The Analysis of Quasistationary Equatorial Precipitations Observation Frequency Dependence From Geomagnetic Activity Level

D.B. Amandzholova, I.V. Arkhangeskaja, A.I. Arkhangelsky, Yu.D. Kotov

Abstract—**As a result of processing data rom AVS-F apparatus onboard CORONAS-F satellite quasistationary equatorial precipitations were found. In the sequence of precipitations temporal profiles was separated by three groups.**

The characteristics of uasistationary equatorial precipitations temporal profiles are discussed in presented work. About 65% precipitations temporal profiles have a fast rise of count rate on the South direction and flat decay on the North direction from geomagnetic equator, 29% ones have a fast rise of count rate on the North direction and flat decay on the South direction from geomagnetic equator and 6% ones are practically symmetrical. So it is possible to separate three groups in the sequence of precipitations temporal profiles. Typical duration of the precipitations is 7÷10 minutes for I and III types (the event region size is 20°÷35°) and 3 minutes for II type events (the event region size is ~10°). The dependence between registered precipitations quantity and geomagnetic activity level analysis results discussed too. II type events are similar to precipitations caused by high-powered SHF-transmitter functioning, obtained in experiment BATSE. But other types of events have different sources.

THE AVS-F (amplitude-time Sun spectrometry) instrumentation [1]-[2] is intended to study characteristics of fluxes of hard X-rays, γ-rays and neutrons from the Sun and solar flares and to detect and record events like gamma ray bursts (non-stationary fluxes of cosmic γ-rays). The experiment is conducted under the CORONAS (Complex ORbiting ObservatioNs of the Active Sun) international project and carry out at the CORONAS-F special-purpose automatic station (NORAD catalog number 26873, International Designator 2001-032A) that had been launched from Russian kosmodrom Plesetsk at 11:00 UT of 31 July 2001 by Cyclone-3 satellite-launching rocket into a circular orbit oriented towards the Sun with inclination 82.5° and altitude ~500 km. It continues the AVS experiment that was run aboard the CORONAS-I satellite. The instrumentation consists of two detectors and AVS-F hardware unit. The AVS-F apparatus use signals produced by the SONG-D and XSS-1

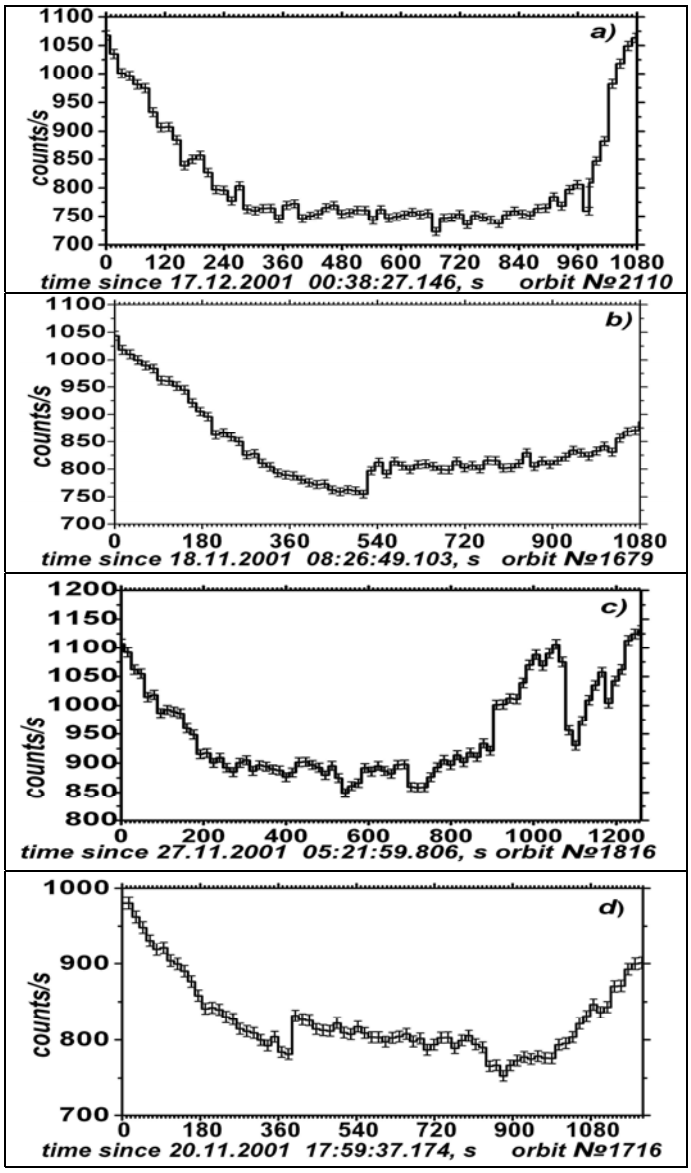

Fig. 1. Typical temporal profiles of the equatorial part of CORONAS-F orbit without precipitation (a) and with I (b), II (c), III (d) types precipitations by AVS-F apparatus data in energy band 0.1-11 MeV in the same coordinate regions.

detectors and the AC – the anticoincidence signal generated by the plastic scintillation counter of the SONG-D. XSS-1 is the semiconductor detector based on CdTe 4.9×4.9 mm (3-30 keV energy deposition range). The SONG-D detector, based on the CsI(Tl) crystal ∅20 cm and height of 10 cm with electronics unit SONG-E were developed at the Research Institute of Nuclear Physics of the Moscow State University for γ-rays and neutron measurements. Energy deposition ranges were 0.1-17.0 MeV and 4.0-94.0 MeV by first year calibration data. The detector threshold and amplification coefficient were changed approximately on 1% per month. At the last period of apparatus operation they were 0.1-22MeV and 2-260 MeV accordingly.

The typical AVS-F apparatus count rate temporal profile in low-energy γ-range have one extensive minimum in the geomagnetic equator region of satellite orbit (in the range of latitude-30÷° +40°) while solar flares and GRB are not observed – see Fig. 1a. But in some equatorial orbit zones the extension of count rate (quasistationary equatorial precipitations) were found – see Fig. 1b-d. These events usually observed in the range of latitude -25÷° +30° and show count rate exceeds by 15-30% relatively central tendency of typical AVS-F apparatus count rate temporal profile, obtained by polynomial approximation of this zones. The shape of 65% precipitations temporal profiles has a fast rise of count rate on the South direction and flat decay on the North direction from geomagnetic equator (see Fig.1b), 29% ones has a fast rise of count rate on the North direction and flat decay on the South direction from geomagnetic equator (see Fig.1c) and 6% ones are practically symmetrical (see Fig.1d).

So it is possible to separate 3 groups in the sequence of precipitations temporal profiles. Typical duration of the precipitations is 7÷10 minutes for I and III types (the event region size is 20÷°35°) and 3 minutes for II type events (the event region size is ~10°). The observed occurrence in region with sizes 10° of longitude and 30° of latitude have a averaged time interval about a 24 hours, maximal one is more then 8 days.

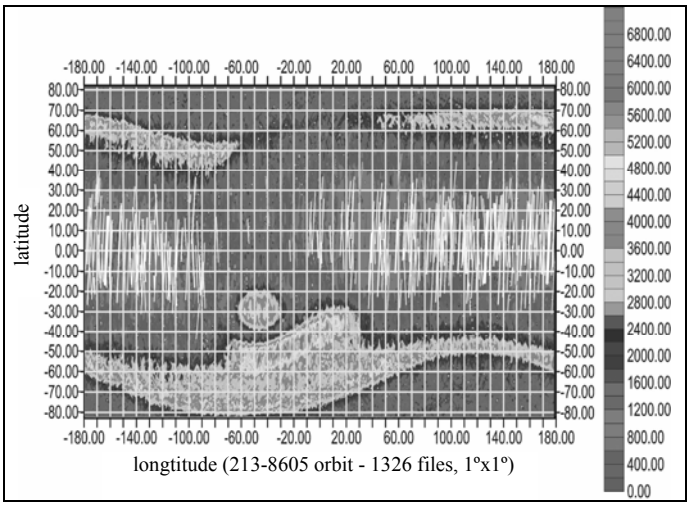

Fig. 2. The AVS-F apparatus count rate map averaged on 1.5 year of its operation in the low-energy γ-band

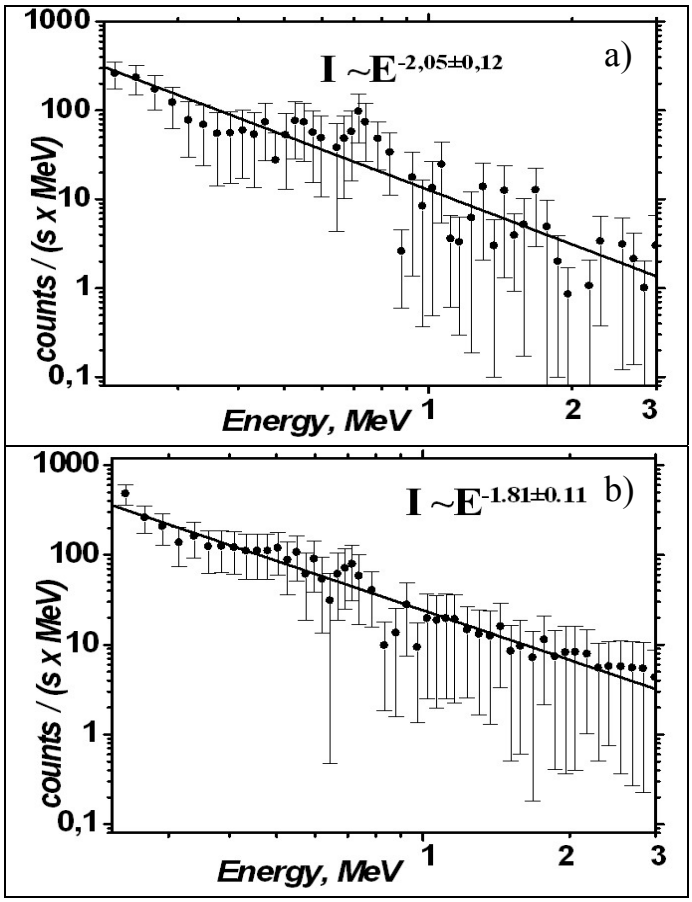

Fig. 3. Spectra of type I and II precipitations (a) and for III type ones (b).

The AVS-F apparatus count rate map averaged on 1.5 year of its operation in the low-energy γ-band is presented at Fig. 2. White lines indicate precipitations (241 occurrence). Most part of precipitations is located in the strip-shape region by width 40° practically symmetrical relatively geomagnetic equator.

So, the most part of precipitations are located in the region in which precipitations of electrons were registered by various satellites at low latitudes (L ~ 1.5) and in equatorial region.

The precipitations of electrons with energy E ~1.3 MeV observed at altitudes 288-350 km in regions with L= 1.14-1.17 even in 60 years of last century. Hydrogen, helium and oxygen ions precipitations with maximum intensity in the equatorial region, but observed up to ±20° of geomagnetic latitude were registered by some satellite instruments. Its intensity quickly increased in layer 180-260 km and then remains constants. Devices onboard COSMOS-900 satellite observed electrons precipitations at altitude approximately 500 km both in the day and night time [3].

The energy spectra of quasistationary equatorial precipitations are presented at Fig. 3. They have power shape I~E-α with α=2.1±0.2 for I and II types precipitations and α=1.8±0.1 for III type ones. This shape of spectra allow to make conclusion about connections of count rate increase in low-energy γ-band of AVS-F apparatus on the some equatorial parts of CORONAS-F satellite orbit and

presented in these regions charged particles bremsstrahlung emission in the detector and satellite materials.

We have analyzed the dependence of registered precipitations amount from the level of geomagnetic activity. It was analyzed a subset of 280 precipitations which was registered in August-December 2001. The dependences of precipitations amount from the level of geomagnetic activity for I and II types of precipitations are shown at Fig. 4ab.

The same distributions but with taking into account Kp-index recurrence rate in the time in which precipitations were observed are presented at Fig. 4cd. We make linear fits of these distributions. There are not any correlations with precipitations amount and geomagnetic activity level were found for I type events. But for II types ones frequency of its registration increase with geomagnetic activity level rise at 95% significance level which allow to make conclusion about connection II type precipitations with high-powered SHF-transmitters functioning, because in this case precipitations observation frequency during time with high geomagnetic activity level should be increase, similarly to experiment BATSE onboard cosmic apparatus CGRO, when was observed braking beaming from electron precipitations, concerned with high-powered SHF-transmitter functioning [4]. Unfortunately type III events subset volume now is not sufficient for statistical analysis.

It is not found any correlations between amount of observed precipitations and satellite CORONAS-F orbit altitude. During period from 14th November 2001 to 12th January 2005 averaged orbit altitude decrease from 510 km to 380 km. We analyzed two subsets of AVS-F apparatus data. 46 precipitations were registered for 9 days from 14th to 22nd November 2001 (exposition 622777 s, altitude range 492 km – 532 km) and 19 precipitations were observed for 9 days from 3rd to 12th January 2005 (exposition 318410 s, altitude range 362 km – 398 km). Taking into account normalization to exposition this two quantities are comparable within the limits of statistical errors. But it is quite possible that analyzing of greater size samples will reveal some correlation.

More than 400 quasistationary equatorial precipitations were observed by AVS-F apparatus in the intervals 14.08.2001-26.09.2001, 9.11.2001-01.12.2001, 8.01.2002-10.02.2002, 31.10.2004-5.11.2004 и 01.01.2005-14.01.2005. It is possible to separate at least 3 groups of precipitations on their temporal profiles types. Approximately 65% (I type) have temporal profiles with fast rise of count rate by south direction from geomagnetic equator and smooth decay by north direction, but 29% (III type) show opposite behavior of temporal profiles and 6% (II type) have symmetrical temporal profiles. The typical duration of I and III types quasistationary equatorial precipitations are 7÷10 min (which correspond to size of area 20°÷35° in latitude) and ~3 min for II type ones (which correspond to size of area ~10° in latitude).

It was not found any correlations between amount of I type quasistationary equatorial precipitations and geomagnetic activity level, but for II type ones frequency of their registration increases with geomagnetic activity level at 95%

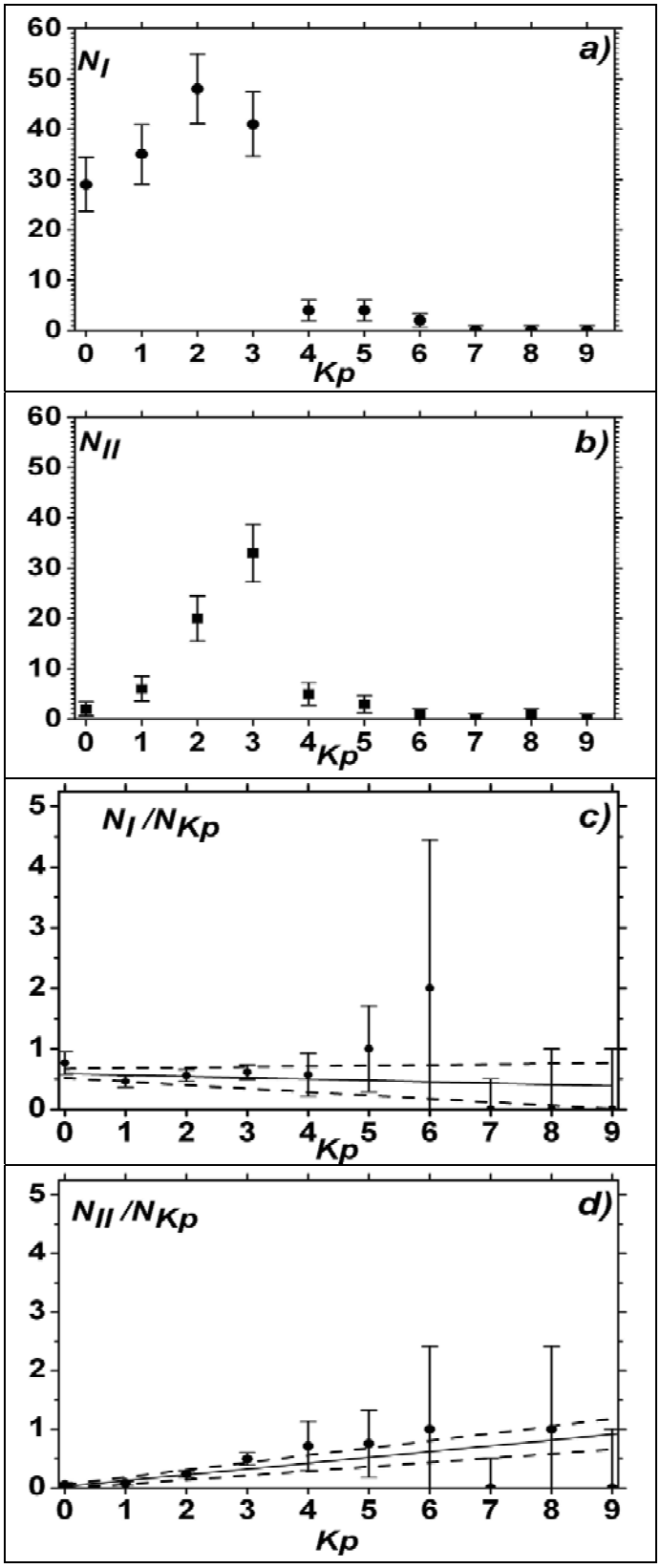

Fig. 4. The distributions of precipitations amount by the level of geomagnetic activity a) for I type precipitations, b) for II type precipitations (c and d – the same distributions but with taking into account Kp-index recurrence rate in the time in which precipitations were observed). Solid lines show linear fits at 95% significance level and dashed lines show limits of fits parameters.

significance level similarly to experiment BATSE onboard cosmic apparatus CGRO, when was observed braking beaming from electron precipitations, concerned with high-powered SHF-transmitter functioning.

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