Publications of the Department of Astronomy — Beograd, № 6, 1976.

NEW OPPOSITION OF THE MINOR PLANET 433 EROS

V. Protić-Benišek

The 1975 Eros opposition occured in January, was one of the more attractive and very rare phenomenon. For the first time since Eros'discovery (Gustav Witt, 1898) this minor planet came as close as 0.15 A. U. to the Earth. That is the smallest distance at which these two planets can approach each other. From the astrometrical aspect, such favorable planets'configuration provide the best means of determining the Solar parallax.

For this and some other purposes, the observations of Eros from Belgrade Observatory were begun on November 10th, 1974 and were continued till April 30th 1975, in an interval of 170 days (observers: M. B. Protitch, V. Protić-Benišek). Altogether 17 photographs were taken, in many different positions. Within these few months of our observations Eros was traveling across the constellations Lynx, Gemini (passing very close to Kappa Geminorum, performing spectacular occultation for the observers inside a very narrow occultation zone over Canada, United States and some other countries) and Hydra. The apparent path which Eros described on the sky was about 70 degrees of arc. Shown here are only some of Eros'precise positions that were calculated on the basis of our observations with Zeiss and Askania astrographs:

		1950.0
1974 Nov.	10.92816 U.T.:	$6^h43^m18^s.056 + 55°08'16''.22$
1975 Feb.	06.84051 U.T.:	7 36 08 .375 + 08 08 19. 54
1975 Apr.	30.82027 U.T.:	9 51 25 .948 — 14 59 35. 85.

The discrepancies ($O - C$) are not considerable but the fact that they exist, requires corrections of Eros orbit. If it will be possible, we shall try to obtain osculating system of elements on the basis of our own observations which cover full 90° of Eros'heliocentric orbit. In that way, we would like to prove the effect of motion of Eros perihelion.

In the meantime we have tried to determine what the value of Solar parallax would be obtained if, the positions derived at two observatories (Belgrade and Uccle) had been used for the moment when Eros was stationary in right ascension. It has to be especially indicated that the aim of such work was to estimate indirectly, once more, the accuracy of our astrographic positions.

The astrographic observations at the Observatory Uccle that have been taken by astronomer Mr. H. Debehogne, were kindly put at our disposal by Dr. J. Dommanget, Chief of II Département d'Astrométrie et Mécanique Céleste, Uccle, whom we express our best gratitude.

Fortunately, on February 6th 1975 Eros was observed at our Observatory nearly at the same time as at Uccle Observatory. Three close exposition were made at intervals of about 20 minutes. Besides, in Uccle Eros was observed several days continually and in the same manner as we have done. So it was possible, by applying rigorous interpolation, to reduce their observations to our times of observations, which differed by about two hours. Because of the nonequidistant intervals between the observations, Newton's method of divided differencies was used (Hildebrand, B. F., 1956) with mean values of right ascension and declination for every night. Consequently, it was obtained for the moment on 1975, February 6.840512 U.T.:

Uccle:	$7^h36^m06\overset{s}{.}932 + 08°08'15\overset{''}{.}07$	Equin. 1950.0
Belgrade:	7 36 08 375 + 08 08 19 54	

On the basis of Eros'elements, geocentric distance has been derived with satisfactory accuracy, namely: $\Delta = 0.1660$ A.U.

In order to determine the value of Solar parallax on the basis of parallactic effect, we started from the following conditions:

$$\begin{aligned}(\alpha_0)_1 + (p\alpha)_1 &= (\alpha_0)_2 + (p\alpha)_2 \\ (\delta_0)_1 + (p\delta)_1 &= (\delta_0)_2 + (p\delta)_2\,,\end{aligned} \tag{1}$$

whereby the positions of object, observed from two observatories at the same moment differ only by the amount of parallactic effect.

Putting into (1) the corresponding expressions for that effect (Newcomb, S., 1960) and solving this system of equations, where $\pi_\odot$ is unknown, we obtain the following relations:

$$\begin{aligned}\pi_{\odot\alpha} &= \Delta\,\frac{(\alpha_2-\alpha_1)_0}{A_1\sin\tau_1\sec\delta - A_2\sin\tau_2\sec\delta_2} \\ \pi_{\odot\delta} &= \Delta\,\frac{(\delta_2-\delta_1)_0\sin\gamma_1\sin\gamma_2}{B_1\sin(\gamma-\delta)_1\sin\gamma_2 - B_2\sin(\gamma-\delta)_2\sin\gamma_1}\,.\end{aligned} \tag{2}$$

in wich:

$$A_i = \rho_i\cos\varphi_i',\quad B_i = \varphi_i\sin\varphi_i',\quad (\mathrm{i}:\ 1,\ 2) \tag{3}$$

and where Δ, τ_i, and γ_i denote, respectively, geocentric distance of planet, hour-angle and angle defined by the expression:

$$\operatorname{tg}\gamma = \operatorname{tg}\varphi'\sec\tau, \tag{4}$$

at the instant of observation.

Substituting in the relations (1) the values from (3) and (4) and other data, the following values of Solar paralləx were found:

$$\pi_{\odot\alpha} = 8''.79\,, \qquad \pi_{\odot\delta} = 8''.80\,,$$

and, as the mean value was obtained:

$$\pi_{\odot} = 8''.795\,.$$

This value is in good accordance with the one adopted as a fundamental constant by IAU (Supplement to the A.E. 1968), and also with the value determined on the basis of radar mesurements of planetary distances ($\pi_{\odot} = 8''.794$).

The plates were mesured on the „Zeiss" measuring machine by M. B. Protitch. The calculations were carried out at „Wang 2200" in the Computing Centre of Belgrade Observatory. The computer program for reductions was prepared by the author.

The author are taking the occasion to express her gratitude to colleagues: V. Radogostić-Sekulović, M. Mijatov and M. Kuzmanoski for their advice in preparing the program of computation. Author expresses also her obligation to M. B. Protitch for many usefull counsels and comments which contributed to this work being carried out successfully.

Belgrade, 24th Aug. 1975

REFERENCES

Newcomb, S., 1960, A compendium of Spherical Astronomy, Dover Publication Inc., New York.

Hildebrand, B. F., 1956, Introduction to Numerical Analysis, New York ....., 1966, Supplement to the A. E. 1968.

Debehogne, H., Observations photographiques de petites planètes effectuées à l'astrographe double de 40 cm de l'Observatoire Royal de Belgique à Uccle au cours du premier semestre 1975 (private).