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Solar Eclipse of 29 April 1976 and the Difference Between ET and UT

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From the observation of the partial solar eclipse of 29 April 1976 the difference between the Ephemeris Time and the Universal Time has been determined.

На основании фотографического наблюдения частного солнечного затмения 29 апреля 1976 г. получена поправка эфеверидного времени.

Z fotografického pozorování částečného zatmění Slunce 29. dubna 1976 byla určena korekce efemeridového času.

The annular eclipse of the Sun of 29 April 1976 was observed photographically as a partial one in the Department of Astronomy and Astrophysics, Prague ($\lambda = -0^h57^m34.88^s$, $\varphi = +50°04'36.0''$, $h = 267$ m). The observation conditions were not too favourable as it was cloudy almost during the whole eclipse. Nevertheless, it was possible to obtain 34 pictures of the eclipsed Sun after the first contact and 18 pictures before the last contact (Table 1.).

Table 1.

Contact	Number of pictures	Period of observation (UT)
First	34	$9^h08^m30^s$ – $9^h17^m00^s$
Last	18	$11^h54^m00^s$ – $12^h00^m00^s$

The photographs were exposed by an automatic heliograph with a 75 mm objective ($f = 500$ mm). The exposure times of all the pictures were 1/500 sec on 35 mm Foma Document Ortho film. The quartz clock TKH 1 continually checked with an atomic clock Hewlett-Packard was used as time standard. The lengths of the chords of the eclipsed Sun on the negatives were measured on an Abbe comparator.

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The times of the first and the last contacts were computed using the well-known equation

$$c^2 = a(T - t) - b\,(T - t)^2$$

where c is the length of the chord of the eclipsed Sun at the time t, a and b are constants and T is the time of the first (or last) contact.

For the determination of the time of contacts T the least squares method was used and the computations were carried out on the Minsk-22 computer. This computer was also used for the computation of the theoretical values of the contacts from the Besselian elements of the eclipse. The results are summarized in Table 2.

Table 2.

Contact	T_{obs}(UTC)	$T_{c(I)}$(ET)	$T_{c(II)}$(ET)
First	$9^h08^m48.37^s \pm 0.69^s$	$9^h09^m35.63^s$	$9^h09^m36.62^s$
Last	$12^h01^m05.02^s \pm 0.84^s$	$12^h01^m52.13^s$	$12^h01^m50.54^s$

The times $T_{c(I)}$ were computed using the Besselian elements published in the Astronomical Ephemeris [1], the times $T_{c(II)}$ from the elements published in the Astronomicheskiy Ezhegodnik [4]. The differences between $T_{c(I)}$ and $T_{c(II)}$ are caused by differences in the two systems of Besselian elements. In both of the Ephemerides the lunar ephemeris designated by the serial number $j = 2$ is published, but in the Astronomical Ephemeris the correction of $-0.6''$ was applied to the tabular latitude of the Moon. This correction in the form of corrections to the right ascension and declination of the Moon is for 29 April 1976 [2]

$$\Delta\alpha = +0.013^s \qquad \Delta\delta = -0.57''.$$

The values of Table 2 yield the differences ΔT(C) between the Ephemeris Time and the Coordinated Universal Time which are summarized in Table 3.

Table 3.

$T(C)$	First contact	Last contact	Mean
$T(C)_I$	$+47.26^s$	$+47.11^s$	$+47.18^s$
$T(C)_{II}$	$+48.25^s$	$+45.52^s$	$+46.88^s$

The index I is used for the system of Besselian elements of Astronomical Ephemeris, the index II for the system of Besselian elements of Astronomicheskiy Ezhegodnik.

From the definition, the Ephemeris Time is

$$ET = TAI + 32.18^s - \Delta UT1$$

where TAI is the International Atomic Time and

$$\Delta UT1 = UT1 - UTC .$$

The interpolated difference between $UT1$ and UTC is for 29 April 1976 [5]

$$\Delta UT1 = UT1 - UTC = +0.36^s.$$

Using this correction and the values of Table 2 the differences

$$\Delta T(1) = UTC + \Delta UT1 - ET$$

summarized in Table 4 were obtained.

Table 4.

$\Delta T(1)$	First contact	Last contact	Mean
$\Delta T(1)_{\mathrm{I}}$	$+46.90^s$	$+46.75^s$	$+46.82^s$
$\Delta T(1)_{\mathrm{II}}$	$+47.89^s$	$+45.16^s$	$+45.52^s$

A first approximation to ΔT, the reduction from Univeral Time to Ephemeris Time, provides the quantity $\Delta T(A)$

$$\Delta T(A) = TAI + 32.18^s - UT1 .$$

The extrapolated theoretical value of $\Delta T(A)$ is for 29 April 1976 $\Delta T(A) = +47.1^s$ [3], and $\Delta T(A) = +46.8^s$ [6] respectively. The theoretical values of $\Delta T(A)$ are in good agreement with the mean values of $\Delta T(1)$ determined from the observation, with regard to the mean errors of the observed times of contacts.

In the Astronomicheskiy Ezhegodnik [7] the predicted theoretical values of ΔT

$$\Delta T0 = ET0 - UT2 \qquad (j = 0)$$
$$\Delta T1 = ET1 - UT2 \qquad (j = 1) .$$

are published. The numerical values of these differences for 29 April 1976 are

$$\Delta T0 = +47.53^s$$
$$\Delta T1 = +47.05^s.$$

The interpolated difference between $UT2$ and UTC is for 29 April 1976 [5]

$$UT2 - UTC = +0.39^s.$$

The values of the correction $\Delta T(2) = ET - UT2$ are given in Table 5.

Table 5.

$\Delta T(2)$	First contact	Last contact	Mean
$\Delta T(2)_{\mathrm{I}}$	$+46.87^s$	$+46.72^s$	$+46.80^s$
$\Delta T(2)_{\mathrm{II}}$	$+47.86^s$	$+45.13^s$	$+46.50^s$

The mean values of $\Delta T(2)$ are also, with regard to the mean errors of the observed times of contacts and to the differences between lunar ephemerides designated by the serial numbers $j = 1$ and $j = 2$, in good agreement with the predicted correction $\Delta T1$.

Nevertheless, the system of Besselian elements of the Astronomical Ephemeris seems to be somewhat more accurate than that of the Astronomicheskiy Ezhegodnik. From Tables 3–5 it is evident that the computed times of the first and of the last contacts are in better agreement with the observed times if the Besselian elements published in the Astronomical Ephemeris are used than if use is made of Besselian elements of the Astronomicheskiy Ezhegodnik.

References

[1] The Astronomical Ephemeris for the year 1976, p. 346.
[2] ibid., p. 343.
[3] ibid., p. vii.
[4] Astronomicheskiy Ezhegodnik USSR 1976, p. 550.
[5] V. Přáček: Říše hvězd 57, 140, 158 (1976).
[6] The Astronomical Ephemeris for the year 1977, p. vii.
[7] Astronomicheskiy Ezhegodnik USSR 1977, p. 643.