Transient events in the upper atmosphere

G. K. Garipov[1], B.A. Khrenov[1], P.A. Klimov[1], V.V. Klimenko[2], E.A. Mareev[2], O. Martines[3], E. Mendoza[3], V.S. Morozenko[1], M.I. Panasyuk[1], I.H. Park[4], E. Ponce[3], L. Rivera[3], H. Salazar[3], V.I. Tulupov[1], N.N. Vedenkin[1], I.V. Yashin[1].

[1] *D.V. Skobeltsyn Institute of Nuclear Physics of M.V. Lomonosov Moscow State University, Leninskie Gory, Moscow,1, str. 2, 119991, Russia.*
[2] *Institute of Applied Physics of RAS, Ulyanov street, 46, Nizniy Novgorod, 603950, Russia.*
[3] *Department of Physics and Mathematics, University of Puebla, C.P. 72570, Puebla, Mexico.*
[4] *Research Center of MEMS Space Telescope of Ewha Womans University, 11-1 Daehyun-dong, Seodaemun-gu, Seoul, 120-750, Korea.*

Abstract

Detectors of transient events (duration of 1-128 msec) in near ultraviolet (240-400 nm UV) and red-infrared (>610 nm red-IR) ranges on board the "Universitetsky-Tatiana-2" for 2 years work detected more than 2500 flashes. Global distribution of transient evens depends on number of photons radiated in the atmosphere. Ratio of photons number emitted in UV and red –IR range, related to excitation of molecular nitrogen, indicates high altitude (50 – 80 km) of origin detected events. Series of every minute transient (from 3 to 16 transients in the series) were observed in one orbit. Remarkable is detection of transients out of thunderstorm area.

1. Universitetsky-Tatiana-2 mission

Moscow State University satellite Universitetsky-Tatiana-2 was launched on September 20 of 2009 to solar synchronous polar orbit with the height 820-850 km and inclination 98,8º [1,2]. The main goal of the scientific program of this satellite is the study of space near the Earth by measuring the charge particle fluxes at the orbit and radiation from the atmosphere. Radiation from the atmosphere was measured by detectors in two ranges of wavelength: 240 - 400 nm (UV) and >610 nm (red-IR)[3]. Both detectors were photomultiplier tubes of Hamamatsu type R1463 with multialcali cathode [4]. Field of view of detectors is oriented to nadir and observe the atmosphere area with effective diameter 300 km (effective area 7 10^4 km^2). Every minute UV detector selects the event with maximal 1 ms signal and recorded was rerecorded in the main memory. The main memory data was transmitted to the mission center when satellite flied over Moscow region.

2. Main results of the Universitetskiy-Tatiana -2 satellite mission

On board Universitetsky – Tatiana - 2 were detected transient events with duration 1 – 128 mc in two wavelength range 240-400 nm (UV) and 600-700 nm(red - IR)[5,6]. Every transient event was presented by number of photons Q, measured during 128 msec, or by number of photons Q_a in the atmosphere calculated from value Q as:

$$Q_a = Q\ 4\pi R^2$$

where S – is operation area of the PM tube cathode, R- is the distance between the atmosphere and the detector.

Differential distribution of transients over photon numbers Qa shows two ranges with a changing exponent of power law approximating the differential distribution: "-1" for $10^{21} < Qa < 10^{23}$ and "-2" for $Qa > 10^{23}$.

Position of every transient event is determined in geographical coordinates by Universal Time (UT) of the event. In 642 of all 797 available "working" orbits there is at least one transient event. It's allowed us analyses the global distribution of transient events. The geographical distribution of flashes depend on their luminosity (transients with $Q > 10^{23}$ are concentrated in equatorial range above continents in thunderstorms region; transients with low luminosity are distributed more uniformly and their appearance not depend on lightning). Interesting fact is
absence of transients above Sahara and Australia deserts and above Siberia.

Measured ratio of number of photons radiated in red-IR range to number of photons radiated in UV related to excitation of molecular nitrogen indicates a high altitude (>50 km) of this type atmospheric discharges[7]. The rate of flashes above continent is so high that series of every minute transient (from 3 to 16 events in series) were observed in one orbit. In series more than 50% (1519) of all transients (2640) were detected. Analysis of “single” and “serial” transient global distribution showed a large difference: serial transients are concentrated in equatorial regions above continents, while single transient distribution is uniform. Interesting observation facts that the events with “small” photons number ($<10^{21}$) are shorter in time (1-5 ms), 60 % of them observed as single transient while large transients have a tendency to be observed in series (75 %). A lot of transients were detected out of thunderstorm area, in cloudless region or thousands km away of thunderstorms. This fact allowed us to assume that transient events are not only consequences of lightning in event-by-event way but are the result of “long distance” influence of thunderstorm electric activity causing break-downs in the upper atmosphere (at altitudes >50 km)[8].

Acknowledgments

Authors are grateful to A.V. Gurevich for helpful discussions. Support from Creative Research Initiatives of MEST/NRF, from RFFI grants 07-02-92004-HHC, 09-02-12162-ofi_ m, 10-05-01045a are gratefully acknowledged.

3. References

[1] V.A. Sadovnichii, M.I. Panasyuk, V.O. Barinova, S.U. Bobrovnokov, N.N. Vedenkin, N.A. Vlasova, G.K. Garipov, O.R. Grigorian, T.A. Ivanova, V.V. Kalegaev, V.S.Morozenko et al. , Investigation of the Space Encirement Abroat the "-Tatiana" and "Universitetsky-Tatiana - 2" Microsatellites, Solar System Research, 2011, V 45(1), p. 3 – 29.

[2] V.A. Sadovnichy et al. , First results of investigating the space
environment onboard the "Universitetsky-Tatiana" satellite, Cosmic Research, 2007 , V 45, p. 273 – 282.

[3] G.K. Garipov, B.A. Khrenov, M.I. Panasyuk, Rubinshtein I.A., Tulupov V.I.,
Salazar H., Shirokov A.V., Yashin I.V.,UV radiation detector of the MSU research educational micro satellite ``Universitetsky-Tatyana" , Instruments and Experimental Techniques, 2006, V 49, p. 126 – 130.

[4] Hamamatsu, data book for PM tubes (1998).

[5] G.K. Garipov, B.A. Khrenov, P.A. Klimov, V.S. Morozenko, M. I. Panasyuk, S.N. Petrova, V.I. Tulupov, V.M. Shahparonov, N.N. Vedenkin, I.V. Yashin, J.A. Jeon, S.M. Jeong, A. Jung, J.E. Kim, W.S. Kim, J. Lee, H.Y. Lee, G.W. Na, S.W. Nam, S.J. Oh, I.H. Park, J.H. Park, J.Y. Jin, M. Kim, Y.K. Kim, B.W. Yoo, Y.-S. Park, H.J. Yoo, C.H. Lee, H.I Salazar, O.B. Martinez, E.L. Ponce, J.P. Cotsomi, Program of transient UV event research at Tatiana-2 satellite, J. Geophys. Res., 2010, V. 115. doi:10.1029/2009JA014765.

[6] G.K. Garipov, P. A. Klimov, V. S. Morozenko, M. I. Panasyuk, and B. A. Khrenov, Time and Energy Characteristics of UV Flashes in the Atmosphere: Data of the Universitetsky-Tatiana Satellite, Cosmic Research, 2011,V. 49, No. 5.

[7] N.N. Vedenkin, G. K. Garipov, P. A. Klimov, V. V. Klimenko,
E. A. Mareev, O. Martinez, V. S. Morozenko, I. H. Park, M. I. Panasyuk,
U. Salazar, V. I. Tulupov, B. A. Khrenov, and I. V. Yashin, Atmospheric Ultraviolet and Red–Infrared Flashes from Universitetsky–Tatiana-2 Satellite Data, JETP, 2011, V 113, 5, ISSN 1063-7761.

[8] A.V. Gurevich, Nonlinear effects in the ionosphere, Uspekhi Fizicheskih Nauk, 2007, 177(11), doi:10.3367/UFNr.0177.200711a.1145.