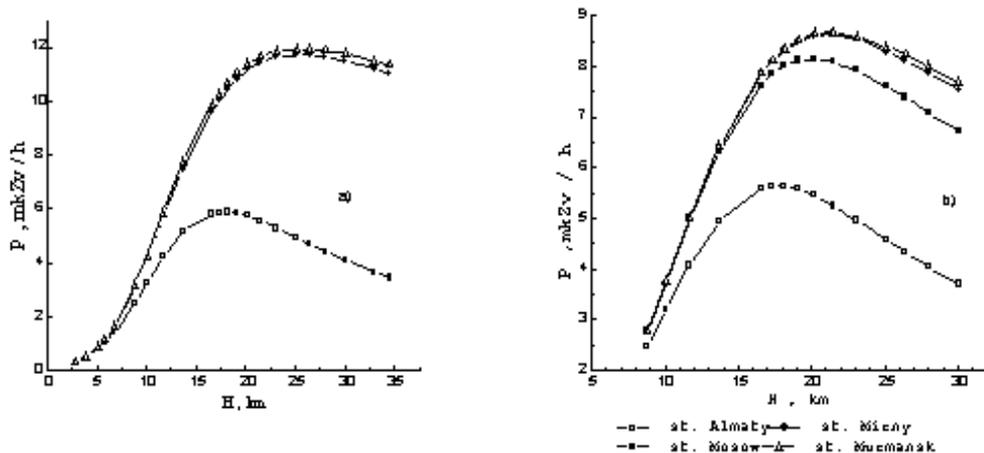


Figure 1. The doses of total ionization component at the different Earth atmospheric levels.

a) for the solar activity minimum

b) for the solar activity maximum .

From fig.1. one can make a conclusion that the maximum of the radiation is at 16-19 km (at the altitude of cruiser flight of supersonic planes). Also one can notice, that the radiation near Almaty is almost twice less than at high latitude stations because of the high geomagnetic cut off rigidity. One can stress that TIC CR includes p, e^\pm , μ^\pm , γ , π^\pm and doesn't include neutrons, which make a significant contribution to the radiation doses. Also from fig.2. we can make a conclusion, that flights on 16-19 km at high geolatitudes and especially during the solar activity minima are very dangerous for 5 hour flight in a supersonic plane through North pole, for instance, at the flight Europe - America a passenger can get a year dose.

Time changes of the radiation doses at the different Earth atmospheric levels are shown in fig.2. From fig.3. one can make a conclusion, that during the solar activity minima at high

latitude stations the radiation doses at altitudes more than 12 km are 1,5 times more. This fact is also observed at middle latitude stations (Moscow), the difference between the radiation doses at minima and maxima equals to 35%, and in Almaty equals to 20%. Calculated radiational doses according to data of SCR produced during the September, 29, 1989 event on the Sun are shown in figure 4.

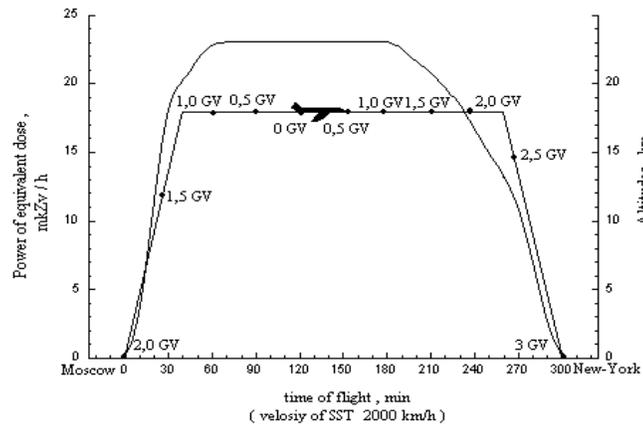


Figure 2. The total doses at the flight Europe-America.

In the figure 4. neutron monitors registration at the ground level of the Earth (high-latitude station Inuvik $R=0,16$ GV, $\lambda=68,35^{\circ}$ S, $\varphi\approx-133,72^{\circ}$ E) are shown. In figure 4. the time variation of radiational doses for the event is shown. It is necessary to note, that the radiational dose increased five times at the cosmic space near the Earth. At the ground level the radiational dose increased ten times. Thus this problem relates to physical ecology (radiational aspects) of natural origin.

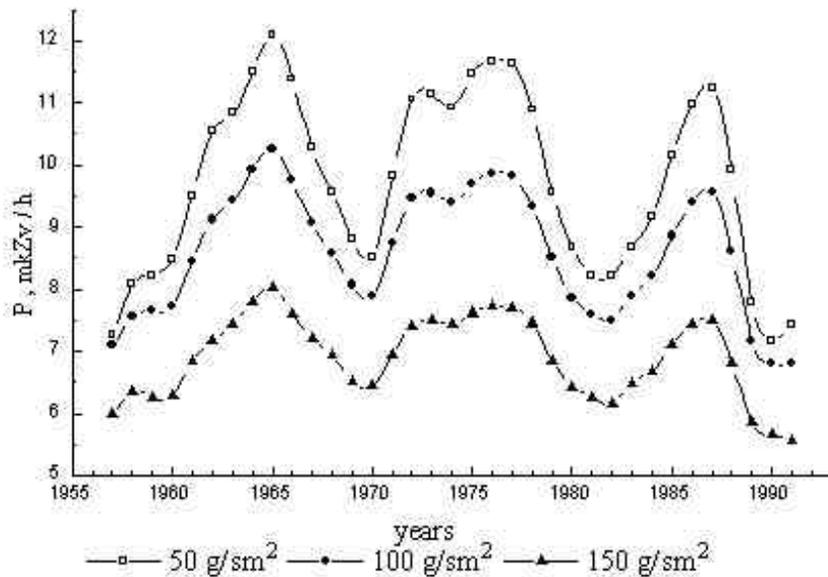


Figure 3. Time changes of the radiation doses at the different Earth atmospheric levels.

Thus the radiation dose variations in the Earth atmosphere for a long period are caused by natural and antropogenous reasons. In conclusion, using the obtained results of the work one can make the next conclusions:

- the radiation doses are several times more than background doses (due to GCR on the Earth surface) at the altitudes of the secondary cosmic radiation maximum in the Earth atmosphere - 16-19 km.

- at high geomagnetic latitudes the radiation doses also exceed background doses in several times.

- the radiation doses have large values at all altitudes during the powerful «proton» chromospherical flashes, such as 23.02.1956 and 29.09.1989 events.

-during the nuclear tests in the Earth's atmosphere the radioactive clouds at latitudes ~12-13 km which go ground the Earth two or three times were created.

-it seems to us that these clouds make a certain contribution to the ecological situation in the Earth atmosphere and on the surface.

From the above mentioned one can make a conclusion that aviation shouldn't flight at the altitudes more than 12 km, especially at high latitude and during the Solar activity minimum.

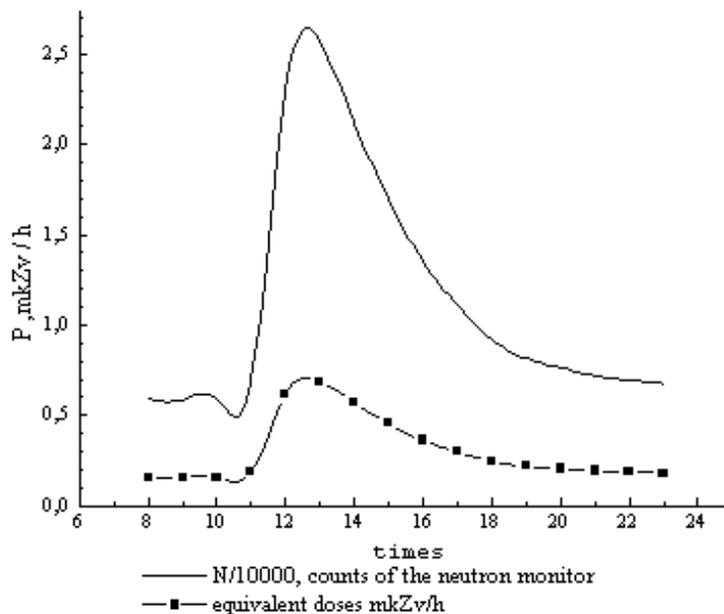


Figure 4. *Calculated radiational doses according to data of SGR produced during the September, 29.1989 event on the Sun*

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