THE INFLUENCE OF THE EARTH'S MAGNETOSPHERE
ON THE HIGH-ENERGY SOLAR PROTONS

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Abstract

The North-South asymmetry in the fluxes of solar protons with the energy $\sim$70-200 MeV in stratosphere at the invariant latitudes 62°-76° is discussed.

1.Introduction. In the earth's polar regions the intensity of the solar protons with the energy above the critical energy of geomagnetic cutoff is, according to the Liouville theorem, the same as in the interplanetary space. The penumbra in the polar regions is small and the East-West effect is also small /1/. However the geomagnetic cutoff rigidity R_C in polar regions is difficult to calculate because it is not sufficient to include only the internal sources of the geomagnetic field. According to /2/, during the magneto-quiescent periods the real value of R_C can be less by 0.1 GV than the calculated value because of the external sources. During the geomagnetic storms the real value of R_C is still lower.

2.Observations. The stratospheric exploration of the cosmic rays (CR) initiated in the USSR in IGY provides information on the energy spectrum and absolute flux of the solar protons intruding into the earth's atmosphere. The detector consists of two Geiger counters forming the telescope interlaid with the 7 mm thick aluminium filter /3/. The data on the stations of the stratospheric CR observations are listed in the Table. Although the calculated values of R_C are 0.5GV and 0.6 GV at Olenya and Apatity respectively, the lower

Table. Polar stratospheric stations

Station	Geograph.coordinates		Invariant	R_C,GV	E , MeV
	Latitude	Longitude	Latitude	/2/	
Olenya, (Murm.reg.)	68.95 N	33.05 E	65.7	0.5	125
Apatity, (Murm.reg.)	67.55 N	33.33 E	62.5	0.6	175
Mirny	66.57 S	92.92 E	76.4	0.03	0.48

energy limit of the observed solar protons at these locations is nevertheless always determined by the ionization ab-

sorption in the residual atmosphere and is sometimes as low
as 50 MeV. This means that even in the magneto-quiet peri-
ods the rigidity of geomagnetic cutoff at Olenya and Apati-
ty is not higher than 0.3 GV.

Since the asymptotic directions of CR arrival in the
Murmansk region (Olenya, Apatity) and at Mirny are diffe-
rent /2/, the N-S anisotropy in the stratospheric observa-
tions can be expected in case of the pitch-angular anisot-
ropy of the solar cosmic ray (SCR)fluxes in the interplane-
tary space. This effect is usually observed only near the
onset of a proton event. If the SCR intensity at the atmo-
spheric boundary is not isotropic this leads to the discre-
pancy between the flux values of solar protons obtained with
a single counter and a telescope. This effect sometimes hap-
pens /4/, but the present paper will deal with the N-S ani-
sotropy which appears after the maximum of a proton event.
In such cases the data of a single counter and a telescope
coincide as a rule, so the pitch-angular isotropy at the at-
mospheric boundary takes place.

3.Comparison of the results for the Northern and the Sou-
thern hemispheres. During the period of combined measure-
ments in the Southern and the Northern hemispheres, star-
ting from 1963, about 60 solar proton measurements simulta-
neously within an hour have been performed. From these data
we excluded the balloon flights during which the temporal
dynamic of intensity was observed and also the data obtai-
ned at the onset of events when according to the neutron
monitor data the SCR angular anisotropy was observed. In 31
of the remainder 43 flights the results agree within 10%
accuracy. In 10 flights the SCR flux was higher in the Nor-
thern hemisphere, among them 6 flights manifested discre-
pancy more than 30%; 2 measurements showed the excess SCR
flux at Mirny.

The most remarkable case of the N-S anisotropy is the
SCR event of 12.10.81 reported in /5/. During this event 10
flights in the Southern hemisphere and 39 flights in the Mu-
rmansk region were carried out. Some energetic spectra me-
asured during this event are presented in Fig.1 together
with the Meteor /6/ and IMP-8 /7/ data. The IMP-8 differen-
tial spectrum is recalculated by us to the integral spectrum
taking into account the intensity of protons with $E > 90$ MeV
according to the Meteor data. The features of the event in
question are: 1/ the anisotropy is not persistent; 2/ when
the N-S anisotropy is observed the satellite data agree with
the Mirny data, and thus in the Northern hemisphere there is
an excess flux of particles. According to Meteor observati-
ons in the polar caps there was no any noticeable anisotro-
py at $E > 90$ MeV during this period /6/. We may infer that an
excess flux of particles in the Murmansk region has a magne-
tospheric origin . The surplus flux causes the steepening of
proton spectrum at $E < 200$ MeV which can be seen in Murmansk
data even without any comparison with simultaneous Mirny da-
ta /5/. This excess cannot be accounted for by the bremsst-

rahlung of the auro-
ral electrons because
these are not regis-
tered with a telesco-
pe. A certain contri-
bution of the brems-
strahlung can be ad-
mitted only at 03-04
UT and 15-16 UT obser-
vations on 13.10.81.
        The time beha-
viour of the anisot-
ropy is shown in Fig.2
It is seen, that the
value of the excess
flux (if occurs) gra-
dually decreases with
time. The spectrum
index of the excess
flux, γ, is equal to
3-5 and it increases
up to ~ 14 during
the last flight on
15.10.81. The aniso-
tropy calculated as
$\alpha = (I_N - I_S)/(I_N + I_S)$

also becomes stronger
to the end of the
event. In the bottom
of Fig. 2 we give the
values of K_p- index
/8/. We failed to re-
veal any correlation
between the N-S anisotropy and geomagnetic disturbances.

Fig. 1 Examples of energy spectra
of solar protons according to
stratospheric and satellite data

4.Discussion. The N-S asymmetry in the fluxes of solar pro-
tons with E≅70-200 MeV is occasionally observed in the
stratosphere. The 700-1000 km height satellite observations
in the polar caps /6/ have not confirmed the presence of
the anisotropy. The SCR fluxes in the polar caps agree with
the Mirny data. The surplus flux of particles in the Mur-
mansk region is not persistent, has a steep energetic spec-
trum and the maximal energy does not exceed ~ 200 MeV.
There is no correlation with the geomagnetic disturbances,
but an especially strong anisotropy was observed during the
latest phase of the event more than a day after the sudden
commencement of the geomagnetic storm marked by a triangle
in Fig. 2. Similar effects against a background of the ge-
omagnetic storms were observed in the stratosphere during
powerful proton events of the 19-th solar cycle /3/. The
spectrum steepening was supposed to be associated with the
particles accelerated or localized near the front of the
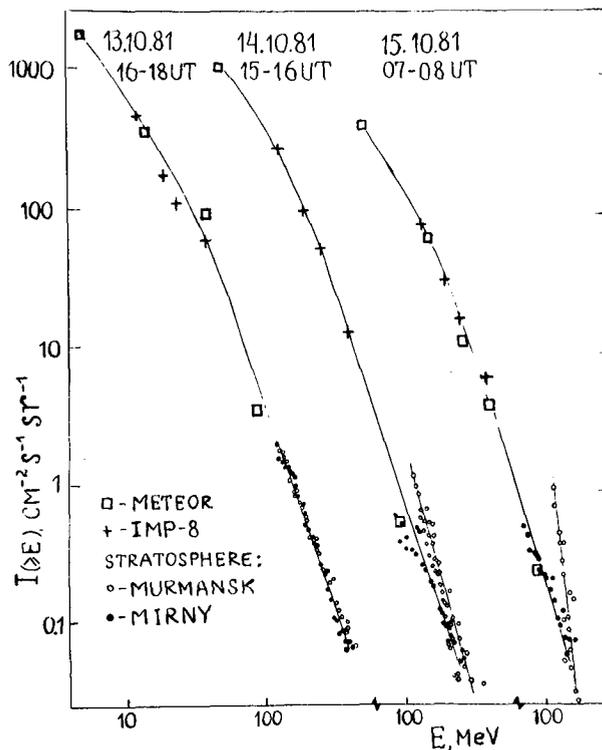interplanetary shock of flare origin. However the direct

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measurements in the interpla-
netary space have shown that
the energy of storm particles
is not higher than 30 MeV /9/.
Unfortunately no measurements
in the Southern hemisphere
were made at that time.

The difference between
Murmansk and Mirny is that
Murmansk is situated on the
closed magnetic shell and Mir-
ny on the open one. An impor-
tant fact is that the effect
is limited in the energy ran-
ge of particles which penetra-
te mainly through the tail of
the magnetosphere /10/. The
nonadiabatic processes leading
to an additional flux of high-
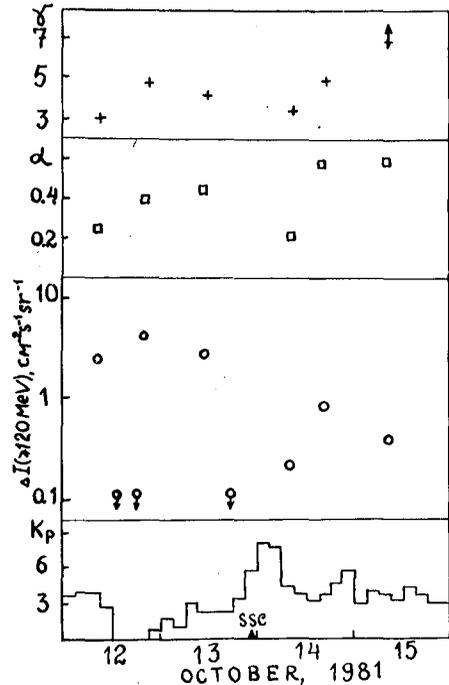-energy protons should play a
role here /11/.

Fig. 2. Time behaviour of
an excess flux of partic-
les in Murmansk region.

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