UNIVERSITY LECTURES.

ASTRONOMY.

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LECTURE IX.

Remarkable Discovery of Neptune.—Its Distance, Period, Magnitude, Density, Weight.—Intensity of Gravity at its Surface.—Inclination of its Orbit.—Satellite. Superficial Contents of the Solar System.

Asteroids.—Location of their Orbits.—Their Discovery.—Intersection of Orbits. Distance between the Interior and Exterior Orbits.—Asteroidal Zone co-extensive with the Solar System.—Meteors only Asteroids in Miniature.—Asteroids as Fragments of a Bursting World an Absurdity.

Sun's Compound Orbit.—Nature of his Elementary Orbits.—Compound Orbits of the Major Planets.—These Resultant Orbits necessary to the Stability of Systems.—Skillful adaptations of Balancing Orbits.—Evidences of a Universal Law manifested in Orbit Projections.

NEPTUNE.

THE discovery of the planet Neptune may be ranked among the greatest discoveries that were ever unfolded in the history of Astronomy—not so much in regard to its future bearings upon that great science, as in relation to the curious and most wonderful manner in which the discovery was made.

In exploring the heavens in search of new planets, the telescope alone seems to have been the grand instrument of research. Some faint analogies, it is true, have guided the instrumental examinations to certain regions of the heavens in preference to others; for instance, all the older planets were known to revolve in orbits not much inclined to the ecliptic—being included within a narrow zone encircling the heavens about fourteen degrees in breadth called the Zodiac. Analogy would naturally lead astronomers to regions in or near this zone, as the most likely place for discovering planetary bodies. But having arrived in the neighborhood of this zone, analogyno longer serves as a guide, and the asstronomer has hitherto launched forth into the unknown abyss to be wafted by the winds of fortune, perhaps to some new planet, but far more frequently he returns disappointed and grieved—his voyage having been unsuccessful.

These have been the difficulties and uncertainties which have attended the explorations of the heavens until within a few years past. But the period has at length arrived, when the mind of man has reasoned its way through the dark clouds of uncertainty—has soared aloft among the vast oceans of telescopic stars—and has pointed out almost the exact position of an unknown world. It would seem almost impossible for the human mind, though guided by the most powerful mathematical analysis, to point out the direction, define the distance, trace out the orbit, and weigh the mass of an unknown planet, so remote as to be imperceptible to the naked eye, yet this has been attempted, and the result has brought to light another great orb of our system, which has rolled its ample rounds for ages unknown.

It may be asked, how was this grand problem solved? We reply that it would be impossible to convey a clear idea of the profound and intricate analysis employed for its solution, to a popular assembly, unless they were prepared by a previous knowledge of the higher mathematics.

We will venture to make a few remarks upon this recondite subject. Since the days of Newton, it has been known that each planet gravitates towards every other planet in the system with a certain force, depending on the distance and quantity of matter. As the planets revolve in their orbits, their distances and directions from each other, are constantly varying; consequently they must be continually acted upon by variable forces, tending to urge them from the path which they would pursue, if only acted upon by one central force. The planetary orbits are ellipses when considered in reference to the force deflecting them towards the sun; they are constantly deviating from these elliptic paths by forces urging them towards other bodies in the system. These deviations are called planetary perturbations; and can be calculated when the direction, distance, and mass of the perturbing body are known.

The perturbations of Uranus towards Saturn and Jupiter were calculated for every point throughout its entire path; so that the form of its path as depending upon its deflections towards these two bodies and the sun was known; but by carefully watching the progress of Uranus, it was soon ascertained that it deviated from its calculated orbit, both in direction and velocity. The disturbing cause was unknown. It could not be the influence of the minor planets, situated within the orbit of Jupiter; for they were altogether too small to occasion the observed perturbations. Various causes were conjectured by the Astronomical world to account for the deviations of Uranus.

Some supposed that the law of gravitation had in some small degree changed its nature; others supposed that the planet was perhaps influenced by a comet which might be traversing those distant regions. All seemed to be uncertainty until two young geometers — Mr. Adams, of Cambridge, England, and Leverrier, of France, conceived the idea, unknown to each other, of determining by analytical investigations, the direction, distance, and amount of the perturbing body, from the amount of perturbations exercised upon Uranus. This is a problem from which any but the most profound mathematicians would have shrunk, as being far beyond the pale of human intellect. But these two mathematicians beheld the light glimmering from afar; they therefore labored and toiled on with the most untiring perseverence, removing obstacle after obstacle—ascending higher and yet higher in their analytical investigations, until they gained an elevation from which by the eye of reason they could see, as yet, an unseen world, rolling in its mighty orbit nearly as far beyond Uranus, as Uranus is from the sun. Having satisfied themselves, not only of the existence of the unknown world, but of the particular regions of the heavens where it existed; they announced the results of their reasonings. Leverrier wrote to his friend Dr. Galle, of Berlin, requesting him to direct his telescope to the point in the heavens which mathematical reasoning had revealed as the one containing the unknown body. The first evening after the reception of this communication, Dr. Galle directed his telescope to the place pointed out, when he at once perceived a star of the eighth magnitude, which, by reference to a map, he found to be a stranger in that region. The next evening, the star had actually moved from its place with a velocity accordant with the computations of Leverrier. The unknown world was found—the theory of the French geometer was demonstrated by actual discovery, and the whole of the learned world were astounded at the penetrating judgment and giant intellect of the men who could by analytical reasoning alone, rescue a world from the depths of space, and assign it a definite orbit among the known orbs of our system.

Independent of the applause of men, how satisfactory and pleasant must be the feelings of a great and good man, when he has been made the instrument of some great and grand discovery,—when he knows that his persevering industry and labor have put him in possession of knowledge and power to open the sublime mysteries of creation, and bring to light things which have slumbered for ages unknown.

This ever memorable discovery took place, or was confirmed on the 23rd of September, 1846. The actual place of the planet was found to be only 52′ of a degree from the computed place assigned by Leverrier, and only 2° 27′ from the place computed by Mr. Adams, both of whom were in entire ignorance of each others calculations.

After the discovery of this distant planet, many astronomers bent all their efforts to ascertain its distance, period, form of its orbit, etc., all of which are called its elements. It was soon learned that the planet was seen on the 10th of May, 1795, and entered on the catalogues as a fixed star. From this discovery, astronomers were enabled to calculate its elements with a very great degree of precision.

It revolves around its orbit at the vast distance of 2,850,000,000 of miles in a period of no less than 60,126.71 mean solar days, or a little over 164 1-2 of our years. This distance is so great, that a cannon ball, flying at the rate of 500 miles per hour, would require 648 years to accomplish the journey. A steam carriage, traveling 20 miles per hour, would be 16,256 years in going the distance; and to traverse the whole circumference of its orbit, would take upwards of 100,000 years. Even light itself would require 4 hours 7 1-2 minutes to come from that body to us.

The diameter of Neptune is 41,500 miles. Its bulk, therefore, is 143 1-2 times greater than the earth; that is, 143 1-2 globes of the size of the earth, if moulded into one, would form a globe of the size of Neptune. The density of this planet is about 1-7 of that of the earth; that is, 7 globes of the size of the earth, composed of the materials of which Neptune consists, would weigh as heavy as the earth; therefore, the materials which enter into the composition of Neptune are only about 5-7 as heavy as water; and the whole of that planet, though 143 1-2 times larger than the earth, will only weigh about 20 1-2 times more.

One pound of terrestrial matter, transported to the surface of Neptune, will only weigh 12 ounces and 2 drachms, or a little over 3-4 of a pound. A clock pendulum that will make 100 oscillations at the surface of the earth, if carried to the surface of Neptune, would only make 87 oscillations in the same time. Bodies will fall near the surface of that planet only 12 feet and 1 inch in a second; whereas on the earth they will fall in the same time 16 feet and 1 inch.

This planet's orbit is inclined to the ecliptic at an angle of 1 deg. 46 min. 59 sec. It seems to be a characteristic of all the larger planets to revolve in orbits but little inclined to each other or to the ecliptic.

Though Neptune is too far from us to determine by observation whether it has a rotatory motion or not, yet from analogy and other theoretical considerations, it is quite probable that it rotates upon an axis from west to east, the same as the three large planets interior to it, and it is presumed in about the same period.

How many satellites attend Neptune is as yet unknown; one only has been certainly observed. It was first discovered by Mr. Lassell, on July 8th, 1847; since which time it has been observed by many other astronomers. Its orbit is inclined to the ecliptic at an angle of 35 deg. Its approximate period is 5 days 20 hours 50 min. 45 sec., and its distance from the centre of the planet is about 249,000 miles. It is from the period and distance of this satellite that the comparative mass of Neptune has been computed with a tolerable degree of accuracy, though it will hereafter, probably, undergo some modification, as observation shall become more perfect.

From Bode's law of planetary distances, it might have been expected that the planet Neptune should be placed at about double the distance of Uranus from the sun; but this is found not to be the case. Bode's law, although verified in the case of all the other planets, and even among the systems of satellites, fails by some six or seven hundred millions of miles in the distance of the new orb.

This law of planetary distances seems to be founded upon no necessity; at least, no causes or reasons can be assigned why this singular relation of distances should have existed in so many instances; and it is rather singular too, that after it had been verified in so many instances, a case should occur so widely deviating from it. This may have occurred by some interference with the original velocity of the planet, by which its period may have been shortened, and consequently its distance.

We have already stated in a former lecture, that the apparent magnitude of the sun as seen from this planet will be about 900 times less than he appears to us. The inhabitants of that planet, therefore, will have 900 times less light than what we have. The light of the sun which we receive is estimated to be equal to about 300,000 full moons; therefore, the light on Neptune would be equal to 333 full moons, which would be amply sufficient for the purposes of vision.

We have now given a very brief description of the primary and secondary planets of the solar system, with one small exception, namely, our moon. We shall next say a few words in regard to the superficial contents of the system.

The number of square miles on the surface of a globe is obtained by multiplying the diameter into its circumference; for instance, the number of square miles on the surface of the earth, including both land and water, is about 197,000,000.

The surface of the sun contains 2,433,000,000,000, of square miles.

The superficial contents of all the planets and satellites amount to about 84,000,000,000 of square miles.

Thus it will be perceived that the surface of the sun is about 12,350 times greater than the surface of the earth; and the surface of all the planets and satellites is 425 times greater than the surface of the earth. Hence there are 12,775 times greater surface in the worlds of our system, than on the earth.

If each of these worlds were inhabited in proportion to the number of inhabitants dwelling upon our globe, the aggregate number would be about 12 billions. But our earth is capable of sustaining at least ten times the amount of population which at present inhabit it; and if the population of the solar system were increased in the same proportion, the numbers would be swelled to 120 billions.

It certainly is perfectly consistent that all of these worlds should be inhabited; otherwise there would be no use in their organization; for certainly an allwise Being would not form such stupendous globes without having some worthy end or design in view. To form them and leave them uninhabited, would exhibit no wisdom—the work would be in vain. Can we, for one moment suppose that life and intelligence are confined within the very narrow limits of our own little globe—that all the other vast orbs of this system exhibit a scene of barrenness and desolation, where no living beings exist to enjoy and appreciate the beauties and glories of creation? Such a view of the works of the Almighty would greatly distort His perfections and attributes. The grand object of the creation of worlds is to people them with living and intelligent beings who are capable of enjoying life and happiness.

When we reflect, then, upon this system of worlds, we are not to suppose them to be dreary wastes, but consider them as the abodes of myriads of animated beings of every grade and species, from the lowest to the highest order of intelligences—all living, moving, and rejoicing in their several spheres of action as on this earth.

THE ASTEROIDS.

The Asteroids are small planetary bodies revolving around the sun, between the orbits of Mars and Jupiter. None of these bodies were discovered until the present century. The great distance between the orbits of Mars and Jupiter, compared with the distances between the other planetary orbits, gave rise to the idea that there should be a planet situated in this great interval. Professor Bode had detected a supposed law relating to the distances of planetary orbits from each other. As you recede from the sun, each planetary orbit is found to be nearly half the distance from the orbit of Mercury which the next succeeding one has. Thus, the interval between the orbits of Venus and Mercury is one half the interval between those of the Earth and Mercury; and the interval between the orbits of the Earth and Mercury is about one-half the interval between those of Mars and Mercury; the interval between the orbits of Jupiter and Mercury is about 1-2 the interval between those of Saturn and Mercury, and so on. But when this law was applied to the interval between Mars and Jupiter, it was found to fail. In order that the law might hold good, it was calculated that a planet ought to be situated from Mars about one-third the distance between that planet and Jupiter.

Astronomers were so thoroughly convicted of the existence of such a body, that they actually called a convention in the year 1800, and resolved to carefully search for the suspected new world. A zone of the heavens, extending several degrees on each side of the ecliptic, was divided into twenty-four equal parts, and parceled out to as many observers, each of whom was required to thoroughly examine the portion assigned to him. This plan was successful. Piazzi, on the evening of the first day of the year 1801, discovered the planet Ceres. After ascertaining its distance from the sun, it was found to occupy the position between the orbits of Mars and Jupiter, required by Bode's law of planetary distances. This discovery was hailed with joy by the whole astronomical world; the great chain in the solar system was filled; the discrepancy in Bode's law vanished, and the harmony in the whole planetary system seemed to be completed.

But scarcely had astronomers time to congratulate one another in relation to this great discovery, when they were startled at the announcement of Dr. Olbers of Bremen, who had, on the evening of the 28th of March, 1802, discovered another planet having its mean distance and periodic time almost identical with those of Ceres. Here was an anomaly presented in the solar system—two planets having about the same distances and periods, and whose elliptic orbits actually intercepted each other, that is, each planet in different points of its path was alternately nearer and then further from the sun than the other. This new planet was called Pallas.

Dr. Olbers conjectured that these two minute bodies might be fragments of some greater planet, which, by some unknown cause, had been bursted asunder or broken in pieces. If such a catastrophe ever happened, it must have taken place at one of the points of the intersections, of their orbits. The force necessary to burst a planet, and project the fragments in different directions, so as to pursue elliptic orbits of various degrees of eccentricity, can be calculated. The larger fragments of such a planet would deviate from the original path, less than the smaller ones; however great the inclinations of their orbits, or however eccentric the ellipses, yet they would all intercept each other at the point where the explosion happened.

Under the influence of this bold hypothesis astronomers pointed their telescopes to the opposite constellations, Cetus and Virgo, where the nodes of the two orbits lie, as the most likely place to discover other fragments, and on the 2nd of September, 1804, Mr. Harding, of Lilienthal, discovered the planet Juno near one of the points of the intersection of the other two orbits.

Dr. Olbers, finding his theory assuming the air of reality, continued his researches with still greater zeal; and on the 29th of March, 1807, he discovered the fourth of these supposed fragments in the constellation Virgo, not far from the point of the intersection of the other three orbits. This planet was named Vesta. The researches continued for nearly forty years and no other fragments were discovered; and it began to be supposed that all the small bodies revolving in this region were detected.

But on the 8th of December, 1845, Professor Hencke, of Dreisen, discovered another asteroid, which was called Astrea; and on July 1st, 1847, the same observer detected another, which was called Hebe. This great success in discovering new worlds in the vicinity of our own system, excited other astronomers to commence a diligent research for these supposed fragmentary bodies. Mr. Hind, of London, on the 13th of August, 1847, discovered a seventh, which was called Iris; and on the 18th of October the same year, he discovered the eighth, which is called Flora. And on the 25th of April, 1848, Mr. Graham, of Ireland, discovered the 9th asteroid, which is called Metis.

During the last quarter of a century, astronomers have searched the asteroidal regions with unwearied diligence, and have succeeded in enlarging the group, until the number now (A. D. 1871) is about eighty.

All of these bodies are extremely small. Vesta, which is probably one of the largest, is believed to be only 250 miles in diameter Juno's diameter is stated to be only about 79 miles, and Ceres, 163 miles. It is extremely difficult to measure these minute worlds at so great a distance; and consequently these approximations may be far from the truth.

Juno is supposed to have a rotation upon