# SPECIAL ARTICLES

## ELEMENTS AND GENERAL JUPITER PERTURBATIONS OF TEN WATSON PLANETS[1]

THE program initiated by the board of trustees in accordance with the wishes of James D. Watson for the theoretical and numerical determination of the elements and general Jupiter perturbations of the twenty-two minor planets discovered by Watson is now completed. The results for twelve minor planets are published in Memoirs, Volume X. General expressions and tables for perturbations of planets belonging to the Hecuba Group, which have a mean motion of approximately twice that of Jupiter, were published in Volume XIV, preliminary to the investigation of the Watson planets of that type. Subsequently, papers have been presented to the Academy giving the results on five critical cases of the Hecuba Group (this paper includes a brief report on two other critical cases of this group). In view of the complicated theories involved, publication was deferred until opportunity had presented itself to test the results on recent observations, decades remote from the oppositions which furnished the basic osculating elements. For the twelve planets already published, the Berlin Rechen-Institut has, from year to year, included predictions in its *Kleine Planeten,* based on the perturbations contained in Memoir X. It has already been reported at the fall meeting of the Academy at Berkeley in 1930 that the predictions have held so well, although originally limited to thirty years, that the tables have been carried forward for another fifty years.

During the past year it became possible to test thoroughly the results of the five most critical cases of the Hecuba Group by recent observations. The departures were less than had been expected theoretically, considering that the perturbations of Saturn, which may be added any time if necessary, are not included. These results have been published in abstract in the October number of the *Publications of the Astronomical Society of the Pacific.* It is now possible to report to the Academy that the value of the investigations on the Watson planets, conducted under the auspices of the board of trustees, is thus established.

In illustration of the size of the perturbations involved in these investigations I may cite one striking case, that of (175) Andromache. The perturbation for the 1935 opposition in the mean anomaly is in excess of $-26°$, which would make the disturbed position geocentrically some 52° different from the undisturbed position. For an ephemeris extending from Aug. 18 to Oct. 5 this component of perturbation, alone, changes by 1,625″. In spite of these large perturbations an observation in 1932 left outstanding differences of only $-0^{m}.32$ and $+2'.04$ although Saturn perturbations are not included. This result is the more gratifying as the last opposition on which the basic elements were based occurred in 1907, a quarter of a century before the year for which the results were tested. The recent work of testing critical cases was done under my general direction and under the more immediate direction of Dr. Sophia H. Levy by Dr. C. M. Anderson and Mrs. Barbara P. Riggs.

The ten Watson planets on which the present report is made, with their approximate mean motions as listed in *Kleine Planeten,* 1934, are: (79) Eurynome, 928″; (94) Aurora, 634″; (100) Hekate, 650″; (104) Klymene, 636″; (106) Dione, 625″; (121) Hermione, 552″; (132) Aethra, 845″; (150) Nuwa, 690″; (168) Sibylla, 572″; and (175) Andromache, 610″. On all these the work was done at Berkeley, except for (132) Aethra. For this planet, which had been lost for many years, results by another investigator have been adopted.

The following is a brief description of the principal features of the investigations for each planet:

(79) *Eurynome,* 928″: Investigations on this planet were originally made under the direction of Simon Newcomb by E. Becker, who developed general perturbations by Hansen's method on the basis of elements by Lachmann, osculating in 1884. The elements were based on eleven oppositions, 1863–81, with special Jupiter perturbations. After Becker had computed first order general perturbations with Hansen's method, representation of positions was begun by Eichelberger and revised and continued at Berkeley. The final work involved revision of the perturbations, with an improved mass of Jupiter, determination of empirical terms due to Mars, and correction of the elements on the basis of an arc of forty-six years, from 1863 to 1909.

(94) *Aurora,* 634″: Work on this planet led originally to uncertain results because of the inadequacy of available basic elements. New basic osculating elements from the oppositions 1867–1875 were made the basis of the application of the Berkeley Tables for the Hecuba Group. This process produced the desired results.

(100) *Hekate,* 650″: Investigations on this planet became complicated on account of the inaccuracy of the adopted basic elements, the slow convergence of the mean motion with successive revision of the perturbations by Hansen's method, and an unfortunate computational error. The perturbations were redeveloped on the basis of elements by Stark with Gaillot's Tables and Hansen's method. The convergence of the mean motion with revision of the perturbations was exceedingly slow, but a satisfactory value was ulti-

[1] Abstract of paper presented to the National Academy of Sciences, Cleveland, November 3, 1934.

mately obtained and was verified by application of the Berkeley Tables for the Hecuba Group.

(104) *Klymene,* 636″: Gratifying results were obtained with the Berkeley Tables.

(106) *Dione,* 625″: The difficulties involved were surmounted by application of the Berkeley Tables.

(121) *Hermione,* 552″: This planet was investigated by various methods and ultimately with the Berkeley Tables. The satisfactory outcome of the work on this planet proves that the tables are satisfactory at the extreme limits for which, theoretically, they were expected to be applicable.

(132) *Aethra,* 845″: The investigations adopted for this planet are by Hartog, who published mean elements from three oppositions, 1873–1924. The planet had been lost for nearly forty years. Hartog also published general perturbations by Jupiter from Bohlin's tables.

(150) *Nuwa,* 690″: General perturbations for this planet were developed by the Hansen-Hill method on the basis of osculating elements by Oppenheim, derived from five oppositions from 1875–1884. The final results are based on seven oppositions, from 1875–1899.

(168) *Sibylla,* 572″: With elements by v.d. Groeben, based on four oppositions from 1876–1883, the general perturbations by Jupiter and mean elements were obtained with the Berkeley Tables.

(175) *Andromache,* 610″: As referred to above, this is the outstanding case as regards magnitude of perturbations of minor planets. It was the motive for constructing the Berkeley Tables for the Hecuba Group, and was successively conquered by their application.

Thus of the planets awaiting publication, six are of the type that required the application of the Berkeley Tables in order to obtain a satisfactory representation of observations from the date of the first discovery in 1857 to the present time. Since there exist several hundred planets of this type, the way is thus clear for the development of their general perturbations as a means of long range prediction of their future positions.

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## VITAMIN $B_2$ (G) AND CANINE BLACK TONGUE[1]

THE cause of black tongue, an acute disease of dogs characterized by stomatitis, diarrhea and frequently by a fatal outcome, remains obscure in spite of the very considerable number of experimental studies of the subject. The disease has been held in turn to be infectious, to be due to an insufficient intake of carotin[2] and to be caused by diets containing inadequate amounts of iron.[3] The most widely held hypothesis, however, has been that advanced by Goldberger and his associates.[4] They were able to cure and prevent the disease by feeding certain foods which are rich in their content of the vitamin-B complex. The effective agent in the materials fed was found to be resistant to autoclaving, a fact which served to differentiate it from the heat-labile, antineuritic vitamin $B_1$. It was then shown that a similar heat-stable food constituent was required for the growth of rats. Because of the similarity in distribution and resistance to heat shown by these two accessory food factors, it was inferred that they were identical. Furthermore, because of the symptomatic, geographic and etiologic likeness between canine black tongue and pellagra of human beings, the suggestion was advanced that pellagra was caused by a lack of the thermostable food factor, termed at first vitamin PP, and later vitamin $B_2$ or G.

Experiments have been performed in this laboratory which were designed to test, under standard conditions, the various theories concerning the cause of canine black tongue. The diet described by Goldberger as No. 114 was employed and regularly caused symptoms in from 6 to 8 weeks. Iron and carotin were both found to be therapeutically and prophylactically ineffective, but autoclaved yeast extract was entirely effective. Since Miller and Rhoads[5] had shown that the same extract was not high in its content of vitamin $B_2$G, and were unable to cause black tongue by feeding diets devoid of that vitamin, a direct test of the vitamin B content of the diet producing black tongue was suggested. Such a test has been made, and results show it is possible to maintain a normal rate of growth in young rats fed only the diet producing black tongue—conclusive proof that it contains vitamin $B_2$G in considerable amounts.

Since lack of the thermostable vitamin required for rat growth does not cause black tongue, and since the diet producing the disease contains that vitamin, it may be inferred that black tongue is not due to a deficiency of vitamin $B_2$G, but rather to a lack of some factor as yet unidentified.

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1 From the Hospital of the Rockefeller Institute for Medical Research.

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5 D. K. Miller and C. P. Rhoads, *Jour. Exp. Med.*, 59: 315, 1934.