

# ELABORATION OF THE BATCH OF THE PROGRAMS FOR CELESTIAL MECHANICS FOR THE COMPUTATION OF THE ASTRONOMICAL EPHEMERIS

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**ABSTRACT.** The batch of the programs for celestial mechanics are elaborated in order to obtain the ephemeris of the Sun, the Moon, the planets and their satellites, the asteroids, the comets, the binary stars, the variables stars, determination of the conditions of the visibility these the celestial bodies at any point of the surface of the Earth, as well as predict the astronomical phenomena's at the celestial sphere and their circumstances.

**Key words:** Batch of the programs for the astronomical ephemeris.

## 1. Introduction

Author from 1991 elaborates the batch of the programs by celestial mechanics. The batch are created in order to obtain the ephemeris of the Sun, the Moon, the planets and their satellites, the asteroids, the comets, the binary stars, the variables stars. The programs of the batch permit determine of the conditions of the visibility these the celestial bodies in the any point of the surface of the Earth, as well as predict of the astronomical phenomena's at the celestial sphere and their circumstances as for the Earth on the whole also for given point Earth's surface.

## 2. Description of the batch of the programs

### 2.1. Possibility of the batch of the programs

When calculation of the ephemeris of the celestial bodies have primary meaning spare to informatively of the programs. The high informatively of the programs of the given batch permit comprehend the great variety of the astronomical phenomena's by ephemerid, universal, zonal and legal time of the any station.

The results of calculations take out as the form of the tables also in the form graphic. The ephemeris of the Sun, the Moon the major planets, as well as the circumstances of the astronomical phenomena's for these the celestial bodies are determine at the temporal

interval about 5000 years in the past and the future. Also have possibility determine the physical ephemeris of the Sun, the Moon, and the major planets.

The database of the batch contains the orbital elements of the 50 bright asteroids and 100 comets. The coordinates of the 1500 stars, are contains in the database of the batch, permit to get the star catalogue and the celestial map for any epoch at the temporal interval about 30000 years in the past and the future. At the celestial map show the geocentric and the topocentric positions of the Sun, the Moon and the planets on the given moment of the time, as well as the visible roads of the their motion. There are represent the phases of the Moon and the planets, the pictures of the solar and lunar eclipses. There are draw the geographic maps of the zones of the visible of the solar and lunar eclipses, the occultations of stars and planets by the Moon, the occultations of stars by the planets, the transits of planets on the disk of the Sun. There are show the pictures of the schemes of the motion of the objects for the lunar eclipses, the transits of planets on the disk of the Sun and the systems of the satellites of the planets.

All programs of the given batch are writes at the algorithmic language Quick Basic, working in the operation system MS-DOS and have the commons resources: the commons library subroutines and the commons database.

### 2.2 The apply methods

At the programs for determination of the position of the Sun, the Moon and the major planets, the asteroids and the comets are apply methods, are describe in the (Meeus, 1988). The position of the Pluto is determinate by the method, is describe in the (Montenbruk, Pflieger, 1993). The main perturbations for the positions of the Sun, the Mercury, the Venus, and the Mars are complete in the (Montenbruk, Pflieger, 1993), for the positions of the planets-giants - in the (Gaillot, 1904; 1910; 1913), for the position of the Moon - in the (Montenbruk, Pflieger, 1993; Ed. Duboshin, 1976).

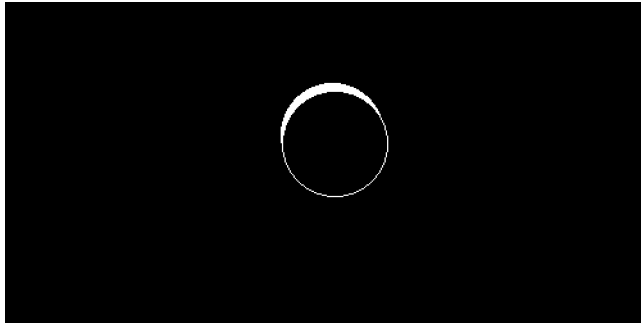


Figure 1: The solar eclipse on 11 August 1999 at 11<sup>h</sup>12<sup>m</sup> UT, visible in Odessa

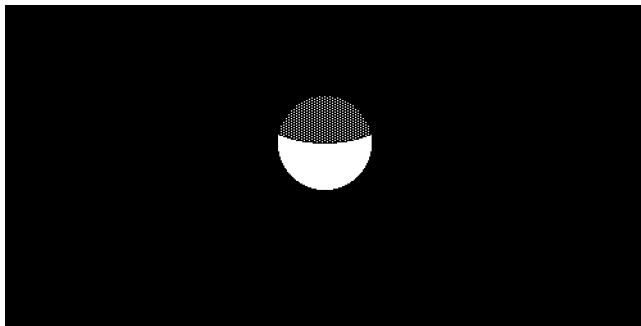


Figure 2: The lunar eclipse on 5 July 2001 at 14<sup>h</sup>55<sup>m</sup> UT

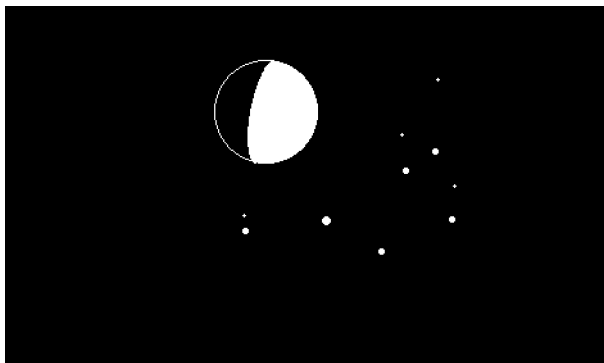


Figure 3: The Moon on 4 February 1990 at 0<sup>h</sup>00<sup>m</sup> UT, visible in Odessa

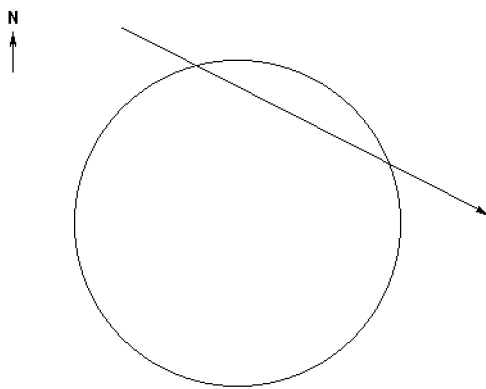


Figure 4: The transit of Mercury on the disk of the Sun on 7 May 2003

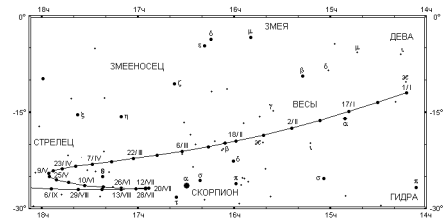


Figure 5: The visible road of the Mars from January to August 2001

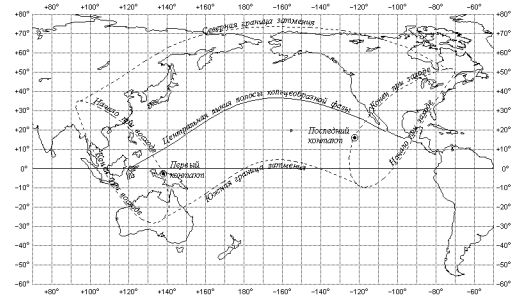


Figure 6: The map of the visible of the solar eclipse on 11 June 2002

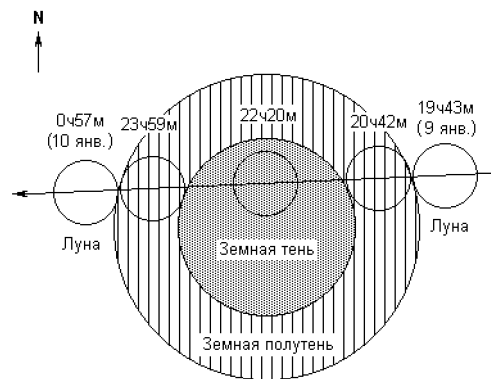


Figure 7: The visible road of the Moon on the eclipse 9 January 2001

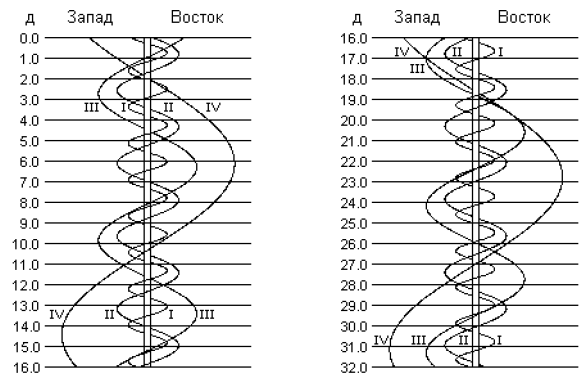


Figure 8: The configuration of Galilean satellites of Jupiter on January 2001

Запад

Восток

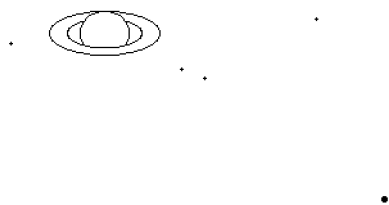


Figure 9: The satellites of Saturn on 6 February 2001 at 0<sup>h</sup>00<sup>m</sup> UT

The physical coordinates of the Sun, the Moon and the major planets are determined by method (Abalakin, 1979; Ed. Abalakin, 1989-1997). The longitude of the central meridian of the illuminated part of the visible disks of the planets is calculated by the exact formulas (Mikhalchuk, 2001). The circumstances of the solar and lunar eclipses, occultations and the transits of planets on the disk of the Sun are determined by methods (Mikhailov, 1954). The mean and the visible places of the stars are determined by methods (Ed. Abalakin, 1989-1997). For determination of the moments of the phases of the Moon, as well as the positions of the planet's satellites and phenomena's in the systems of the planet's satellites are apply methods, are elaborated by author.

### 2.3 The accuracy of the output information

The accuracy of the information, which output by the programs, is equally: for the moments of the time 1 min.; for the coordinates of the points of the Earth's surface 0.1°; for the heliocentric and the geocentric ecliptic coordinates 0.1°; for the distances 0.001 AU; for the heliocentric and the geocentric equatorial coordinates of the Sun 0.1<sup>s</sup> by the right ascension and 1'' by the declination; for the geocentric and the topocentric equatorial coordinates of the Moon, the planets, the asteroids and the comets 1<sup>s</sup> by the right ascension and 0.1' by the declination, for the physical coordinates of the Sun, the Moon, and the planets 0.1°. Equatorial coordinates of the mean and the visible places of the stars are outputted with the accuracy to 0.1<sup>s</sup> by the right ascension and 1'' by the declination.

All celestial coordinates of the Sun, the Moon, and the major planets are reference to the mean equinox of the date. The coordinates of the Pluto, the asteroids, the comets and the stars are can reference both to the mean equinox of the date and to any standard equinox.

### 2.4 The composition of the batch of the programs

In the composition of the considered batch come in the following programs:

EPHEMECL - calculation of the ephemeris of the Sun, the Moon and the major planets (the heliocentric and the geocentric ecliptic coordinates, the geocentric and the topocentric equatorial coordinates, the conditions of the visibility in the any point of the surface of the Earth (the information about the rises, the settings and the culminations of the celestial objects and about the duration their visibility), the visible diameter, the phase, the magnitude), the physical coordinates of the Sun, the Moon and the major planets, the moments of the transits of the main points of the orbits of the Earth, the Moon and the major planets, the moments of the conjunctions of planets with the Moon and with each other, the phases of the Moon, the configurations of the planets, the circumstances of the solar and lunar eclipses, occultations of planets by the Moon, the transits of planets on the disk of the Sun as for the Earth on the whole also for given point Earth's surface, the positions of the satellites of the Jupiter and the Saturn;

ASTERCOM - calculation of the ephemeris of the Sun, the Moon, the major planets, the asteroids and the comets (the heliocentric and the geocentric ecliptic coordinates, the geocentric and the topocentric equatorial coordinates, the conditions of the visibility in the any point of the surface of the Earth, the magnitudes, the visible diameters of the Sun, the Moon, the major planets and the asteroids), the moments of the beginning and the end of the twilights, the moments of the transits of the main points of the orbits of the Earth, the major planets, the asteroids and the comets, the configurations of the major planets, the asteroids and the comets;

STARS - determination of the mean and the visible places of the stars, the conditions of the visibility of the stars in the any point of the surface of the Earth, the moments of the conjunctions of the Moon and the planets with the stars, the circumstances of the occultations of stars by the Moon and the planets, the construction of the celestial maps;

SATELLIT - determination of the positions of the satellites of the planets (Galilean satellites of Jupiter and 6 the most bright satellites of Saturn), the configurations of the satellites, the phenomenon's in the systems of the satellites of the planets, as well as calculation of the ephemeris of the Sun, the Moon and the major planets;

BINSTAR - calculation of the ephemeris of the visual binary stars;

VARSTAR - determination of the moments of the maximums (minimums) of the brightness of the periodic variable stars;

MAPS - construction in the various projections of the geographic maps of the zones of the visibility of the solar and lunar eclipses, occultations of stars and planets by the Moon, occultations of stars by the planets, the transits of planets on the disk of the Sun;

ELORB - determination of the elements of the orbits

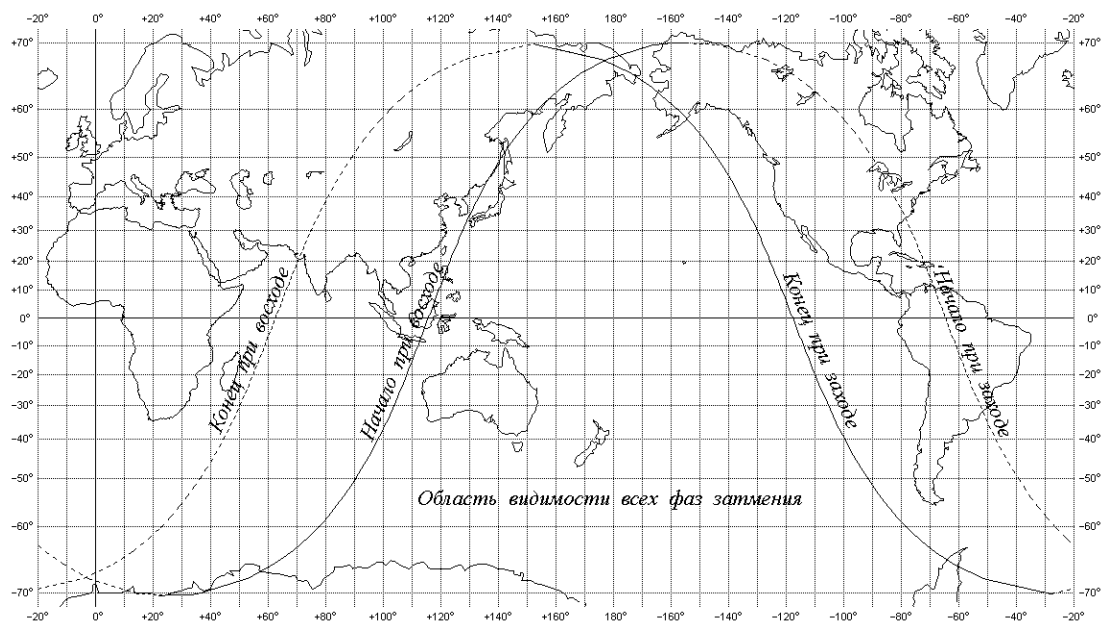


Figure 10: The map of the visible of the lunar eclipse 26 May 2002

by 3 points;

HORIZON - calculation of the correction for geographic latitude to the moments of the rising and the setting of the celestial bodies, as well as to the azimuths and the hour angles of the points of their rising and setting.

### 3. Conclusion

The results, are give by this batch of the programs, was permit the author do begin the annual issue of the collection of the scientific-popular articles "The Odessa Astronomical Calendar" (OAC) from 2000 in common with the Astronomical Observatory of the Odessa National University. These results are publication in the main part of the OAC and are intended for the amateurs of astronomy and the professional workers of southern locale of Ukraine.

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