ON CONDUCTION OF THE ORBITS OF ARTIFICIAL SATELLITES

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ABSTRACT. Two-channel photoelectric photometer was made in 1971 in the Uzhgorod State University, which was intended for calculating of brightness of low-orbital satellites. And from that time the observations for satellites in the integral light were regularly conducted on it.

In 1989 new two-channel photoelectric photometer, working in the system B,V Johnson-Morgan, was made.

Large experimental material was collected, the light-curves of 154 satellites during about 2500 observations were obtained. In particular, by 790 observations of 46 satellites, the periods of visible change of the brightness of the objects were calculated. The maximal accuracy of the determination of the period was 0.001-0.003 second for the object 86061.

The light-curves of satellites were use for solutions of different tasks. They may be given consumers who are interested.

Key words: Artificial satellites, photoelectric photometer, light curve, visible period of rotation

Having results of electrophotometry of artificial celestial bodies (ACB) one cane solve the task of applied and fundamental characters (Venkateswaran et al., 1962; Emmons et al., 1967; Vanderburgh and Kissell, 1971; MeGue et al., 1971; Kissell, 1974, Vovchik and Fedoriv R.F., 1976).

Taking into account the perspective of the method, employees of the astronomical laboratory of Odessa University and of the laboratory of cosmic studies (LCS) of Uzhgorod University in 1971 worked out and produced a two-channel photometer for the photometry of low perigee satellites (Bratiychuk et al., 1974). The electrophotometer, that works in the regime of intensifying direct current has been a reliable device for obtaining photometric information for almost ten years.

A complete set of devices for ensuring electrophotometric observations of the ACB in the regime of photon counting was worked out at the LCS in 1980. The complex allows to change the time of signal storage from 10 sec to 0.04 sec (Bratiychuk et al., 1982). Both electrophotometers have as then basis an objective-glass MTO-1000 (F=1m, Def=8.6cm). The penetrating capacity of both electrophotometers is 9m. The error of measuring the brightness of bright objects (2m - 4m) is 0.03m, of weak - (8m - 9m) is 0.1m - 0.2m. With the help of these electrophotometers about to thousand of qualitative light curves for about one hundred different satellites have been obtained.

A two-color B,V electrophotometer was worked out and put into operation in the LCS in 1989. This new device was built upon the basis of the operation electrophotometer working in the pulse regime. Such on approach allowed to transfer from measurements in the integral light to measurements in the B,V bands depending on the tasks. It is guaranteed with the peculiarities of the optic-mechanical construction of the device. The bands of passing B,V are realized with glass light filters. The effective lengths of the instrumental system of the colorimeter are close to the standard Johnson-Morgan system ($\lambda_{ef,B}$=4337 Å, $\delta\lambda$=875 Å; $\lambda_{ef,V}$=5504 Å, $\delta\lambda$=750 Å).

Beginning with 1989, 256 light curves in bands B,V for 31 satellites were obtained. We have scores and even hundreds of light curves some objects together with the previously obtained ones in the integral light. Analyzing these materials, the employees of the LCS have carried out the studies of the rotating of some objects around their mass centers; they have defined the orientation of axes of rotation; some other tasks have been solved too. Known and newly worked methods have been applied (Bratiychuk et al., 1980, 1987, 1986, 1983; Epishev et al., 1983).

Periodic changes of brightness have been discovered at the majority of the obtained light curves. The visible periods changes brightness of the objects have been computed. The period of brightness changes for 790 passings of 46 different satellites have been defined in this way.

For some satellites, that have been observed for a long time, the tendency changes periods of brightness is evident. The data about the objects with the increase of period within the time is evident are given in Table 1. The periods of changes brightness are given for the start and the end interval of the observations.

It should be noted that the length of the light curve of the satellite according to which we define the value of the period T is up to 10 - 15 minutes, and often the very period is significantly less than this interval of time. In such cases some periods have been computed according to one light curves; these periods provided the average value and its error. It is obvious that the larger the relation of the length of one light curve to the average value of T, the more precise is the definition of the very period.

The results of Table 1 witness the braking of rotation of the objects that have ended their active existence. It is well seen with the objects 73108, 74029, 74032; the time periods of them have changed radically. These objects are cylinder-shaped, and in the reflected light diffusive component prevails. The character of the changes the periods of its brightness testify to the fact that the rockets - carriers within the time of their orbit - existence take a position that leads to minimal loss of kinetic energy. The latter occurs when during one period of the satellite rotation round the Earth there occurs one rotation of the satellite round its own mass center.

The accuracy of computing of the visible periods changes of brightness is also defined by the characters of the satellite surface reflection. When there are flat mirror elements construction the accuracy of computing of the visible periods changes of brightness is much higher than in the case of the sun light diffusion dispersion. The maximum accuracy, thousandth parts of second, is achieved for objects 84065.03 and 86061.01.

Oscillation of the values periods relative to the average value at the large interval of observation have been noted for some satellites. This is illustrated in Table 2 for object 84065.03.

The light curves are used for solving various tasks. They can be transformed to the organizations that have interest in them.

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Table 1. The increase of the brightness change periods with time

N	N of the objects	Interval of observations start end	Starting and final values of the period in the given time interval T(sec)	Average error the defining the brightness change periods σ_T (sec)
1	63053	1974.03.20-1980.06.13	10.40 - 16.10	0.20
2	68092	1978.04.24-1978.08.02	1.00 - 2.50	0.10
3	70047	1978.03.07-1982.05.28	7.00 - 55.00	0.21
4	71059	1979.08.08-1980.05.20	30.00 - 49.00	1.00
5	72066	1976.03.23-1976.09.14	35.00 - 39.00	0.60
6	73108	1976.03.23-1982.06.08	31.00 - 135.00	0.80
7	74029	1976.04.29-1982.06.02	25.60 - 117.00	0.64
8	74032	1976.03.23-1983.08.27	25.00 - 86.00	0.57
9	79003.02	1986.02.26-1986.05.07	32.78 - 41.00	0.25
10	85097.02	1986.09.04-1987.05.04	13.50 - 63.00	0.26
11	86061.01	1986.11.28-1992.03.19	1.493 - 1.625	0.002

Table 2. Results of defining the brightness change periods for the object 84065.03 (the time of signal storage $\Delta t = 0.1$ sec).

N	: D a t e	Interval of observation	T(sec)	σ_T (sec)
1	1986.05.05	20 50 40.3 - 20 51 48.5	1.206	0.003
2	1986.05.06	21 30 21.6 - 21 32 37.8	1.207	0.001
3	1986.05.07	20 32 12.5 - 20 34 41.2	1.207	0.001
4	1986.05.08	21 13 13.3 - 21 15 25.2	1.208	0.001
5	1986.05.13	21 20 12.5 - 21 22 30.0	1.194	0.001
6	1986.05.21	20 11 58.8 - 20 13 28.3	1.200	0.002
7	1986.09.02	18 19 57.8 - 18 21 44.6	1.202	0.001
8	1986.09.12	18 31 36.4 - 18 33 17.2	1.192	0.001
9	1986.09.16	19 35 48.7 - 19 37 11.4	1.196	0.002
10	1986.09.19	18 18 50.5 - 18 22 59.1	1.199	0.001
11	1986.09.25	19 06 41.8 - 19 08 49.7	1.205	0.001
12	1986.10.01	18 14 10.1 - 18 17 23.6	1.191	0.001
13	1987.01.03	16 08 53.3 - 16 09 50.6	1.195	0.002
14	1987.02.24	03 14 55.6 - 03 19 02.3	1.210	0.001
15	1987.02.25	02 19 02.1 - 02 20 09.6	1.202	0.002
16	1987.02.27	02 38 55.9 - 02 42 00.4	1.191	0.001
17	1987.03.02	02 24 34.5 - 02 26 02.6	1.193	0.002
18	1987.06.12	00 42 03.1 - 00 43 41.4	1.196	0.001
	The average value of the periods		1.200	0.001

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