

*Sect. 4.—Application of the Newtonian Theory to Secular Inequalities.*

SECULAR Inequalities in the motions of the heavenly bodies occur in consequence of changes in the elements of the solar system, which go on progressively from age to age. The example of such changes which was first studied by astronomers, was the Acceleration of the Moon's Mean Motion, discovered by Halley. The observed fact was, that the moon now moves in a very small degree quicker than she did in the earlier ages of the world. When this was ascertained, the various hypotheses which appeared likely to account for the fact were reduced to calculation. The resistance of the medium in which the heavenly bodies move was the most obvious of these hypotheses. Another, which was for some time dwelt upon by Laplace, was the successive transmission of gravity, that is, the hypothesis that the gravity of the earth takes a certain finite time to reach the moon. But none of these suppositions gave satisfactory conclusions; and the strength of Euler, D'Alembert, Lagrange, and Laplace, was for a time foiled by this difficulty. At length, in 1787, Laplace announced to the Academy that he had discovered the true cause of this acceleration, and that it arose from the action of the sun upon the moon, combined with the secular variation of the eccentricity of the earth's orbit. It was found that the effects of this combination would exactly account for the changes which had hitherto so perplexed mathematicians. A very remarkable result of this investigation was, that "this Secular Inequality of the motion of the moon is periodical, but it requires millions of years to re-establish itself;" so that after an almost inconceivable time, the acceleration will become a retardation. Laplace some time after (in 1797), announced other discoveries relative to the secular motions of the apogee and the nodes of the moon's orbit. Laplace collected these researches in his "*Theory of the Moon*," which he published in the third volume of the *Mécanique Céleste* in 1802.

A similar case occurred with regard to an acceleration of Jupiter's mean motion, and a retardation of Saturn's, which had been observed by Cassini, Maraldi, and Horrox. After several imperfect attempts by other mathematicians, Laplace, in 1787, found that there resulted from the mutual attraction of these two planets a great Inequality, of which the period is 929 years and a half, and which has accelerated Jupiter and retarded Saturn ever since the restoration of astronomy.