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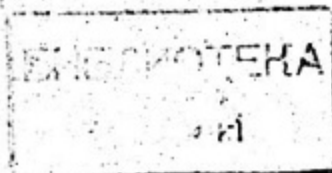
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Results of experiments carried out on board orbital stations "Saljut-7" and "Mir", and satellites "Meteor-3" and "Intercosmos-Bulgaria-1300" indicate that sharp deviations of high-energy particle trapped in the geomagnetic field correlate with Earth seismicity. In a number of cases, such deviations occurred 2.5-3 hours before the earthquakes.

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Introduction

Evidence of a correlation between high energy particle fluxes in the inner radiation belt and seismicity was first found in 1985 in the experiment "Maria" on board the "Saljut-7" orbital station [Voronov et al., 1987, 1988]. Three sharp increases in charged particle counting rates lasted several minutes were detected during the experiment on a day when neither solar activity nor geomagnetic disturbances were observed, instead, seismic activity all over the Earth was increased. Therefore, the suggestion was put forward that there may be a correlation between increased intensity of high-energy particle fluxes and seismic activity [Voronov et al., 1987, 1988].

Experimental Results

We present a possible correlation between increased intensity of high energy particle fluxes in the radiation belt and seismic activity in the basis of experimental data obtained with the instrument "Electron" on board the satellites "Meteor-3" (orbital altitude - 1250 km) and "Intercosmos-Bulgaria-1300" (orbital altitude - 350 km) and with the spectrometer "Maria" on board the orbital stations (altitude - 350 km) "Saljut-7" in 1985 and "Mir" from 1987 to 1989. The total number of measurements analyzed is about 200 for all the three experiments.

The instrument "Electron" [Galper et al., 1983] detects the directed flux of charged particles: electrons with an energy >30 MeV and protons with an energy >400 MeV. The field of view of the instrument is 18° . The "Maria" spectrometer [Voronov et al., 1988] allows the detection and identification of charged particles in the momentum range from 20 to 200 MeV/c. Its angular resolution is 2° . The analysis of the data of the experiment on board the satellite "Meteor-3" showed 36 sharp fluctuations in counting rates (>5 standard deviations) with durations from 1 to 8 minutes. One third of them are counting rate increases and two third - decreases. All of them are distributed in the radiation belt region within geomagnetic shells $L=1,1 - 1,25$ (Fig.1).

34 out of 36 events were related to periods when there were neither strong geomagnetic disturbances nor essential solar activity. However, on those days, global seismic activity was increased. Fig.2 shows the distribution of time intervals Δt between the moments of fluctuations in counting rates and the beginnings of all earthquakes with magnitude $M > 4$ (Richter scale). There is an obvious peak in the distribution for time intervals of 2.5-3 hours, which could be interpreted as a precursor of earthquakes.

Performed was the analysis of the effect dependent on a depth seat H , local time LT and an epicenter position. The time interrelation of seismic events with counting rate deviations manifests itself more pronounced for strong earthquakes with $M > 4$, at small depth ($H < 80$ km), with the epicenter located on land (Fig. 3) occurring at a local night time $18 < LT < 6$ hr.

Analysis of data from the satellite "Intercosmos-Bulgaria-1300" showed 11 sharp fluctuations in counting rates, 5 of which

occurred in the absence of geomagnetic disturbances but were followed by earthquakes of the mentioned type (land, $M > 4$) [Galper et al, 1989]. The "Maria" spectrometer detected 12 tenfold increases in high energy particle fluxes intensities for energies of a few dozens MeV. Protons constituted 80% and electrons - 20% of the detected particles. The deviations of intensities were accompanied by changes in pitch-angle distributions and energy spectra of particles. Fig. 4 shows the examples of pitch-angle distributions, measured near Brazil anomaly in case of high-energy particle intensities deviations and without them. 2.5-3 hours after each deviation there happened an earthquake of the type mentioned.

For deviations of intensities detected by the "Maria" spectrometer the time analysis was made in order to find periodicity. Two methods - statistical and Fourier - were used. No significant periodicities were found in the range 2-50 seconds the analysis covered.

Table 1 presents data on detected intensity deviations and the earthquakes, followed these deviations 2.5-3 hours later. All detected deviations fall on the days with increased seismic activity. Also, for measurements that didn't show counting rate changes in the region between $L=1.1$ and $L=1.5$ there were only a few earthquakes 2.5-3 hours later.

Conclusion

The results of three different experiments demonstrate a stable interrelation between the fluxes of high-energy charged particles in the Radiation belt and Earth seismicity. In most cases the forerunners of earthquakes were registered as particle flux deviations 2.5-3 hours before the earthquakes.

In a number of experiments on board satellites above the places of approaching earthquakes an anomalous electromagnetic emission was detected in advance of several hours before the earthquakes [Gohberg et al., 1988]. This emission possibly results in the development of the processes impacted on the geomagnetically trapped particles motion and their pitch-angle distribution changes. Because of the particles longitudinal drift these changes reach the region of the Brazil geomagnetic anomalous and turn into intensities deviations, detected when satellite cross the corresponding geomagnetic shell. We also can not reject the possibility that the found flux-seismicity correlation is defined by near space processes which on one hand influence the last stage of a developing earthquake, on the other hand are connected with such magnetosphere phenomena as sporadic changes of high energy charged particle fluxes and generation of electromagnetic emission.

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Table 1

Date	Intensity change		Earthquakes (M>4)			Remarks
	Time	Experiment	Time	Longitude (degree)	Latitude (degree)	
10.09.85	13.22	Saljut-7	15.52	150.2	-6.7	
10.09.85	15.21	Saljut-7	18.09	150.2	-6.6	
10.09.85	18.12	Saljut-7	20.57	1.3	35.8	
27.07.88	10.25	Mir	13.30	171.0	-22.9	
29.07.88	9.40	Mir	12.08	289.4	-22.8	
17.01.89	11.21	Mir				M.D.
20.01.89	9.11	Mir	15.25	158.8	-8.0	M.D.
01.11.89	17.37	Mir	20.20	142.8	39.9	
02.11.89	16.43	Mir	19.42	143.5	39.5	
03.11.89	15.51	Mir				M.D.
06.11.89	13.11	Mir	15.42	267.2	14.09	
25.01.90	5.45	Mir		no information		
19.09.81	7.06	Bulgar-1300	10.04	170.1	-22.6	M.D.
28.12.81	11.29	Bulgar-1300	10.18	143.6	21.5	
31.12.81	12.24	Bulgar-1300				M.D.
16.02.82	15.58	Bulgar-1300	18.43	25.7	38.7	M.D.
25.02.82	4.50	Bulgar-1300				M.D.
02.03.82	3.43	Bulgar-1300	6.39	120.3	-7.3	M.D.
16.03.82	7.51	Bulgar-1300	10.24	165.5	-12	
24.10.85	12.14	Meteor-3	13.53	127.2	6.24	
02.11.85	11.23	Meteor-3	13.57	126.5	-3.9	
11.11.85	10.28	Meteor-3	13.05	126.5	-3.9	
01.12.85	22.18	Meteor-3	1.04	129.5	27.9	
12.12.85	5.38	Meteor-3	8.23	267.0	14.2	
16.12.85	5.32	Meteor-3	8.07	126.8	3.7	
21.12.85	6.22	Meteor-3	8.53	166.4	-14.3	
23.12.85	5.38	Meteor-3	8.10	245.8	62.3	
03.02.86	13.16	Meteor-3	15.00	129.7	-0.03	

M.D. - magnetodisturbed dates

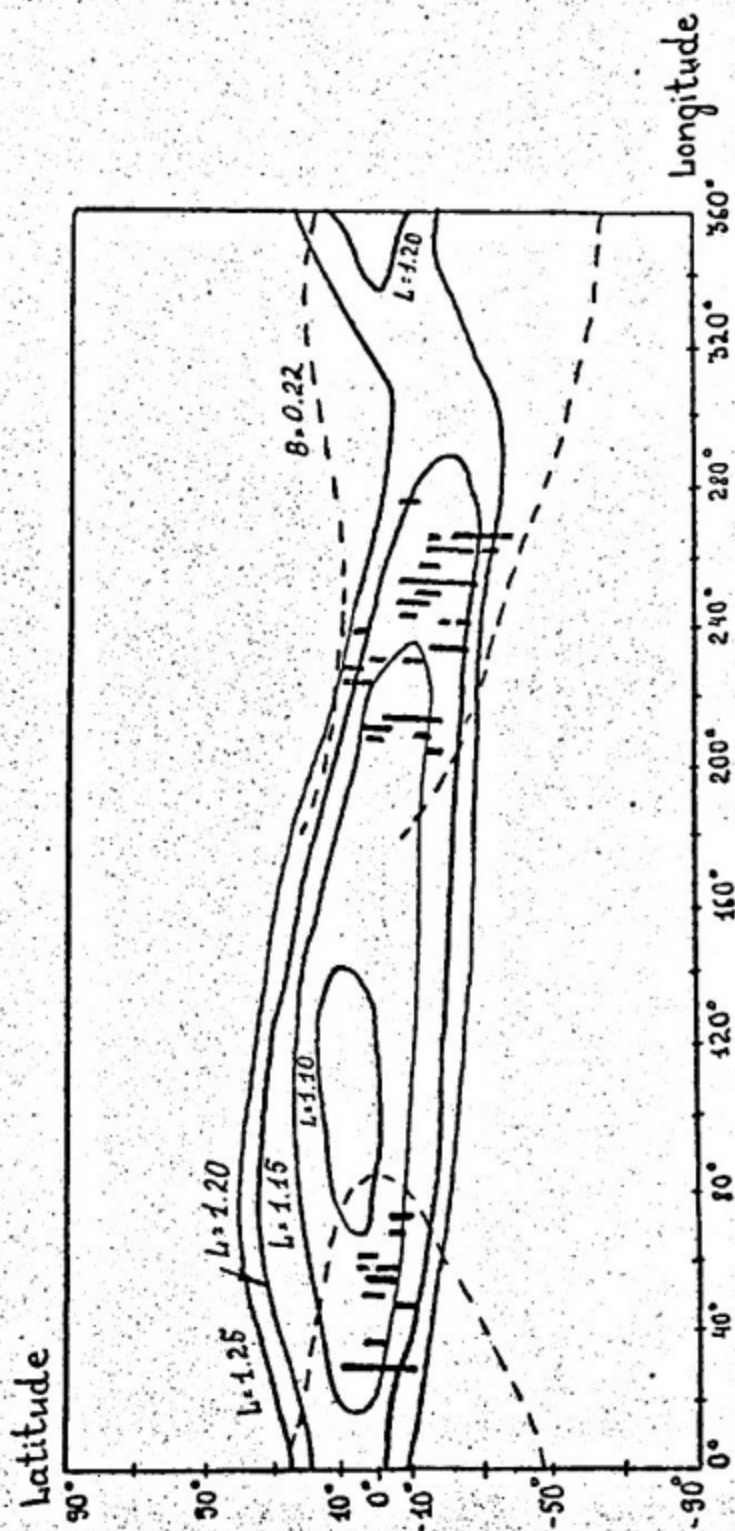


Fig. 1

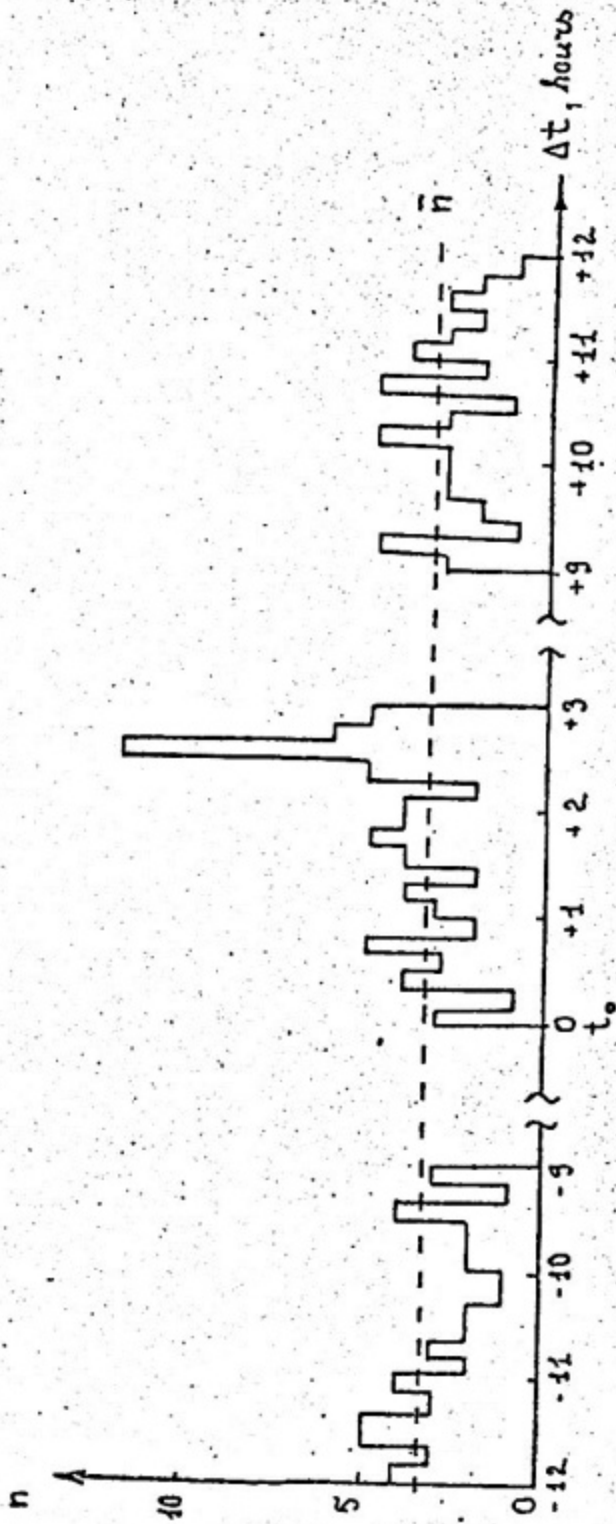


Fig. 2

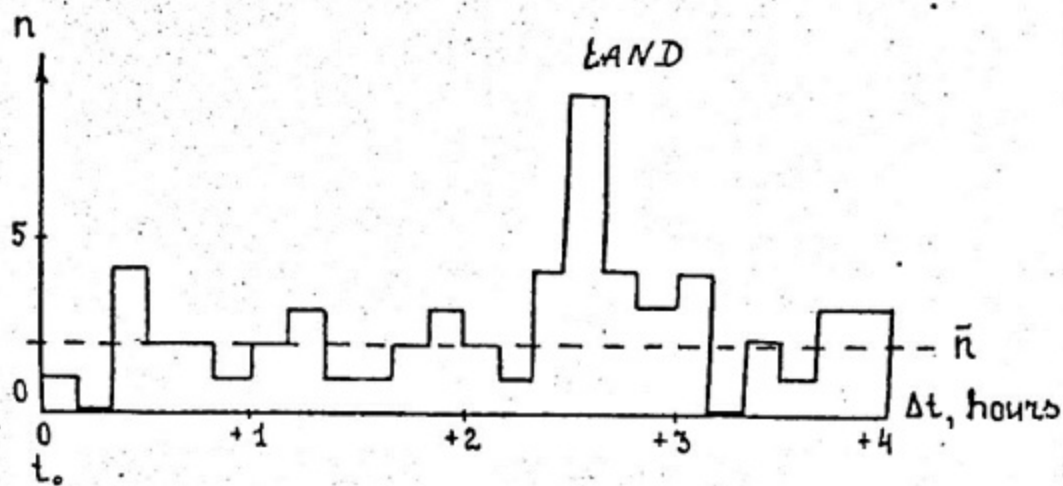
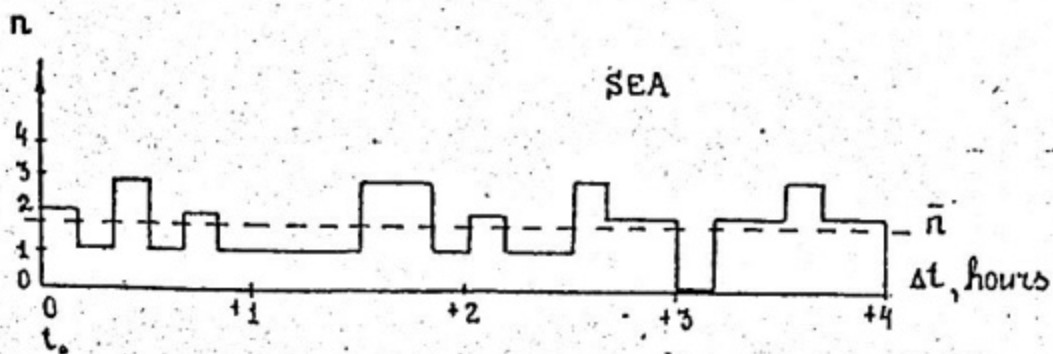
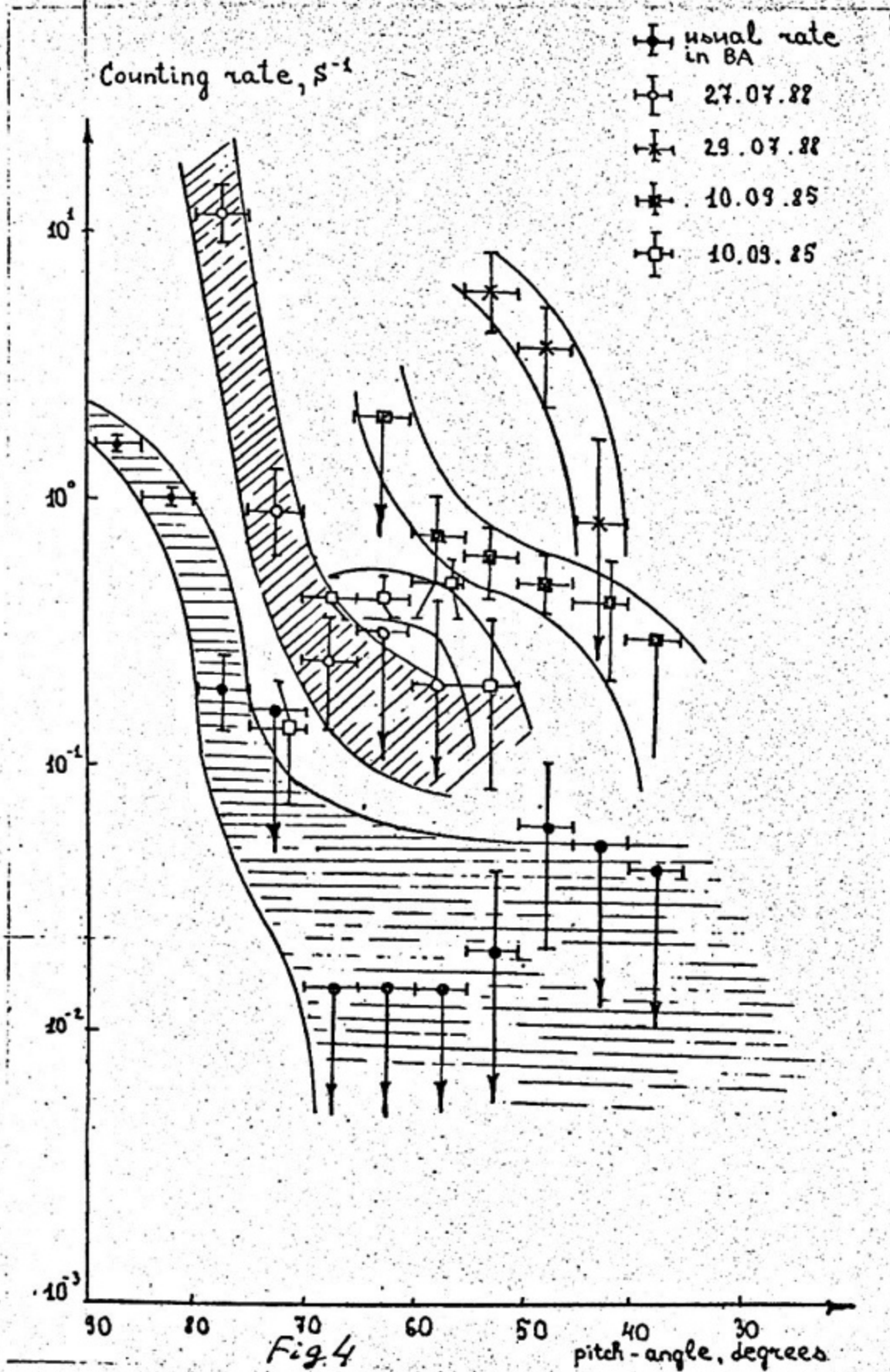


Fig. 3



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