ASTROPHOTOMETRICAL OBSERVATION OF ARTIFICIAL SATELLITES AND STUDY OF THE TECHNICAL STATUS OF PARENTAL BODIES OF SPACE DEBRIS AT GEOSTATIONARY RING

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BACKGROUND

The amount of faint objects has been observed form a significant portion of all population of a GEO orbit objects. According to statistical observation[1-2] the magnitudes of those faint objects are in a range from 16 up to 19 (V). These mean that debris have the sizes less than one meter. It is accepted to count, that these debris were formed as a result of explosions and destructions of several space vehicles and means of their mulflucatins or dead such as the Soviet satellites the Ekran 2 and 4 and the last stage American buster Transtage. In the literature some documentary certificates of the explosion and destructions also are resulted. But on the other hand, almost all SC from the list of the objects which are suspected of destruction had observed too enough a long time and in detail and their observably magnitudes does not differ from average magnitudes which we are considered as the intact. They also are registered in a range of the magnitudes from 11 up to 14, which does not allow us speaking about their full destruction. There is one of the basic questions concerning nature small sized debris on GEO. Basically conclusions about destructions and collisions are based on the analysis of the ballistic information. This analysis has its own restrictions. Other in formations does need which has not been connected to measurement of orbits of satellites. In the report we shall show that the photometric information received on these objects is not allowed to draw conclusions on that, these objects in partly or completely destroyed. Thus we in any degree do not call in question about existence small sized faint debris on GEO. The first that we want is to establish their nature and origin. Further it is necessary to remove the contradiction between amount of fragments which observed and on the average by normal photometrical observed behaviors of those space vehicles. In connection with the received results on spacecraft "Ekran 2", that was published early we carried out additional observations of geostationary objects which were considered to be destroyed by different reasons. The objects of observation were chosen from the lists published in the works[3-6]. We shall try to establish nature of the "faint population" GEO debris with use of methods of precision multi-color astrophotometrical observations of GEO satellites.

OBSERVATION OF THE GEO SC LIGHT CURVE

Satellite observations on GEO were carried out in Sayan Observatory on 50-cm telescope AZT-14. The basic recording equipment on the telescope was ICCD - electron-optical intensifier with __D array established in Cassegrenian telescope focus. The received photometric observation arrays represent measurement runs of integrated satellite brightness. Light curves were received by method of television images photometry in the mode of object autoguiding with storage time ~1.4 sec. Observations were made at different phase angles and satellite perspectives with respect to observer; in series with duration of about 600 sec. Typical light curves for objects under investigation are given in Fig. 1. From 2 to 6 of such light curves were received for each object. In order to determine the period of the magnitudes change for all obtained light curves of these objects the fast Fourier transformation method was used.

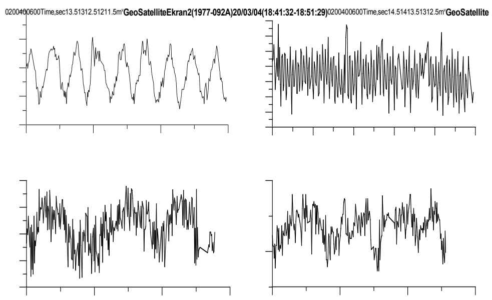

Figure 1. Light curves for the upper stages of the American buster rocket Titan 3C Transtage and GEO satellites Ekran- 2 and 4.

This method was applied to each obtained set of brightness measurements. The received periods are represented in Table 1. The range for determination of rotation periods was taken from 10 to 200 sec. The phase angle was calculated for the middle point of observation moment. As one can see from Table 1, the average magnitude of all Transtage rockets lays near 13 magnitudes. Power spectra for the obtained realizations have well resolvable peaks, that allowed to determine periods of rotation more authentically.

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Magnitude, presence of the stable period and the form of the light curve of debris Transtage 30 may mean, that it is a large (~175sm) enough fragment of launching. The assumption that this fragment is a splinter of Transtage 30 is no longer relevant, because Transtage 30 is bright enough and has brightness value +12.8 magnitudes.

Two integrated light curves for the top stage Transtage-14 also received in Sayan observatory on a telescope AZT-14, 22.01.04 and 22.04.04 were used for analyses. The account was carried out on all interval of observation, with a step on time for the first series for 22.01.04 - 1.6 sec., for the second series for 22.04.04 - 1.4 sec.

Table 1. Observation of hypothetically exploded spacecraft and booster

Name and Internatuonal designation	**Data observation**	**UT**	**Lentgh (seconds)**	**Period (sec).**	**PA (deg.)**	**m_V**
Transtage 14 (1967-066G)	22.01.04 22.04.04	13:33:41-13:38:46 18:45:45-18:55:39	305 591	**13.32** **6.65**	21.2 20.7	12.13 13.33
Transtage 26 (1973-100D)	22.01.04 20.03.04 21.03.04 22.03.04	13:19:00-13:26:20 18:26:57-18:37:06 16:05:32-16:15:03 16:29:29-16:39:04	440 603 580 575	163.93 - 147.85 156.25	25.3 24.1 30.9 45.5	12.55 12.89 12.63 12.37
Transtage 30 (1976-023F)	21.01.04 21.04.04 22.04.04	20:15:04-20:20:59 16:35:41-16:45:02 17:42:49-17:52.40	355 557 589	71.94 13.88 13.90	38.2 17.4 25.7	12.69 12.83 12.95
Ekran 2 (1977-092A)	21.01.04 20.03.04 21.03.04 22.03.04 21.04.04 22.04.04	20:27:56-20:32:58 18:41:32-18:51:29 16:17:15-16:24:12 16:03:24-16:13:04 19:42:25-19:52:05 18:33.13-18:43:53	304 595 405 578 578 636	**69.37** **69.05** **68.49** **68.96** **68.49** **68.96**	29.9 13.4 25.8 29.1 30.7 14.3	12.60 12.64 12.34 12.52 13.15 12.15
Ekran 4 (1976-087A)	21.01.04 20.03.04 21.03.04 22.03.04 24.04.04	20:47:28-20:52:11 20:43:05-20:49:23 16:44:32-16:54:32 16:42:35-16:52:14 18:16:23-18:26:23	285 375 582 555 598	5.18 6.37 232.26 188.67 164.21	14.4 13.7 48.1 48.4 17.7	13.00 13.85 13.34 13.22 13.25
Debris Transtage 30 (1976-023J)	21.04.04 24.04.04	20:22:08-20:32:04 18:33:06-18:43:11	594 598	**67.56** **68.49**	20.9 28.2	13.70 13.84

SIMULATION OF THE GEO SC LIGHT CURVE

The technique of remote diagnostic of the GEO SC S has been developed [6-8]. It gives us an opportunity to apply the results of observation with the optical telescopes and high-sensitivity equipments for various conditions of flight. To use this technique the data about S'C construction, laboratory measurements of optical properties of materials, and data on changes of their properties under action of the space environment are necessary.

Primary goal of mathematical simulation of S'C optical characteristics is to calculate SC radiation in the given range of wavelengths of waves in a direction of the observer. The task of S'C radiation calculation is reduced to summation of intensity of various elements of S'C surface with allowance for mutual obscuration and re-reflection. An S'C surface is approximated by a system of flat plates. For each giving plate incident and reflected fluxes coming from the Sun and the elements are taken into account.

For the analysis of a large quantity of observational data it is worthwhile using light curves simulation technique with simplified set of geometrical and kinematical parameters. The advantage of such approach is the possibility of active change of the modeled object form, its optical characteristics and kinematical parameters. The performed analysis is essentially facilitated by use of the convenient graphic interface. The mathematical simulation software was integrating to the program "TRACER 1" (Fig.2)

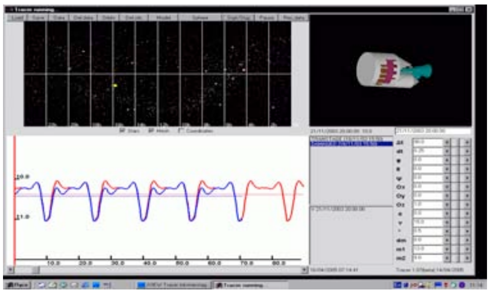

Figure 2. Tracer 1 program GUI . The comparison of experimental and calculation dependences of magnitudes of the probably malflucated upper stage Transtage-14.

ANALYSES AND CONCLUSIONS

Using this approach, modeling of spacecraft "Ekran 2" has been done [9-10], which was considered destroyed according to some data because of "explosion" of nickel – cadmium storage batteries. The results of modeling show that this apparatus was not exposed to destruction and can not be considered as a source of a large quantity of small-size debris. All elements of a surface of a stage have diffuse character of reflection, except for a surface of the body Control Module, which has the_mirror character of reflection. For the body of Transtage-14, as well as for the early analyses of a SC Ekran-2, we executed the computer modeling of the light flow reflected from its surface in the real conditions of flight.

The model of the upper stage, designed with the help of the program "TRACER 1.04". The materials, concerning the description of a design and the sizes of a stage, were found in a network. All elements of a surface of a stage have diffuse character of reflection, except for a surface of the surface Control Module, which has the mirror character of reflection. The comparison of experimental and calculation dependences of brightness from time is given in Fig. 3.

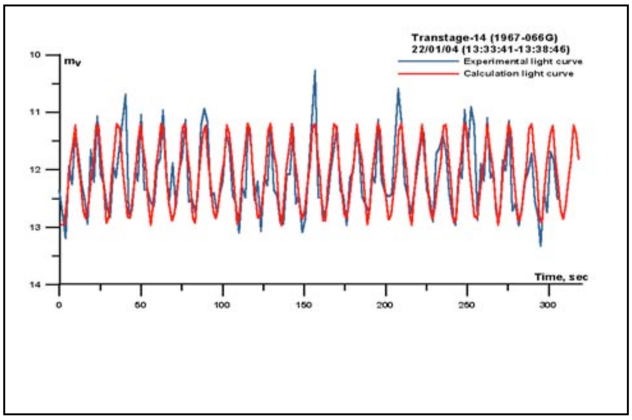

Figure 3.
X=mv 14,13,12,11,10 / Y=Time,sec 0,50,100,150,200,250,300

General view of the calculated curves repeats experimental curves in the basic details: 2 mirror reflections from lateral surfaces and two peaks of absorption, which are given by the back platform with nozzles and forward - with injector installation.

From the results of optical observations of light curves of uncontrolled geostationary spacecraft and means of their insertion it is possible to deduce that the conclusions made in a number of works about objects' destruction are premature. Thus, the criteria of "explosions" used in these works: change of drift velocity according to longitude and change of large orbit half-axle value cannot be considered sufficient for establishment of the fact of spacecraft destruction.

Additionally we must conclude that photometrical observations of SC need better accuracy. The stronger requirements to photometric accuracy follow from a comparison of the magnitude observable for the whole S'C and the magnitudes of fragments. The statistical researches, allow us to assume, that the average magnitude of the whole satellite, is near to 13^m, and magnitude of a fragment is 18^m. Proceeding from statistical estimations of the dispersion of readout (at use of a mode of the account photons, for example) it is not easy to show, that for detection of a fragment with the characteristic area about 1 m^2 from the whole geostationary satellite, the accuracy of photometric measurements should be not worse than 0.01 value. There are also other arguments, indicating necessity of the achievement of high photometric accuracy for an estimation of a technical condition S'C and detection of the attributes of its partial destruction.

Achievement of accuracy of the order 1 % is a rather difficult task, even in usual astrophysical practice. It is obvious, that the achievement of such meanings of accuracy at observation of the mobile S'C, is an even more difficult task.

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