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NOTE ON BRADY'S HYPOTHETICAL TRANS-PLUTONIAN PLANET

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It is shown that a planet having the mass and orbital elements derived by Brady from the residuals in the times of perihelion passage of Halley's comet will affect the motions of the five planets Jupiter–Pluto to a degree that is completely incompatible with the observations. Furthermore, careful reexamination of plates obtained during the Lowell Proper-Motion Survey does not reveal a planetary object anywhere near the position predicted by Brady and brighter than magnitude $16^{m}5$. It is concluded that the anomalous motion of Halley's comet has some other cause.

Key words: comet — Halley's comet — planet — trans-Plutonian

Brady (1972) has attempted to reduce the residuals in the times of perihelion passage of Halley's comet and other long-period comets through the introduction of a hypothetical trans-Plutonian planet of mass only slightly less than that of Jupiter and moving in a nearly circular, but highly inclined ($i = 120°$) orbit at 60 a.u. from the sun. He acknowledges that the motions of many comets, of both long and short period, are affected by "nongravitational forces" and that the perturbations by this distant planet obviously will not explain the anomalies in the motions of typical short-period comets with their aphelion distances of some 4–6 a.u. The problem with cometary motions is essentially a secular acceleration; the observed delay of about four days at each return of P/Halley with a 75-year period is equivalent to a delay of $0^{d}04$ for a comet of period 7.5 years, which is in accord with the observed delays for short-period comets (cf. e.g. Marsden 1968, Table VI). It seems more reasonable to ascribe the anomalies of both short- and long-period comets to the same general causes, rather than to hypothesize a massive planet as the explanation of only long-period comet residuals. In fact, it is shown that the planet does not appear on photographic plates and that the observed motions of the outer planets do not permit such a hypothetical planet.

The motions of the five planets Jupiter–Pluto, as well as of the hypothetical Planet X, have been integrated for an interval of 300 years. The integration was fitted to the observational data as previously specified (Seidelmann 1971). Based on the improved elements, a second integration was performed and again fitted to the observations. The residuals of this final integration are shown in Figures 1–9. It was presumed that the effect of Planet X on the four inner planets would be negligible. Further, no attempt was made to improve the masses of the outer planets to satisfy the effects of the hypothetical planet, for the residuals, particularly in latitude, were judged to be greatly in excess of what could be eliminated by any reasonable mass corrections. Table I gives the sums of the squares of the residuals in longitude and latitude for each of the known outer planets, first for an integration of the known planets only and second with Planet X included as described above.

Since the hypothetical new planet has an orbit that is considerably inclined to the ecliptic, its effect on the latitude of the known planets would be very large. Figures 1–5 show this effect for Jupiter, Saturn, Uranus, Neptune, and Pluto, respectively. Even for Jupiter the residuals are

TABLE I

SUMS OF THE SQUARES OF THE RESIDUALS

	Known Solar System	With Planet X
Jupiter (1913–70)		
Longitude	136.0536	172.5313
Latitude	145.5703	374.6467
Saturn (1913–68)		
Longitude	144.5148	876.2358
Latitude	168.1212	1642.6147
Uranus (1830–1968)		
Longitude	11.3916	13644.3151
Latitude	14.3146	3913.0325
Neptune (1846–1968)		
Longitude	5.4228	2464.3439
Latitude	12.0129	3788.3330
Pluto (1914–68)		
Longitude	46.8153	43.7333
Latitude	42.5415	1298.9459

quite unacceptable, while the changing ordinate-scale (in arc seconds) for the other planets speaks for itself.

The residuals in longitude (also in arc seconds) are shown in Figures 6–9 for Jupiter, Saturn, Uranus, and Neptune, respectively. Since the observations of Pluto cover only about one-fifth of a revolution, there is no detectable systematic effect on the longitude of this planet. It should be further noted that the presence of Planet X causes the residuals in longitude of the 1795 observations of Neptune to increase to 49 arc seconds.

Brady (1972) indicates that if the hypothetical planet has the albedo of Pluto and any reasonable density it will be of 13th or 14th magnitude. On the assumption that the geometrical albedo is 0.13, the density is equal to that of the earth, and the empirical quantity $\ln K$ equals -4.6, the visual mean opposition magnitude, as calculated by Seidelmann (1971), is 11.6. Adopting the

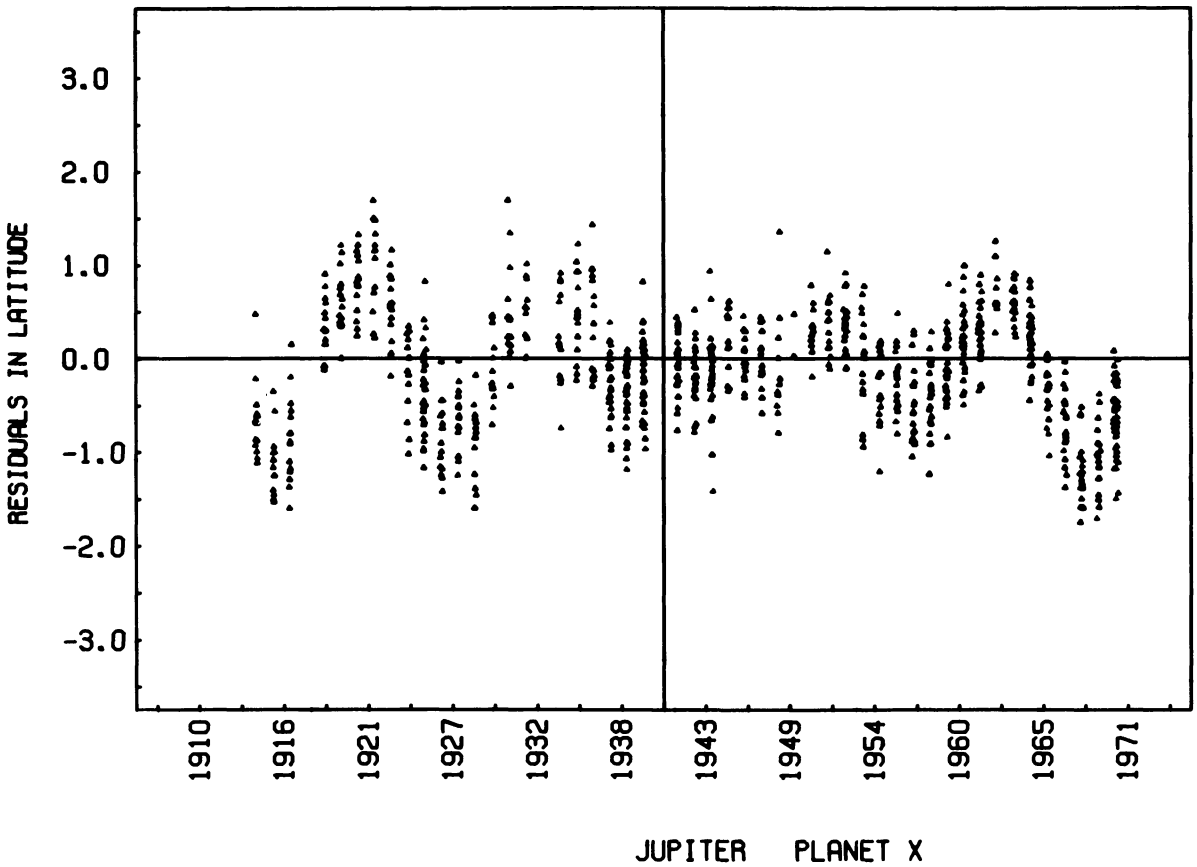

FIG. 1 — Residuals (in arc seconds) in the latitude of Jupiter caused by the presence of Planet X.

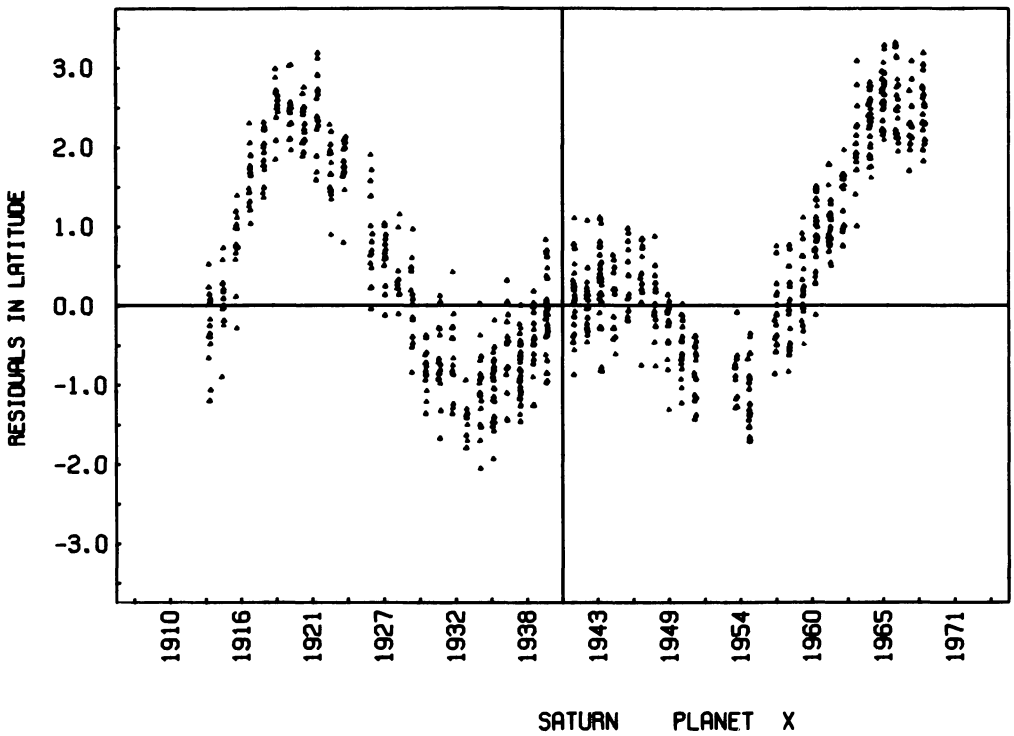

FIG. 2 — Residuals in the latitude of Saturn.

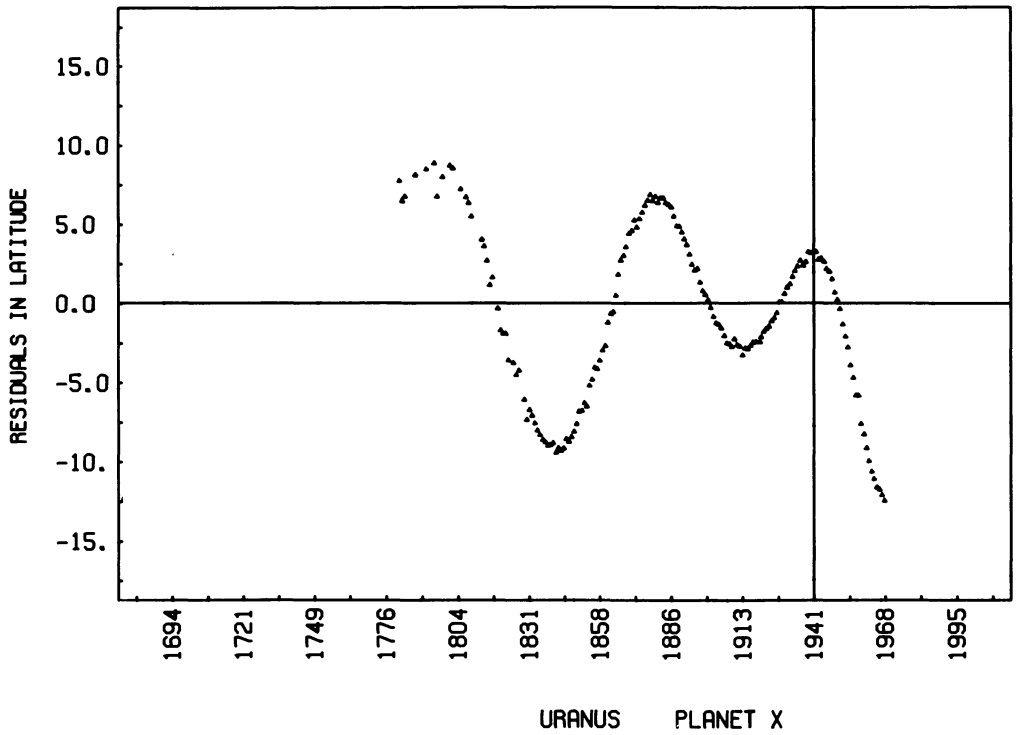

FIG. 3 — Residuals in the latitude of Uranus.

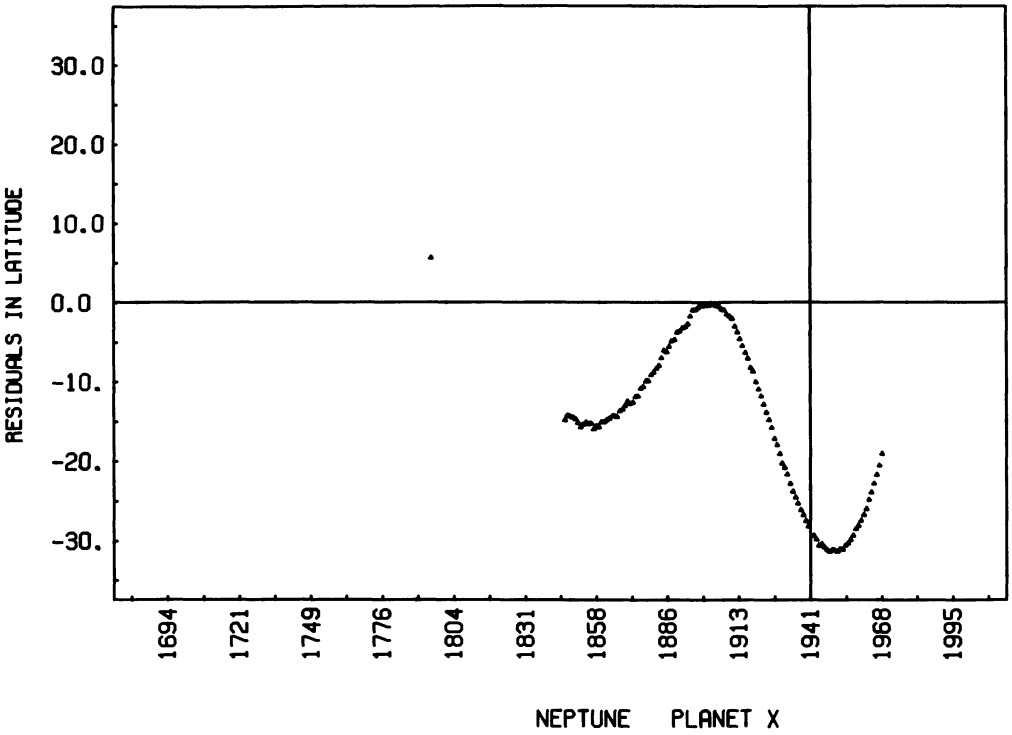

FIG. 4 — Residuals in the latitude of Neptune.

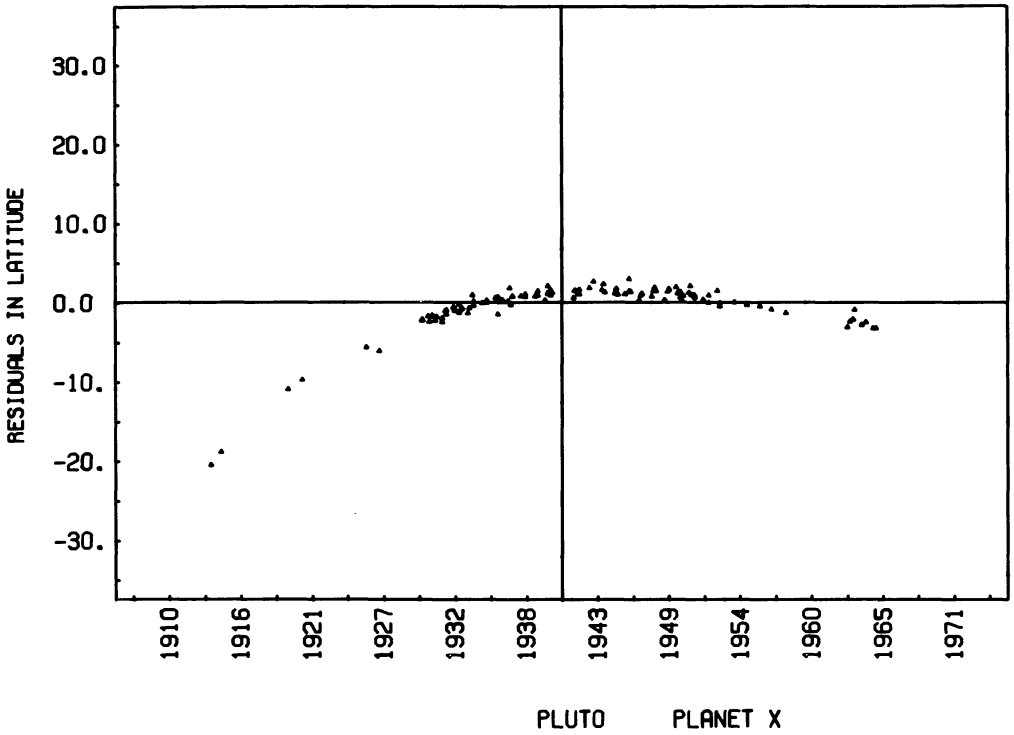

FIG. 5 — Residuals in the latitude of Pluto.

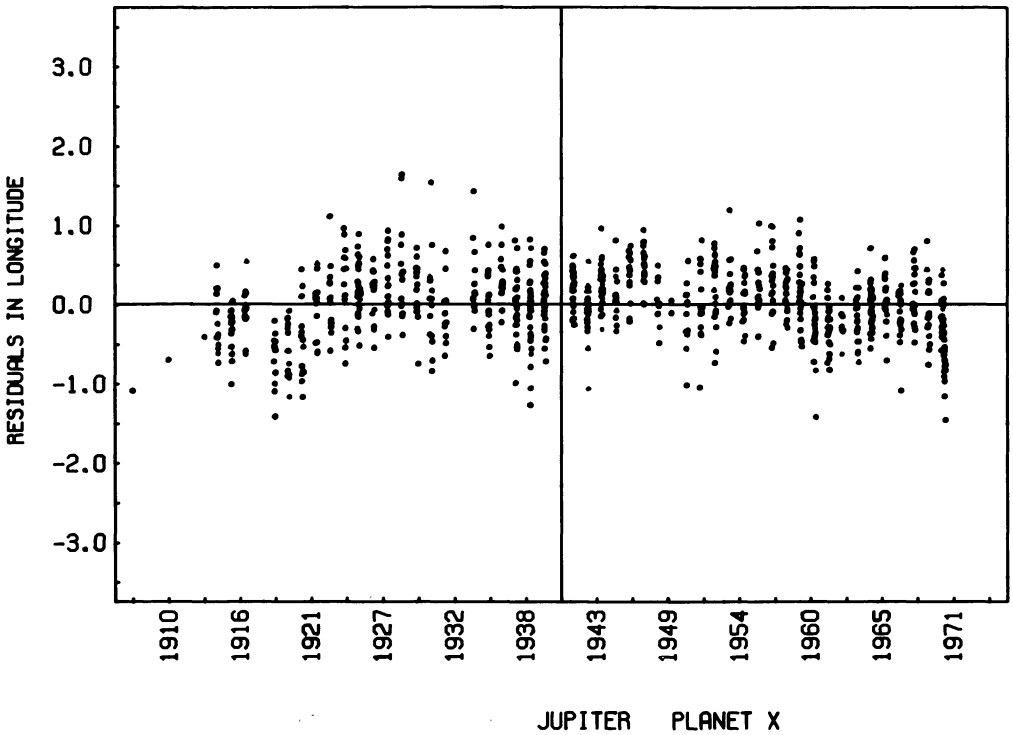

FIG. 6 — Residuals (in arc seconds) in the longitude of Jupiter caused by the presence of Planet X.

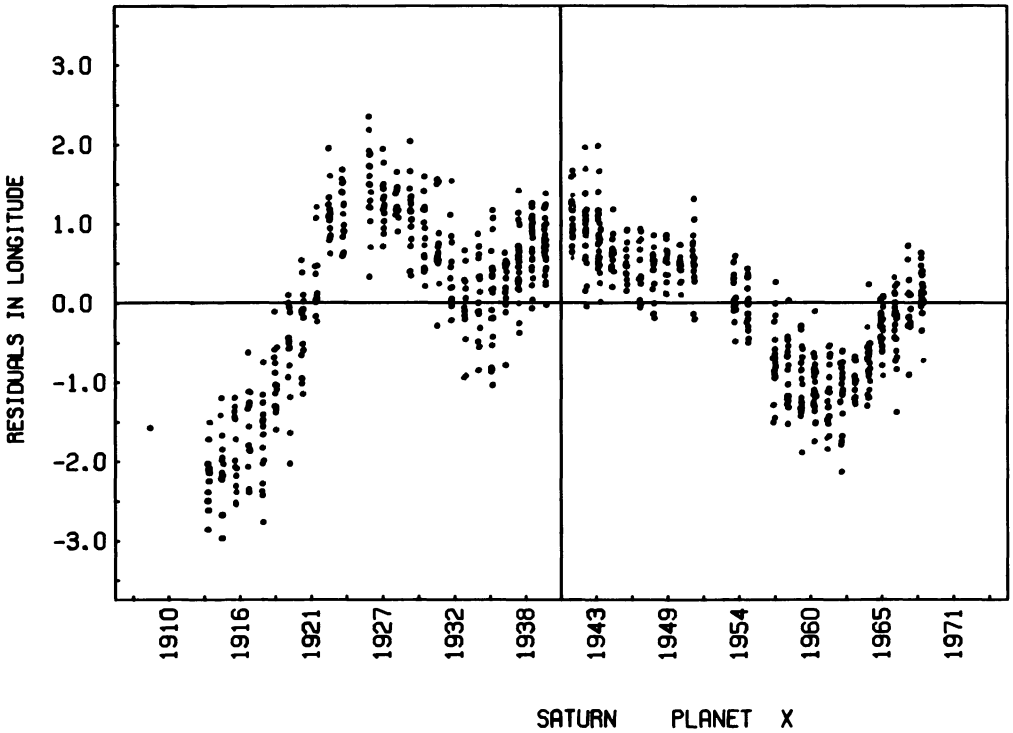

FIG. 7 — Residuals in the longitude of Saturn.

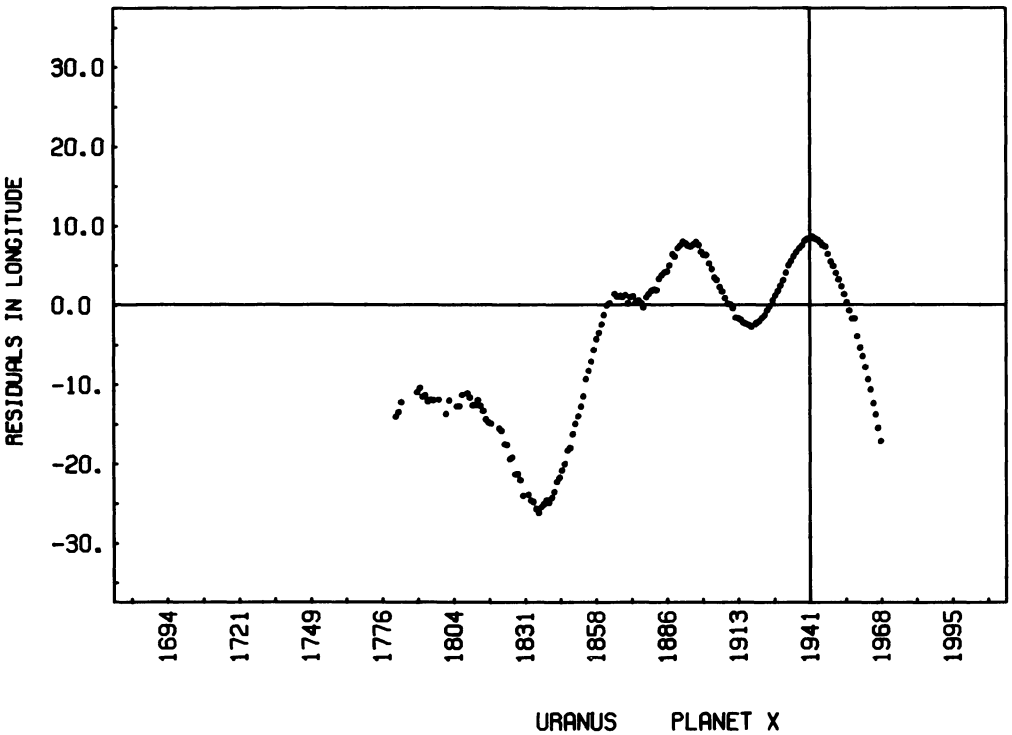

FIG. 8 — Residuals in the longitude of Uranus.

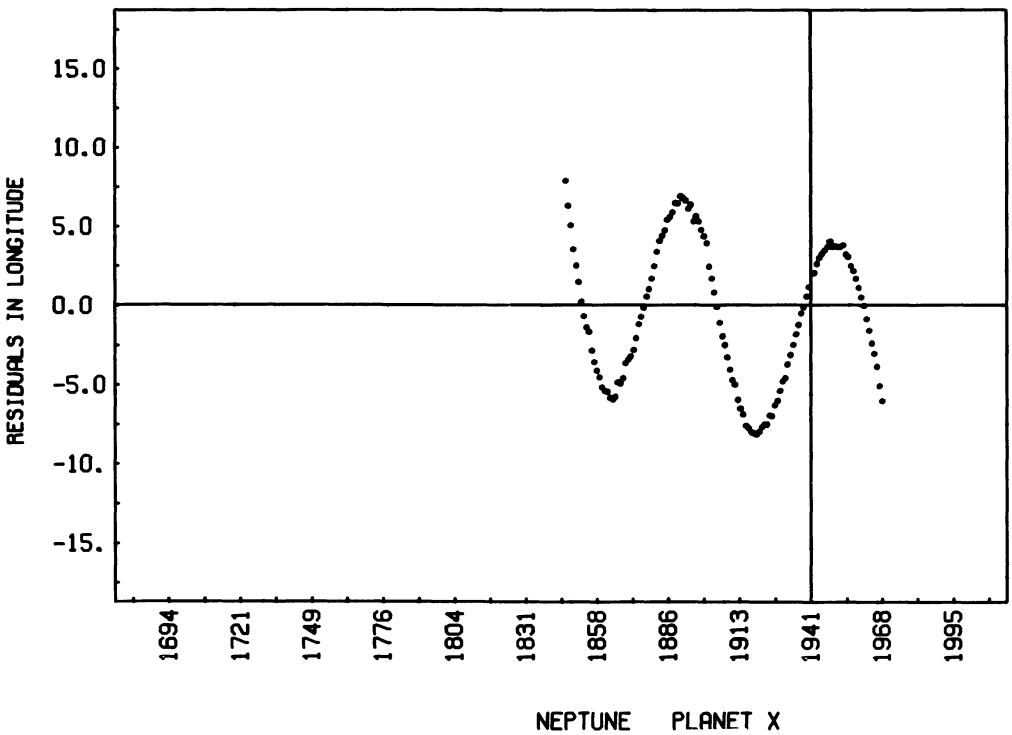

FIG. 9 — Residuals in the longitude of Neptune.

value ln K equals -5.1 (as more representative of the giant outer planets), an albedo of 0.4, and a density only one-third that of the earth — values which are also compatible with those of the giant planets, yet they are still conservative — we find a visual mean opposition magnitude of 9.0.

Even accepting the magnitude of 13–14, it seems rather surprising that a planet with an annual average motion of 46 arc minutes has been overlooked. It ought to have been discovered in the course of the Lowell Proper-Motion Survey (Giclas, Burnham, and Thomas 1971), for example, which covers the whole northern sky down to magnitude 16–17 and is reasonably complete for stars of annual proper motion 0.″27 and larger. Luyten (e.g. 1966) has also made a rather exhaustive proper-motion survey of the northern sky with the 122-cm (48-inch) Palomar Schmidt.

The predicted position of the planet is contained on plates taken by Tombaugh at Lowell in 1940–41. These plates, centered at $\alpha = 5^h50^m$, $\delta = +64°20'$ and covering an area of 12° by 15°, have now been carefully blink-examined to limiting magnitude 16.5, but no planet has been found. They have also been blinked against Lowell plates obtained of the same area in 1969. Reexamination of the notes made at the time these plates were blinked, as well as of those concerning the region centered at $\alpha = 2^h00^m$, $\delta = +75°53'$ (where the planet should have been in 1968.8), has revealed no suspicious objects. All these modern plates have again been carefully blink-examined in their entirety to a limiting magnitude of 16.5 or fainter. It is extremely improbable that an object as bright as magnitude 13–14 could have escaped detection during all these passes over the predicted area.

A final point concerns the manner in which the period of the hypothetical planet was derived. The supposition was made that the period of revolution was the same as the period in the residuals of the P/Halley perihelion times. Figure 1 of Brady (1972) shows that the attraction of Pluto yields an effect of approximately the same 500–600 year period; yet the revolution period of Pluto is only 250 years. Richardson (1942), based on an analysis of the motion of P/Halley, indicated that Planet X would have been then in Libra, not in Camelopardalis.

We conclude that, while small or very distant unknown planets may exist, there is no planet having the mass, magnitude, mean distance, and orbital inclination hypothesized by Brady (1972). The anomalous motion of P/Halley, and indeed of the other short-period comets, must have some other cause.

We wish to thank Elizabeth Roemer for comments and Clyde W. Tombaugh for drawing our attention to the earlier calculation by Richardson and the search he made as a result.

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