

preface to the second edition of the *Principia*, Cotes remarks,<sup>18</sup> that the perturbation of Jupiter and Saturn is not unknown to astronomers. In Halley's Tables it was noticed<sup>19</sup> that there are very great deviations from regularity in these two planets, and these deviations are ascribed to the perturbing force of the planets on each other; but the correction of these by a suitable equation is left to succeeding astronomers.

The motion of the planes and apsides of the planetary orbits was one of the first results of their mutual perturbation which was observed. In 1706, La Hire and Maraldi compared Jupiter with the Rudolphine Tables, and those of Bullialdus: it appeared that his aphelion had advanced, and that his nodes had regressed. In 1728, J. Cassini found that Saturn's aphelion had in like manner travelled forwards. In 1720, when Louville refused to allow in his solar tables the motion of the aphelion of the earth, Fontenelle observed that this was a misplaced scrupulousness, since the aphelion of Mercury certainly advances. Yet this reluctance to admit change and irregularity was not yet overcome. When astronomers had found an approximate and apparent constancy and regularity, they were willing to believe it absolute and exact. In the satellites of Jupiter, for instance, they were unwilling to admit even the eccentricity of the orbits; and still more, the variation of the nodes, inclinations, and apsides. But all the fixedness of these was successively disproved. Fontenelle in 1732, on the occasion of Maraldi's discovery of the change of inclination of the fourth satellite, expresses a suspicion that all the elements might prove liable to change. "We see," says he, "the constancy of the inclination already shaken in the three first satellites, and the eccentricity in the fourth. The immobility of the nodes holds out so far, but there are strong indications that it will share the same fate."

The motions of the nodes and apsides of the satellites are a necessary part of the Newtonian theory; and even the Cartesian astronomers now required only data, in order to introduce these changes into their Tables.

The complete reformation of the Tables of the Sun, Planets, and Satellites, which followed as a natural consequence from the revolution which Newton had introduced, was rendered possible by the labors of the great constellation of mathematicians of whom we have spoken in the last book, Clairaut, Euler, D'Alembert, and their successors; and

<sup>18</sup> Preface to *Principia*, p. xxi.

<sup>19</sup> End of Planetary Tables.