EXPERIMENTAL CONFIRMATION OF THE EXACTNESS OF ORBITAL ARTIFICIAL NEAR–EARTH OBJECTS "SICH–1" MEASURINGS WITH OPTICAL INSTRUMENTS BY ASTRONOMICAL OBSERVATORIES OF UKRAINE

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ABSTRACT. In the article it is shown, that by photographic cameras AUF-75 with a consequent astrometric reduction of images artificial celestial bodies it is possible to make on observations from one item to calculate orbit of the satellite "Sich–1". A method to receive some orbit elements during the short time interval is present. Observations from three items will enable to update elements of orbit. The accuracy of calculation of orbits of the satellite makes up 10–20 meters.

Key words: artificial space objects, photographic camera, astrometric processing, orbit.

The artificial space objects differ from traditional objects in astronomy, therefore special equipment, and also special methods of astrometric processing are necessary for their observations.

The observations artificial celestial bodies (ACB) at different heights above the Earth's surface are necessary for a solution of many practical problems, and it means necessity of observation of the satellites of various visible stellar magnitudes. Photos of the weaker satellites will receive applying a method of compensation of a velocity of transition of its image on photoemulsion.

Universal semi-automatic camera of the AUF-75 type on the four-axial mounting is such an instrument Camera is devoted to the photographic observations of the active, passive, bright and weak satellites. Camera has the seven-lenses objective of the URAN–16 type with D=210mm, F=735mm. Width of film is 190 mm, rewinding of the film is automatic. The size of photos is 140×200 mm ($10° \times 15°$.). Camera permits object's photographing with the brightness up to 10–11 magnitude in the interval $0.02 - 1°$ per second of the topocentric angular speed.

Main difficulties of photographic observations of artifical Near–Earth objects 500 km/s $< H <$ 5000 km/s (Kirichenko, 1970) are:

1. Complexity of simultaneous registration of an exact time and deriving of exact coordinates.

2. For majority of the existing satellites the effective exposure time for fixed camera lies within the limits of the 100-th parts of a second and results that the trace of the weak satellite is impossible on photoemulsion

$$t_{ef.} = d/F \times m,$$

where d – object's image diameter in mm, m – angular velocity concerning a photomaterial in rad/sec, F – focal length of the camera in mm.

The sources of errors, which influence the accuracy of definition of a position ACB, are learned and investigated (Kirichenko, 1970).

The astrometric reduction of negatives with ACB is made by Turner's method making allowances for all features and single-error corrections in a system of the catalogue SAO on epoch 1950.0, i.e. if the photographic observations are obtained, the positions of the satellite on epoch 1950.0 with an accuracy 3" on coordinates and 0.001 seconds of time. For calculation of orbit parameters it is necessary:

1. To reduce the moments of observations in a system of standard time UT1 (using the Report of world time) making allowance for single-error corrections for delay of signals of time in camera and equipment of a service of time. For the radioreceiver "Wolna" is recommended to accept the following significance of single–error corrections:

Band	Correction
0.5 kHz	0.001 sec,
1.5 kHz	0.0006 sec

It is necessary to enter into instants in a system UT1 a single-error correction for berration time – space of time, for which light passes a distance from the observer up to the camera: $t = 0.0213 \times R$, where R – distance from the observer up to the satellite.

2. It is necessary to reduce topocentric coordinates obtained on epoch 1950.0 (in systems of the catalogue SAO), on moment of observations (Kirichenko and Klimik, 1985). The program takes into account not only the precession and nutation, but also the daily aberration. The year's aberration is entered by coordinate's

calculation by Turner's method. The accuracy of coordinate's reduction on other epoch makes about 0.001 seconds.

The program allows to enter a single-error correction for a daily aberration for many items, only it is necessary to enter coordinates ϕ and λ for the given item. The items, such as Uzhgorod and Kiev are entered in the program. It is possible to enter lot of items.

If the observations are made in such a manner that the coordinates of the satellite in a horizontal system are obtained, for deriving elements of orbits it is necessary to transfer then in to equatorial coordinates. We compose the program on computer with this purpose. The program works under the following scheme: $A, h \longrightarrow \alpha, \delta \longrightarrow x, y, z, vx, vy, vz \longrightarrow$ elements of orbit.

In this case we have a,d already will be in a system of observations. By results of observations we define space coordinates of the satellite and their modification, i.e. x, y, z, vx, vy, vz , where the coordinate x is directed exactly of vernal equinox, and coordinate z – on the north celestial pole.

$$x = X_0 + R \times \cos\delta \times \cos(\alpha - S),$$

$$y = Y_0 + R \times \cos\delta \times \sin(\alpha - S),$$

$$z = Z_0 + R \times \sin\delta$$

Where X_0, Y_0, Z_0 – are coordinates of items in a system of the Standard Earth III (Lunquist and Weiss, 1969), R – topocentric distance, S – local stellar time.

As it is visible from the formula, it is necessary to know a distance, which can be obtained by laser or photographic observations. The coordinate x can be directed to a Greenwich meridian, then it is necessary to replace S on $s = S - \lambda$ (λ – longitude of item of observations).

According to observations from other items of Ukraine, where there are photographic cameras "AUF-75" or other equipment, which gives the accuracy of a Near–Earth object position up to 5", it is possible to update the calculated elements of orbit and ephemerides.

Thus, using the above-stated programs, and also actual observation's results, it is possible to improve elements of orbit for the object "Sich–1" upto $10 - 20m$ even on observations from one station.

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