34. A NON-NEWTONIAN ORBIT FOR PERIODIC COMET BORRELLY

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Abstract. A non-Newtonian orbit has been determined for P/Borrelly which successfully represents all eight apparitions. Although this comet has a substantial secular acceleration in its mean motion, the transverse nongravitational force is time independent over the 64-yr observed interval.

Alphonse Borrelly discovered the comet that bears his name at Marseilles in December 1904. P/Borrelly has been observed at eight apparitions and missed at its returns in 1939 and 1946. Using Newtonian equations of motion, Marsden (1968) noted a secular acceleration in the motion of this comet approximately equal to 0.05 day per (period)^2.

The computational procedure used in the present work is similar to that employed by the author in his investigation of P/Giacobini-Zinner (Yeomans, 1972). Three nongravitational terms were added to the standard Newtonian equations of motion and the differential correction yielded solutions for selected nongravitational parameters as well as the osculating orbital elements.

Table I displays the various successful non-Newtonian orbits for P/Borrelly. For each orbit, the observed interval is given above the epoch of osculation, and the mean residual is placed above the number of observations employed in the differential correction. The given nongravitational parameters are a result of the differential correction, and the units of acceleration are AU per (40 ephemeris days)^2. Orbit

TABLE I
Nongravitational parameters for P/Borrelly

Orbit	Interval Epoch	Mean resid. Obs.	$A_1 \times 10^5$	$A_2 \times 10^6$	B_2
1	1918–54 18 July 26.0	1″32 70	$+0.6375 \pm 0.1195$	-2.5211 ± 0.0160	
2	1954–68 53 May 23.0	1.00 20	$+0.7941 \pm 0.5357$	-2.9600 ± 0.0126	
3	1918–68 18 July 26.0	1.23 76	$+1.0876 \pm 0.0638$	-2.6022 ± 0.0062	
4	1918–68 18 July 26.0	1.21 76	$+1.0477 \pm 0.0630$	-2.5374 ± 0.0164	-0.0327 ± 0.0084
5	1904–68 04 Dec. 6.0	1.48 172	$+0.8427 \pm 0.0385$	-2.6470 ± 0.0027	
6	1904–68 04 Dec. 6.0	1.45 172	$+0.8082 \pm 0.0392$	-2.6661 ± 0.0059	$+0.0123 \pm 0.0035$
7	1904–68 04 Dec. 6.0	1.41 164	$+0.8669 \pm 0.0373$	-2.6478 ± 0.0028	

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No. 7 in Table I is considered the best solution over the entire 64-yr observed interval. The mean residual (1″.41) is quite satisfactory and there are no systematic residual trends. As is evident from Table I, there is no indication of a time dependence in the magnitude of the transverse nongravitational term ($B_2 \simeq 0$) over the entire observed interval. Marsden (1969) has pointed out that the nongravitational forces of some, but not all, comets appear to have been enhanced following a close approach to Jupiter. P/Borrelly made a moderately close approach to Jupiter in March 1936

TABLE II

Nongravitational orbit for P/Borrelly

Epoch (ET)	1904 Dec. 6.0
T (ET)	1905 Jan. 17.29547 ± 0.00023 (p.e.)
e	0.6152593 ± 0.0000002
q (AU)	1.3953626 ± 0.0000006
☊ (1950.0)	77°.38168 ± 0.00004
ω (1950.0)	352°.35243 ± 0.00015
i (1950.0)	30°.48415 ± 0.00003
$A_1 \times 10^5$	+0.8669 ± 0.0373
$A_2 \times 10^6$	−2.6478 ± 0.0028

TABLE III

Osculating elements for epochs near passages through perihelion

1905 Jan. 15.0	1911 Dec. 10.0	1918 Nov. 23.0	1925 Oct. 17.0
1905 Jan. 17.29511	1911 Dec. 18.49032	1918 Nov. 17.09841	1925 Oct. 7.52656
0.6152297	0.6140728	0.6150881	0.6164495
1.3953650	1.4026547	1.3957867	1.3881794
77.38117	77.37547	77.37065	77.37869
352.35244	352.37496	352.39845	352.42255
30.48471	30.44170	30.49142	30.51054
1932 Aug. 21.0	1939 June 6.0	1946 June 9.0	1953 June 12.0
1932 Aug. 27.29210	1939 June 8.85191	1946 June 9.44330	1953 June 9.49829
0.6167257	0.6054618	0.6044994	0.6040735
1.3855408	1.4416113	1.4479157	1.4500429
77.30822	76.21477	76.16989	76.17790
352.55089	350.82753	350.93275	350.95574
30.52947	31.09903	31.06621	31.08975
1960 June 15.0	1967 June 19.0		
1960 June 13.24020	1967 June 17.71729		
0.6033964	0.6044628		
1.4541183	1.4465989		
76.19417	76.14186		
350.97387	351.02879		
31.06647	31.11549		

For each set of elements, the consecutive lines represent the osculation epoch, time of perihelion passage (ET), eccentricity, perihelion distance (AU), the longitude of the ascending node, argument of perihelion, and the inclination. The three angular elements are in degrees and are referred to the ecliptic and mean equinox of 1950.0.

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(minimum separation 0.54 AU), but there was apparently no noticeable effect upon the nongravitational forces. In addition, it seems unlikely that there will be any discontinuity in the nongravitational forces when P/Borrelly approaches to within 0.61 AU of Jupiter in 1972.

Table II gives the osculating elements for orbit No. 7 of Table I. This orbit was run forward to provide the osculating elements given in Table III for various epochs.

References

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