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Origin of electron spectra and its characteristics

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Abstract

This work presents the data on differential energy spectra of cosmic electrons with energies 0.1-6.0 *MeV* from the Pioneer-8-11, Prognoz-4-10, IMP-6,7,8, and Intercosmos-19 (polar cap measurements) spacecraft during 1975-1998. Some different sources of energetic electron are discussed. Analysis of the spectra permits a conclusion about a preferential contribution of galactic, solar and Jupiterian sources, depending on energies and on time of measurements. The dependencies of the sign and values of north-south asymmetry on the sector structure of the interplanetary magnetic field are obtained. The asymmetry sign and the size of cosmic electron fluxes for the above energies are compared with the earlier data in the high and low electron energy ranges for solar cycles 21-22.

1 Introduction:

The electron spectra, anisotropy and north-south asymmetry of charged particles (electrons and protons) have long been studied on satellites. However, the data obtained do not give an unambiguous picture of electron spectra, anisotropy and north-south asymmetry (e.g., Mineev et al. 1978 & Gorchakov et al. 1995). Therefore, new measurements are required which would permit the data to be interpreted more precisely. Electron fluxes with energies of hundred of keV detected during quiet time period have the galactic origin (Ramaty et al. 1972 & Simnet et al. 1969). However the main source of them is not clear yet these electrons may be primary electrons accelerated by Fermi mechanism, or secondary.

For clarifying a source of these electrons a comparison of changes in differential energy spectra during the last cycles of solar activity is of interest.

This work analyzes the spectra of energetic electrons obtained from Pioneer-8,9 (1968) (Webber, et al., 1973 & Hurford, 1974), IMP-6 (1971), IMP-7,8 (1972-1980), Prognoz-4 (1976) (Mineev, 1978), Intercosmos (1979) (Mineev, 1980), Ohzora (1986) (Kohno, 1998).

2 Experimental data:

The differential energy spectra of 0.1-6.0 *MeV* cosmic electrons obtained from satellites are plotted in Fig. 1, which also presents the differential energy spectra measured on spacecraft in 1968-1986 years for comparison. Despite the fact that measurements were made by a semiconductor telescopic systems, there are significant discrepancies in the measured spectra. The largest flux sizes were obtained on Ohzora satellite, the minimal value was obtained on IMP-7. Possibly, the extremely large flux sizes measured on Ohzora are explained by inadequate side protection of the semiconductor telescope against radiation, mainly against proton fluxes. Measurements on IMP-6,7 and Prognoz-4 satellites, and on Pioner-8,9 space probes were made by semiconductor telescopes with active anticoincidence shielding. This minimized the additional counts of cosmic protons.

The differential energy spectrum measured during quiet Sun on Prognoz-4 is:

$$dI / dE = a\, E^{-g} \cong 0.05\, E^{-1,6\pm 0,2} \tag{1}$$

and depends little on time.

Measurements on the satellite IMP-6,7,8 are similar to equation (1). Simultaneous measurements on near-Earth satellites IMP and Prognoz types showed that is the magnetosphere of Jupiter a source of near to Earth electrons with energy $\geq$0.3 *MeV* (Mineev, Spir'kova, 1980). During solar flares considerable increasing in electrons with small and middle energies can be observed in the space.

The Earth magnetosphere serves a source of electron increasing in the space. Identification of electron increasing requires data on anisotropy and asymmetry of fluxes. On the Fig. 2 an example of observation on space electron spectra having been detected on the Prognoz-4 satellite is shown. These electrons seem to be of Jupiterian origin.

Spectrum 1 in Fig. 2 belongs to the "background" interval, whereas spectra 2 and 3 belong to increases caused by the Jupiter.

We have obtained $g = 1.6 \pm 0.2$ for spectrum 1 and $g \cong 2.5 - 3.0$ for spectra 2 and 3.

The spectral coefficient "a" in spectra 2 and 3 increases significantly, by an order of magnitude and even more. Variation of the spectral coefficient at ~1.5 *MeV* for Jupiterian electron increases can indicate that the conditions for arrival of electrons with different energies are different. Predominance of the low energy side of spectrum can indicate an effect of the electron scattering mechanism.

Contrary to solar electrons, which propagate along the direction of middle interplanetary magnetic field, Jupiterian electrons propagate predominantly across the middle direction of the field.

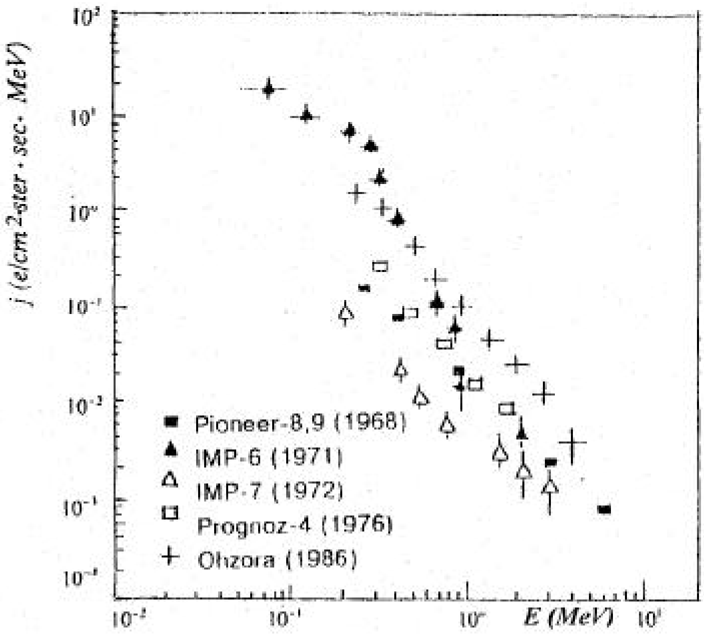

Fig. 1. Differential energy spectra of 0.2-6.4 *MeV* electrons

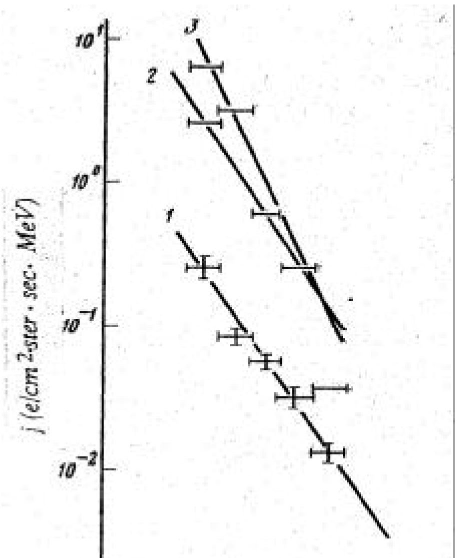

Fig. 2. Differential energy spectra of electrons: “background” spectrum (1); spectrum at the rise front (2); spectrum during the rise maximum (3).

3 Conclusions:

For calculation of numeral of Jupiterian electrons u and diffusion coefficient K_j it is necessary to solve the equation for diffusion

$$du / dt = \frac{d}{dx}(K_j \frac{du}{dx} - vu) \tag{2}$$

where v is velocity of the solar wind.

Equation (2) is solved on assumption that the Jupiterian magnetosphere is a point source.

Solving equation (2) gives the K_j value.

K_j is the diffusion coefficient f along the axis at the middle magnetic field direction.

In doing so, the calculations of the diffusion coefficient from the Prognos-4 data give $K_{||} \approx 5 \cdot 10^{22}\ cm^2 / s$ and $K_{\perp} = 5 \cdot 10^{20}\ cm^2 / s$.

The sign and value of the north-south asymmetry of cosmic electrons have been found (Gorchakov et al, 1995, & Mineev, Kohno, 1998). A comparison of the spectral index $g$with the anisotropy of north-south electron flux asymmetry clarifies the origin of cosmic electrons.

4 References:

1. Mineev Yu.V., et al. 1978. Kosm. Issled. 16. p.953.
2. Gorchakov E.V., et al. 1995. Proc. 24th ICRC. 4. p.518.
3. Ramaty R., et al. 1972. Phys. Rev. Lett. 29. p.1039.
4. Simnett G.M., F.B. 1969. Donald. ApJ. 1969, 157. p.1435.
5. Webber W.R., et al. 1973. J.G.R., 78, 10. p.1487.
6. Hurford C.J., et al. 1974. ApJ., 192. p.1974.
7. Mineev Yu.V. and T.Kohno. 1998. Proc. 16th ECRS. p.75.
8. Mineev Yu.V. & E.S. Spir'kova. 1980. Kosm. Issled. 18. p.805.