THE MOON'S ROTATION EXAMINED BY THE NEWTONIAN THEORY OF GRAVITATION

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BY

THOMAS F. TYERMAN.

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THE MOON'S ROTATION.

It never happens that the man who makes a great discovery, lives long enough to learn every possible application, or every possible consequence, of the important discovery he has made. One life is too short, however laborious it may have been. There is comprehended, under every great law of nature, such a vast series of particulars, that the future has more fruit to bring forth than the broadest generalization of the facts already known, even if aided by a glowing imagination, can possibly suggest. Science cannot achieve all its ends *per saltum*, but must be content to advance by the slow accumulation of facts and evidences, with, now and then, a sudden start in advance. One man discovers one thing, and another, another, while a third man finds the application of what the other two have brought to light. If then a man has succeeded in making a great discovery, has set a noble example, and has pointed out the true path of investigation, it is all that can be expected of human nature, even in its exaltation.

Newton's life was sufficiently laborious, but with all his application he was obliged to leave a good deal of

unfinished work for his successors to take up. His thoughts were always practical; and in the endeavour to unite practice with sound theory, he felt that the real advancement of the natural sciences must depend upon the interpretation of nature, and a suitable application of the laws of nature to given examples.

He nobly led the way by the application of his own theory to the problem of the "moon's variation and "parallactic inequality"; but how great would his satisfaction have been had he lived long enough to know that all the difficult problems connected with planetary perturbation and compensation had been, one after another, solved by the proper application of his theory.

The problems of the "great inequality of Jupiter and "Saturn," and "the sæcular acceleration of the moon's "mean motion," were long before the world, and it was denied, over and over again, that these could be solved by any application of the theory of gravitation; but in the hands of Laplace they both yielded to that theory.

It would be a pleasing subject for contemplation, had Newton lived long enough to learn that the solar system, for the stability of which he trembled, had been shown to be, for ever, stable, and upon his own theory. Lagrange has demonstrated, in his three celebrated theorems, the entire stability of the system; his only postulate being that the force of gravitation should, for

ever, continue as at present, or that the members composing the solar system should always mutually gravitate as they do now. This being granted, he shows such a connexion between the masses, major axes, mean motions, and periodic times of the planets, that these must, for ever, continue to revolve about the sun in orbits of the same magnitude as those in which each of them now moves. In another theorem he shows the stability of the system as regards the inclination of the planes of the planetary orbits; and, in a third, its stability as regards the excentricities, although immense periods of time may be necessary for the compensations.

The difficulty arising out of the problem of the revolution of the lunar apsides, and the circulation of the apogee, which Newton did not succeed in clearing up, was, after repeated attempts, removed by the French astronomer, Clairaut, who showed the exact agreement between theory and observation, the demonstration being made on the Newtonian theory. It was by reliance on the theory of gravitation, that Bouvard, after satisfying himself that the perturbations of Uranus could not be due to the influence of Saturn or Jupiter, threw out the suggestion that these might be caused by some unknown force by which the planet was acted on, that is, by a mass of matter revolving in space many hundreds of millions of miles beyond the orbit of Uranus. Many years afterwards, the same thought having been suggested and acted upon, the hypothetical

planet was converted into a real one by the discovery of Neptune, the undisputed boundary-keeper of the planetary orbits.

A solar system may be described as a vast machine, constructed of widely separated parts or members, which parts, at the same time that they are allowed the utmost freedom of motion, within certain limits, are held together, with the greatest firmness, by the invisible and indissoluble bond of gravitation. In a system so constructed, we find the two great forces employed by nature, viz., motion and gravitation, in constant operation. The result is determined, not by magnitude, but by mass, or the quantity of ponderable matter contained by each body; for, upon this depends its gravitating force or energy. The sun has a twofold office to fulfil: 1. By his great and overpowering mass, to retain the planets in their orbits about himself. 2. To radiate light and heat, to be received by their surfaces as they move round him.

It might naturally enough be thought, at first, that the great object would be to bring all these globes as near as possible to the sun, whereas the inter-planetary spaces continue to get wider and wider almost to the last; this mode of distancing being without doubt very exactly designed, according to the force of gravitation; and so fertile is the invention of the Great Creator, that He finds no difficulty in adapting the several anatomical and physiological peculiarities of the various races

of animated beings which He has called into existence, to the climate and atmospheric constitution of the abodes appointed for them.

A centrally placed sun then, with all these world-dwellings revolving around him, and turning round on their axes, so that their surfaces might catch, one part after the other, his light and heat, is a conception of the most wonderful beauty.

Most of the planets have satellites, or moons, revolving around them, and the motions of these about their primaries are regulated by the same laws as those which determine the orbits of the planets about the sun; and while studying the several constituent parts of the system, it is impossible not to be struck by the sparing distribution of satellites to those planets which revolve in the immediate neighbourhood of the sun. Mercury has no moon, and Venus has no moon, the earth being the first planet, reckoning from the sun, which has a satellite. The conviction of exactness of plan is here actually forced upon us. Should Mercury, in his very excentric ellipse, at a distance of only thirty-six millions of miles from the sun, and moving at the rate of thirty miles every second, be made to carry the orbit of a moon, we should tremble for the safety of a satellite so circumstanced. But Venus has no moon; why should not Venus have a moon as well as the earth? would not a satellite be safe in her keeping?

Is the proper answer to the question then—why should not Mercury and Venus have moons?—Because, according to the established laws of gravitation, the operation of which, the Creator never interrupts, such moons would not be in safety? The earth is allowed one satellite: but so powerful is the gravitation of this to the sun, that if the sun's mass were only a little greater, or the moon a little farther from the earth, there would be danger of her being drawn off from her allegiance to her primary, and made to move round the sun in an orbit of her own. With such exactness then are the several masses composing the solar system, adapted to one another, in reference to the force of gravitation! As we get further from the sun, the satellites are more plentifully distributed; Mars has two, very minute, Jupiter four, Saturn eight, &c.

Since the discovery of Uranus and Neptune, we can better understand the reason why the sun's mass should so greatly preponderate over the united masses of all the planets and satellites, than when the orbit of Saturn was believed to be the boundary of our system. Uranus is as far from Saturn as Saturn is from the sun; and now we have to stretch out into space many hundreds of millions of miles beyond the orbit of Uranus, to reach that of Neptune; the sun's gravitating influence then has to extend over a much wider range than to the limit formerly assigned to it.

As our attention now is to be especially directed to