UNIVERSITY OF CALIFORNIA PUBLICATIONS

ASTRONOMY

LICK OBSERVATORY BULLETIN

NUMBER 444

EPHEMERIS OF PLUTO FOR 1932-33—FOURTH PAPER

By

ERNEST CLARE BOWER

The ephemeris of *Pluto*, given below, is from Orbit XIX¹ and includes the perturbations by the four major planets. Though the residuals remain small it is planned to correct the orbit on the basis of all available material and publish the results in full in a later paper.

Because photographic observers of *Pluto* take their comparison stars from the astrographic catalogue, their observations are referred to the equinox of 1900. The ephemeris is also given for the equinox of 1900, and hence it is evident that the computation of precession to another equinox becomes entirely unnecessary. The $\cos\delta\Delta\alpha$ and $\Delta\delta$ of visual observations can very simply be transferred to 1900 without special tables.²

Observers who do not plan to publish their positions referred to 1900 are again kindly requested to send such positions to the writer, who is grateful to those responding to his earlier request.

The constants used in the computation of precession should always be stated. The difference between the Newcomb and the Struve constants accumulates in 35 years to 0".2, a systematic quantity which, though small, should not be introduced unnecessarily.

A plate of the star field occupied by *Pluto* in 1903 was recently secured by the writer with the 36-inch Crossley reflector and sent to Dr. Crommelin for comparison with the Franklin-Adams plate of this region. The object very close to *Pluto*'s position computed from Orbit XIX with perturbations proves to be a star. No additional precovery observations are known.

Because the early positions will have great weight in the determination of the orbit for many years, it seems worth while to obtain these positions as accurately as possible. The following procedure, suggested by Dr. Lampland, the writer, and others, will practically elimi-

nate coma and guiding error. Let *Pluto* and at least six well distributed "step" stars of about the same brightness as *Pluto* be measured; let a check plate of the region be taken so that good images of the step stars are central thereon; and let them be measured on the check plate with at least six astrographic comparison stars. If the reduction is by Wilson's method, the constants of the check plate are found that produce the equivalent astrographic coordinates of the step stars; then these in turn yield the constants of the *Pluto* plate that produce *Pluto*'s equivalent astrographic coordinates. The work involved is less than doubled, and the resulting positions are entitled to far greater weight.

ADDITIONAL NOTE ON THE MASS OF PLUTO

Pluto's mass is too small to be found gravitationally with any degree of confidence from the residuals yet available of any planet. In addition to the method of finding the mass from certain assumptions of its albedo and density,¹ the following argument merits consideration. If *Triton*, the satellite of *Neptune*, were removed from 30 A. U. to *Pluto*'s distance, 40 A. U., the visual magnitude would increase 0.7, from 13.5, to about 14.2, which is just that found for *Pluto*.³ If both bodies have about the same albedo and density, they have, therefore, about the same mass. Now the mass of *Triton* has been preliminarily determined directly from its action on *Neptune* to be 0.06 or 0.09 of the Earth's mass, depending upon the weighting of 27 plates.⁴ It is again concluded that, until better evidence is forthcoming, the most probable value of the mass of *Pluto* may be taken to be about 0.1 that of the Earth.

¹ Nicholson and Mayall, *Positions, Orbit, and Mass of Pluto: Ap. J.* **73**, 1-12, 1931.

⁴ Nicholson, van Maanen, and Willis, *A Preliminary Determination of the Mass of Neptune's Satellite: Publ. A.S.P.* **43**, 261, 1931.

¹ Bower, *On the Orbit and Mass of Pluto with an Ephemeris for 1931-32: Lick Obs. Bull.* **15**, 171-8, 1931.

² Bower, *On the Use of 1900 as a Standard Equinox: A. J.* **42**, —, 1932 (in press).

ASTROGRAPHIC* EPHEMERIS, 1932-33

	G.C.T. 1932-33	α (1900.0)	a	b	δ (1900.0)	a	b
Aug	20	114° 5' 11".2			+22° 20' 51".3		
	25	12 19.8	+428".6	-22".8	20 8.3	-43".0	+3".6
	30	19 5.6	405.8	25.4	19 28.9	39.4	4.1
			380.4			35.3	
Sept	4	114 25 26.0	+352.5	-27.9	+22 18 53.6	-30.9	+4.4
	9	31 18.5	322.6	29.9	18 22.7	26.0	4.9
	14	36 41.1	290.8	31.8	17 56.7	20.9	5.1
	19	41 31.9	257.3	33.5	17 35.8	15.5	5.4
	24	45 49.2	222.0	35.3	17 20.3	9.8	5.7
	29	49 31.2	185.0	37.0	17 10.5	-3.8	6.0
Oct	4	114 52 36.2	+146.8	-38.2	+22 17 6.7	+2.4	+6.2
	9	55 3.0	107.8	39.0	17 9.1	8.7	6.3
	14	56 50.8	68.4	39.4	17 17.8	15.0	6.3
	19	57 59.2	+28.3	40.1	17 32.8	21.4	6.4
	24	58 27.5	-11.9	40.2	17 54.2	27.8	6.4
	29	58 15.6	52.2	40.3	18 22.0	34.2	6.4
Nov	3	114 57 23.4	-91.8	-39.6	+22 18 56.2	+40.3	+6.1
	8	55 51.6	130.3	38.5	19 36.5	46.2	5.9
	13	53 41.3	167.5	37.2	20 22.7	51.9	5.7
	18	50 53.8	203.5	36.0	21 14.6	57.3	5.4
	23	47 30.3	237.8	34.3	22 11.9	62.2	4.9
	28	43 32.5	269.8	32.0	23 14.1	66.9	4.7
Dec	3	114 39 2.7	-299.1	-29.3	+22 24 21.0	+70.8	+3.9
	8	34 3.6	325.6	26.5	25 31.8	74.4	3.6
	13	28 38.0	348.9	23.3	26 46.2	77.2	2.8
	18	22 49.1	369.2	20.3	28 3.4	79.7	2.5
	23	16 39.9	386.1	16.9	29 23.1	81.4	1.7
	28	10 13.8	399.1	13.0	30 44.5	82.5	1.1
Jan	2	114 3 34.7	-408.0	-8.9	+22 32 7.0	+83.0	+0.5
	7	113 56 46.7	412.9	4.9	33 30.0	82.8	-0.2
	12	49 53.8	414.1	-1.2	34 52.8	82.0	0.8
	17	42 59.7	411.3	+2.8	36 14.8	80.6	1.4
	22	36 8.4	404.6	6.7	37 35.4	78.6	2.0
	27	29 23.8	393.7	10.9	38 54.0	76.1	2.5
Feb	1	113 22 50.1	-378.9	+14.8	+22 40 10.1	+73.0	-3.1
	6	16 31.2	360.7	18.2	41 23.1	69.4	3.6
	11	10 30.5	339.1	21.6	42 32.5	65.4	4.0
	16	113 4 51.4	314.5	24.6	43 37.9	61.1	4.3
	21	112 59 36.9	286.7	27.8	44 39.0	56.3	4.8
	26	54 50.2	-256.2	+30.5	+22 45 35.3	+51.2	-5.1

* The observed astrographic position, corrected for parallax and "constant" term in the aberration, is to be compared with the ephemeris position interpolated with the observed time. The correction to the ephemeris is about $-0".8$ in α and $-0".3$ in δ .

G.C.T. 1933		α (1900.0)	a	b	δ (1900.0)	a	b
Mar	3	112°50'34"0	-223"2	+33"0	+22°46'26"5	+45"9	-5"3
	8	46 50.8	188.5	34.7	47 12.4	40.4	5.5
	13	43 42.3	152.2	36.3	47 52.8	34.8	5.6
	18	41 10.1	114.5	37.7	48 27.6	29.1	5.7
	23	39 15.6	75.4	39.1	48 56.7	23.1	6.0
	28	38 0.2	-35.6	39.8	49 19.8	17.3	5.8
Apr	2	112 37 24.6	+4.4	+40.0	+22 49 37.1	+11.3	-6.0
	7	37 29.0	44.4	40.0	49 48.4	+5.6	5.7
	12	38 13.4	84.1	39.7	49 54.0	-0.1	5.7
	17	39 37.5	123.4	39.3	49 53.9	5.8	5.7
	22	41 40.9	162.2	38.8	49 48.1	11.3	5.5
	27	44 23.1	199.8	37.6	49 36.8	16.7	5.4
May	2	112 47 42.9	+236.0	+36.2	+22 49 20.1	-21.7	-5.0
	7	51 38.9	270.6	34.6	48 58.4	26.7	5.0
	12	112 56 9.5	303.6	33.0	48 31.7	31.2	4.5
	17	113 1 13.1	334.9	31.3	48 0.5	35.7	4.5
	22	6 48.0	364.2	29.3	47 24.8	39.8	4.1
	27	12 52.2	391.3	27.1	46 45.0	43.6	3.8
June	1	113 19 23.5	+415.7	+24.4	+22 46 1.4	-47.1	-3.5
	6	26 19.2			45 14.3		

Mt. HAMILTON, CALIFORNIA,
May 10, 1932.

Issued August 4, 1932.

OBSERVATIONS OF PLUTO, 1931-32 WITH THE 36-INCH CROSSLEY REFLECTOR

By

ERNEST CLARE BOWER

G.C.T.	α (1900.0)	δ (1900.0)	Nr. Images	Comparison Stars Paris Astr. Cat.	$\Delta\alpha$	O-C $\Delta\delta$
1931 Oct 19.5189	113°32'31"9	+22 6 59.7	2	+22.0736: 39, 242, 41, 42, 46, 60, 61, 64	-0"9	-0"4
Dec 6.4438	113 9 29.5	+22 14 0.4	3	+22.0736: 8, 10, 12, 19, 26, 27, 32, 34	-0.4	-0.4
1932 Jan 9.4473	112 27 12.4	+22 22 30.8	3	+22.0728: 191, 205, 209, 213, 215, 221, 230, 235	-1.0	+0.1
Feb 12.3097	111 43 6.8	+22 30 47.2	3	+22.0728: 91, 100, 106, 109, 124, 126, 131, 132	-1.0	-0.3

These are uncorrected for parallax and the "constant" term in the aberration. The residuals are from Orbit XIX with perturbations.¹

The greatest source of error of large scale plates is usually the inaccuracies of star places. Hence many

comparison stars were used, in a single reduction by Wilson's method. Relatively few observations reduced with care are more satisfactory than many less accurately treated.

¹ Bower, *On the Orbit and Mass of Pluto with an Ephemeris for 1931-32: Lick Obs. Bull.* 15, 171-8, 1931.

Mt. HAMILTON, CALIFORNIA
May 1, 1932.

Issued August 4, 1932.