



# LXIII. On a new binary progression of the planetary distances, and on the mutability of the solar system

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LXIII. *On a new Binary Progression of the Planetary Distances, and on the Mutability of the Solar System.* By HENRY WILDE, D.Sc., D.C.L., F.R.S.\*

1. **I**N the paper which I read before the Society in March last "On the Moving Force of Terrestrial and Celestial Bodies in relation to the Attraction of Gravitation"†, it was demonstrated that the moving force of celestial bodies is as the square of the velocity, in accordance with the experimental results obtained with moving bodies at the surface of the terrestrial globe. I further announced and demonstrated the new dynamical law that the moving force of celestial bodies is inversely proportional to the square of the distance, and correlatively equal to the static attraction of gravitation. For if the moving force were simply as the velocity, the attraction of gravitation would require to be in the like proportion, otherwise planetary bodies would either fall upon the central body, or be projected into outer space. But it has been demonstrated that the moving force and the attraction of gravitation are alike inversely proportional to the square of the distance to maintain and retain celestial bodies in their orbits during their revolutions round their primaries.

2. As some confusion of thought has arisen in the use of the term "gravitating force" by various writers, it cannot be too clearly stated that moving force and the static attraction of gravitation, although strictly correlated, are as distinct properties of body as dynamic electricity is from the static force of magnetism, as each of these forces manifests itself and may be treated upon independently of the others.

3. As the moving and attractive forces of planetary bodies are correlatively equal, and are expressed by the same numbers, the radius vector of Mercury appeared to me the most natural, as well as the most convenient unit to which the other planetary distances should be referred. A further reason for this selection was the fact that the terrestrial unit is an obvious survival of the geocentric system of the universe which has dominated science for ages, and still retains its hold on ultra-anthropocentric writers on astronomy and astrophysics.

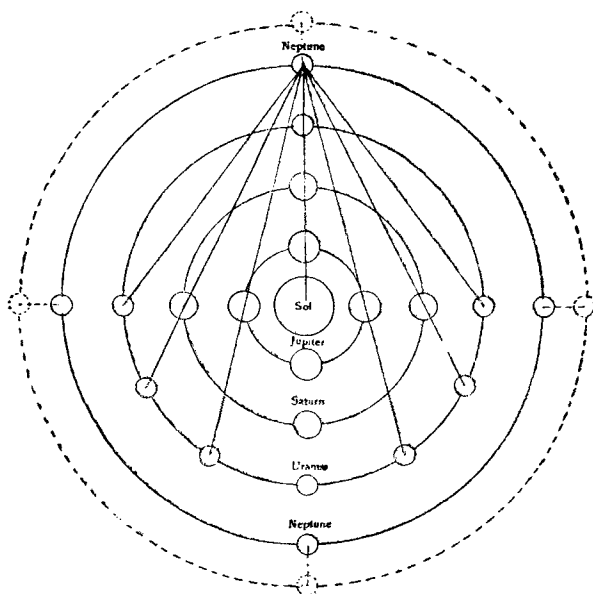
4. An apparently adverse feature, however, of the change of unit in the new table, was the excision of the binary

\* Communicated by the Author. Read at a Meeting of the Manchester Literary and Philosophical Society, October 5th, 1909.

† Manchester Memoirs, vol. liii. (1909); Phil. Mag. (6) vol. xviii. p. 523, 1909.

progression of the planetary distances known as Bode's law, which, as Airy and Herschel have rightly said, "is not founded upon any theory which connects it either with Kepler's laws, the gravitating force, or any other known physical law."

5. Notwithstanding the brilliant results which followed the adoption of Bode's law by independent thinkers, in the discoveries of the minor planets and of Neptune, the complete isolation of the law from all physical causes (which admits only of a teleological interpretation), appears to have created a strong prejudice, amounting to hostility, in the minds of eminent astronomical writers to disparage and obscure what



Diagrammatic Representation of the Contraction of the Radius Vector of Neptune.

they have been pleased to term Bode's "supposed" or "so called" law of planetary distances, ostensibly on account of minor differences from the observations, and its discordance with the distance of Neptune. So accustomed have these writers been to viewing the more exact relations of Kepler's laws with the law of gravitation, and the extreme refinements involved in the measurement of these relations, that their power of forming a just estimate of probabilities becomes

atrophied by disuse, to the great hindrance of the science which they endeavour to advance. This habit of mind is all the more deplorable in its consequences from the fact of its being unsuspected, and associated with attainments of the highest order in men occupying important positions in observatories and seats of learning, where the influence of their peculiar idiosyncracies makes itself felt through a long course of years\*.

6. Bode's law briefly stated is as follows:—The *radii vectores*, or the relative planetary distances from the Sun, proceed in multiple proportions, each one after the second being double the one which precedes it, and, by adding the constant 0.4 to each progression, we obtain approximately the distances of the planets as shown in Table I. (p. 602).

7. The parallelism of the discovery of new planets through the law of multiple proportions of the distances, and the discovery of new elementary substances through the law of multiple proportions of the atomic weights, as shown in my former papers†, will not fail to be evident to serious investigators in the natural sciences.

8. The correlation of a series of nebular condensations, represented by the planetary distances on the one hand, and the further condensation of the nebular substance into well defined series of elements, with their like series of atomic weights and specific gravities, on the other, rendered it imperative that the binary progression of planetary distances should again appear in connexion with the Mercurian unit of distance.

9. The solution of this problem is shown in the same Table I., in columns 4 and 5, parallel with 1 and 2, containing Bode's numbers, and expressed in astronomical units of the distance of Mercury from the Sun.

10. Taking the unit distance of Mercury = 1.00, as a plus constant, instead of the empirical number 0.4, as in Bode's table, the binary progression now appears as :

0.00    0.75    1.50    3    6    12    24    48    96 ;

and the value of each term of the new series becomes :

1.00    1.75    2.50    4    7    13    25    49    97.

\* The attacks made by astronomical writers on Bode's law have been discussed at greater length in my paper published in the Manchester Memoirs, vol. xxxix. (1895).

† Manchester Memoirs, vols. 30, 39, 40, 46, 48, 52, 1878-1907; Chemical News, vol. xxxviii. pp. 66, 96, 107, 1878; Phil. Mag. (6) vol. xvi. p. 824 (1908).

11. The observation distances in column 2 are in close accordance with those derived from Kepler's third law, as will be seen by multiplying each of the terms in column 5 of the new table of distances from my former paper\*, by the terrestrial unit distance of Mercury, 0.3871. The additional decimal place is brought in for greater accuracy not required in the general tables.

12. A comparison of the sums of all the distances in column 1 of Bode's table with those of the observation distances in column 2, shows that the difference between the two sums only amounts to one-fortieth part of the whole.

13. By the like comparison of the sums of the new binary progression in column 4 with the distances from the new table in column 5 (which are in strict accordance with Kepler's third law), the difference between the two sums is only one hundredth part, or two and a half times less than that derived from Bode's table, and abundantly establishes the validity of the binary progression of the planetary distances of both tables as a law of nature.

14. The substitution of the Mercurian radius vector for the terrestrial unit of distance, brings out several variations in the tables, the most conspicuous of which is the minus difference, 0.417, of the distance of Uranus in Bode's table, and the plus difference, 0.550, in the new table for the same planet, the plus difference being accounted for by the attractive influence of Neptune.

15. The anomalous minus difference of Saturn, 0.360, column 6, between the plus differences of Jupiter and Uranus is interesting as indicating the large amount of attraction exercised by the enormous mass of the Jovian planet on the outer side, and by the plus differences of the Earth and Venus on the inside of his orbit from the same cause.

16. The plus difference of Jupiter in the new progression, 0.437, column 6, is remarkable as showing the attractive influence of the large planets, Saturn, Uranus, and Neptune.

17. Other differences will also be seen between the observation and calculated distances in Bode's table and in the new progression, the final effect of which is to reverse the order of the plus and minus differences of the total sums of the distances shown in columns 1, 2 and 4, 5 of the table.

18. The smaller minus difference of Mars would appear to be caused by his proximity to the intra-Martian planets, together with the interruption of the binary progression of a

\* Manchester Memoirs, vol. liii. (1909); Phil. Mag. (6) vol. xviii. p. 523 (1909).

major planet revolving in the orbit of the asteroids, of which Ceres is the chief representative.

19. It will be further observed that, while the plus and minus differences in the distances are irregular in amount, they are rectified by the mutual attraction of the planetary bodies among themselves, to effect an approximate ratio of equality between the binary progression of the distances, shown in columns 1 and 4, and those derived from observation.

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20. Turning now to the anomalous departure of the distance of Neptune from the binary progression of distances of the other members of the solar system; it will readily be admitted that, had the agreement between the numbers of the binary progression and the observation distances, as shown in the table, been absolute, the outstanding minus difference of the distance of Neptune, 19.410, would have still remained an exception to the law.

21. In my former paper on the multiple proportions of the atomic weights, it was laid down as a general principle of philosophic reasoning, that, when a number of recurring instances was sufficient to establish the relation of cause and effect, or, in other words, the general accuracy of a law, the road to further discovery was rather in the direction of explaining the anomalous departures from it, than in challenging the truth of the law itself\*.

22. That the distance of Neptune, at the genesis of its history, was the first and exact term of the binary progression is an inference justly to be drawn from the like progression observable in the distances of the other planetary bodies, and it was on this same distance (38.4) that Adams, in 1845, based his first determination of the then unknown planet.

23. The Astronomer Royal (Sir George B. Airy) in his historical review of the circumstances connected with the discovery of Neptune says that, "if the mathematicians, whose labours I have described, had not adopted Bode's law of distances (a law for which no physical theory of the rudest kind has ever been suggested), they would never have arrived at the elements of the orbit"†, or, in other words, would never have discovered Neptune.

24. The most probable, as well as the most obvious, cause of the anomalous minus difference in the binary progression

\* Manchester Memoirs, vol. xxxix. p. 71 (1895).

† Proc. Roy. Astronomical Society, Nov. 13 (1846); Phil. Mag. (3) vol. xxix. pp. 520, 537 (1846).

TABLE I.—*New Binary Progression of the Planetary Distances.*

	1	2	3	4	5	6
	Bode's Law. Astronomical Units. Earth = 1·000.	Observation Distances.	Differences.	New Progression. Planetary Distances. Mercury = 1·000.	New Table of Distances. Kepler's Law.	Differences.
Mercury .....	0·0 + ·4 = 0·400	0·387	0·013 —	0·00 + 1 = 1·000	1·000	0·000
Venus .....	0·3 + ·4 = 0·700	0·723	0·023 +	0·75 + 1 = 1·750	1·868	0·118 +
Earth .....	0·6 + ·4 = 1·000	1·000	0·000	1·50 + 1 = 2·500	2·583	0·083 +
Mars .....	1·2 + ·4 = 1·600	1·523	0·077 —	3·00 + 1 = 4·000	3·936	0·064 —
Ceres .....	2·4 + ·4 = 2·800	2·776	0·024 —	6·00 + 1 = 7·000	7·148	0·148 +
Jupiter .....	4·8 + ·4 = 5·200	5·202	0·002 +	12·00 + 1 = 13·000	13·437	0·437 +
Saturn .....	9·6 + ·4 = 10·000	9·539	0·461 —	24·00 + 1 = 25·000	24·640	0·360 —
Uranus .....	19·2 + ·4 = 19·600	19·183	0·417 —	48·00 + 1 = 49·000	49·550	0·550 +
	41·300	40·333	.....	103·250	104·162	.....
Neptune .....	33·4 + ·4 = 33·800	30·036	8·764 —	96·00 + 1 = 97·000	77·590	19·410 —

TABLE II.—*New Table of Elements of the Lunar and Planetary Orbits.*

	Distances in Radii. Mercury=1.	Squares of Times and Cubes of Distances.	Times. Astronom. Units.	Time. Constant. 87.97.	Periodic Times, Days.	Moving and Attractive Forces.	
						Squares of Radii. Mercury = 1.	Reciprocals.
Mercury . . . . .	1.000 =	1.000 =	1.000 ×	87.97 =	87.970	1.000	1.00000
Venus . . . . .	1.868 =	6.522 =	2.554 ×	87.97 =	224.700	3.489	0.28661
Earth . . . . .	2.583 =	17.239 =	4.152 ×	87.97 =	365.256	6.671	0.14990
Mars . . . . .	3.936 =	60.980 =	7.809. ×	87.97 =	686.980	15.492	0.06455
Ceres . . . . .	7.148 =	365.200 =	19.110 ×	87.97 =	1681.400	51.094	0.01957
Jupiter . . . . .	13.437 =	2426.000 =	49.250 ×	87.97 =	4332.580	180.633	0.00553
Saturn . . . . .	24.640 =	14957.000 =	122.300 ×	87.97 =	10759.000	607.129	0.00165
Uranus . . . . .	49.550 =	121661.000 =	348.840 ×	87.97 =	30687.000	2455.202	0.00041
Neptune . . . . .	77.590 =	467142.000 =	683.494 ×	87.97 =	60127.000	6020.208	0.00016
Moon . . . . .	60.28 =	219038.000 =	468.000 ×	84.07 <sup>m</sup> =	27.322	3634.000	0.00027



of the distance of Neptune is the outermost position of the planet in relation to the other members of the system, with the consequent conjoint attractions of all the planets, acting through every part of their orbits, to contract continuously and permanently his radius vector to the amount shown in the observations. The large amount of this contraction is strong presumptive evidence against the existence of a planetary body beyond the orbit of Neptune.

25. A further consequence of the outermost position of Neptune is the small amount of the eccentricity of his orbit, 0.009, or nearly six times less than the eccentricities of Uranus, Saturn, and Jupiter, which, excepting Venus, 0.007, is the nearest approach to a circular orbit of any member of the system.

26. It is not a little remarkable that the inevitable effect of the outermost position of a planet, to contract continuously its radius vector, has never presented itself to Lagrange, Laplace, and other writers on celestial mechanics, who have elaborated the doctrine of the absolute stability of the solar system. The effect of the conjoint attractions of all the planets upon Neptune is clearly demonstrated by the diagram, whereon, from the exigencies of space, the intra-Jovian planets are not included.

27. Reverting to the small amount of the difference between the sums of the binary progression in column 4, Table I., and the observation distances in column 5, it will be seen that the latter is a plus quantity, as  $104.162 - 103.25 = 0.912$ . Now as the amount of the contraction of the radius vector of Neptune is 19.410 Mercurian units (696,000,000 miles), as shown in column 6, the plus difference, 0.912, between the two sums of the binary progression and the observation distances may well be accounted for as being the amount of the reciprocal attractions of all the planets upon Neptune in accordance with Newton's third law of motion, acting through periods of time too immense for calculation in the present state of our knowledge.

28. Assuming the future contraction of the orbit of Neptune to be continuous, his radius vector will ultimately coincide with that of Uranus, when the two bodies would either revolve together about their common centre of gravity in the same orbit, or coalesce to form a single self-luminous planet, when the same operation would be repeated in succession with other members of the system.

29. It is further postulated that all the planets would ultimately coalesce to form one or more self-luminous bodies revolving round the Sun, as one of the binary or ternary

systems of stars, of which upwards of ten thousand have been discovered and catalogued during the last century.

30. The probability that the ultimate transformation of the solar system will be brought about by the means, and in the order herein set forth, derives further support from the fact that one of the stars of long recognised binary systems is itself a close double star, revolving about its common centre of gravity, as instanced in  $\mu$  Herculis and  $\gamma$  Andromedæ.

31. *Recapitulation.*—(1) That the exact binary progression of the planetary distances is the primordial and fundamental law (shining forth alone in the formless void) from which the principal elements of the planetary orbits have been derived; (2) that the apparently irregular differences from the law are the direct consequence of the mutual attractions of the planetary bodies amongst themselves, but without affecting the validity of Kepler's laws, as the distances and periodic times are necessarily correlated; (3) that as planetary systems have been evolved in regular order from a nebular substance, so the transformation of these systems will proceed in like order to form the numerous binary and other revolving systems observed in the immensity of the stellar universe.

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LXIV. *Absorption of  $\beta$  Rays from Radium by Solutions and Liquids.* By W. A. BORODOWSKY, M.A., Privat-docent of Chemistry, Tourjew (Dorpat) University, Russia\*.

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*Introduction.*

A LARGE amount of work has been done by various observers in determining the absorption of  $\beta$  rays from radioactive matter by metals and solids, but little attention has been given to the allied problem of absorption of the rays by solutions and liquids.

N. Campbell† examined the absorption of the  $\beta$  rays from uranium by liquids and solutions, but his method of obtaining uniform layers of liquid by means of filter paper is open to objection. The results obtained by him were somewhat irregular, but he concluded that "it is possible that the value of  $\frac{\lambda}{\rho}$  (where  $\lambda$  is the coefficient of absorption and  $\rho$  the density of the solution) for a solution should be greater than either of the values for the solvent or the solute, or should be less than either of these values."

While the present work was in progress a paper was

\* Communicated by Professor E. Rutherford, F.R.S.

† Phil. Mag. 1909, vol. xvii. p. 180.