Biographical Encyclopedia of Astronomers

d'Alembert [Dalembert], Jean-Le-Rond

Born Paris, France, 16 November 1717

Died Paris, France, 29 October 1783

The works of Jean Le Rond d'Alembert in astronomy focused on celestial mechanics, then called "physical astronomy." His greatest works were his theoretical explanation of the observed phenomena of precession and nutation and his lunar theory. The mathematical operator called the d'Alembertian is used today in special relativity, among other applications. The illegitimate son of Madame de Tencin and the Chevalier Louis-Camus Destouches, he was abandoned by his mother in front of a small church in Paris called Saint-Jean-Le-Rond, whose name was given to him by the authorities. Soon after, his father had him placed in the care of a glazier's wife, to whom Jean always remained attached. Thanks to Destouches and his family, Jean Le Rond received a good education and entered a famous school, the Collège des quatre nations, where he was initiated into mathematics. At that time, he began to be called d'Alembert, probably on the initiative of the Destouches family.

After early works on pure mathematics and mechanics, d'Alembert entered the Paris Royal Academy of Sciences in 1741 and wrote several memoirs and treatises in the same disciplines, in particular the first edition of his *Traité de dynamique* in 1743. His astronomical output began in 1746, when he sent a memoir titled *Solution de quelques problèmes d'astronomie* (published in 1749) to the Berlin Academy, to which he had recently been elected a foreign member. More astronomical memoirs were sent to Berlin during 1747; they concerned the motion of the Moon and planets, but were withdrawn from publication by d'Alembert

In June 1747, d'Alembert read two memoirs on celestial mechanics to the Paris Academy. The first, *Méthode générale pour déter-miner les orbites et les mouvemens de toutes les planètes, en ayant égard à leur action mutuelle* (published in 1749), contains the basic principles of his lunar theories and his method for determining apsidal motion. The second (manuscript in the Bibliothèque nationale, published in 2002), which presents the results of an early theory for the Moon's motion and perturbations of the Earth's motion by the Moon, was withdrawn from publication. Toward the end of 1747 and the beginning of 1748, d'Alembert concentrated on lunar theory Partial results were quoted in several pamphlets deposited at the Paris Academy of Sciences; two of them still exist at the archives of the academy and in the memoir *Application de ma méthode pour déterminer les orbites des planètes à la recherche de l'orbite de la Lune* (published in 1749). His second lunar theory was finished in August 1748 (manuscript in the Bibliothèque nationale, published in 2002 under the title *Théorie de la Lune de 1748*). But like Alexis Clairaut's and Leonhard Euler's calculations, d'Alembert's theoretical calculations yielded only half the value of the mean motion of the lunar apsides. On November 15, 1747, Clairaut read a memoir to the academia, attributing this discrepancy to the Newtonian law of gravitation and suggesting that the inverse-square term must be completed by another term. D'Alembert did not participate in the controversy raised by Clairaut's communication, but he discussed the problem in his correspondence with Euler, and both tried unsuccessfully to explain the discrepancy by perturbations due to the shape of the Moon. Finally, one of the conclusions of the 1748 lunar theory is that the Newtonian law must not be changed, but that another force (a magnetic force perhaps) acts in the vicinity of the Earth.

During the last months of 1748 and the first months of 1749, d'Alembert worked on theories of the precession of equinoxes and nutation. James Bradley had announced his discovery of nutation in the 1748 volume of *Philosophical Transactions*, but it had been known for several years. D'Alembert succeeded in completely explaining the observed phenomena within the framework of Newtonian law, by using the third principle of his Traité de dynamique. His new treatise, *Recherches sur la précession des équinoxes et sur la nutation de l'axe de la Terre dans le systême newtonien*, appeared in July 1749. It also contains a critical analysis of the precession theory in Isaac Newton's *Principia* and a determination (close to the modern value) of the ratio of the Moon's mass to the Earth's

Meanwhile, Clairaut had found the origin of the discrepancy concerning lunar apsides: an insufficient precision in the resolution of the differential equations. In fact, Euler, Clairaut, and d'Alembert had obtained the developed expression of the apsidal motion up to

the second order only, with respect to the ratio of the Moon's and Earth's periods, while the contribution of the third-order term is almost as large. Nevertheless, d'Alembert's 1748 lunar theory presents a theoretical interest in the calculation of periodic inequalities and stands for the first literal theory of the lunar motion

D'Alembert returned to lunar theory in December 1749. By the end of February of the following year, he had a correct value for the apsidal mean motion, and his new theory was finished in January 1751. However, a dispute with Euler prevented him from submitting his manuscript to the St. Petersburg Academy for the 1752 prize, which was won by Clairaut. This third lunar theory of d'Alembert was close to his 1748 theory; the primary difference lies in the expression of the apsidal mean motion, now developed up to order five. It was published in January 1754 as the first book of *Recherches sur différens points importans du systême du monde*

Completed by a third part published in 1756, the treatise on mechanics of celestial bodies contains six books. Books II and V are devoted to planetary motion. Some remarks in Book V about Nicolas de La Caille's observations of the Sun gave rise to a controversy between the two academicians, illustrated by a memoir read by d'Alembert to the academy in 1758 (published in 1762). The first chapter of Book III is a continuation of the 1749 treatise on precession and nutation. It was completed by the memoir *Recherches sur la précession des équinoxes et sur la nutation de l'axe de la Terre dans l'hypothèse de la dissimilitude des méridiens*, read to the academy at the end of 1756 (published in 1759). The second chapter of Book III and Book VI deal with the Earth's figure

Two sets of lunar tables were constructed by d'Alembert from his third theory. The first is inserted in Book I of the 1754–1756 treatise. The second, *Nova tabularum lunarium emendatio*, was published separately in January 1756 in the form of corrections to late tables by John Flamsteed inserted in Pierre le Monnier's *Institutions astronomiques*, but its construction is described in Book IV. Lunar tables gave rise to a controversy between d'Alembert and Clairaut; the subjects were methods of construction, the form of the 1756 tables, and doubts expressed by d'Alembert about the accuracy of Tobias Mayer's tables. It ended with an insertion by d'Alembert in the second edition (1758) of his *Traité de dynamique*

The subsequent works of d'Alembert in celestial mechanics were, for the most part, published in the eight tomes of his *Opuscules mathématiques*, which appeared between 1761 and 1780. They can be divided into several groups

Memoirs about comets belong to Volumes II (1761), V (1768), VI (1773), and VIII (1780). The memoirs in Volume II are related to the 1759 return of Halley's comet (IP/Halley). The first gives a method to determine the perturbations of comet orbits by planets, following two plis

cachetés deposited by d'Alembert in 1759 (manuscripts at the archives of the Paris Academy of Sciences), but no numerical application is performed. The second is merely a contribution to the polemic about Clairaut's and Lalande's calculations. In 1762, this polemic gave rise to a hard confrontation between Clairaut and d'Alembert about the whole three-body problem, illustrated by several papers in journals

Tome II also contains d'Alembert's third lunar tables, in which the arguments for inequalities were provided by theory, and the coefficients were evaluated by comparing several lunar tables. Lalande was very critical of these tables in his *Bibliographie astronomique*

Several memoirs, in Volumes II, IV (1768), V, and VI of the *Opuscules*, are theoretical studies about the motions of the Moon and planets. Some of them can be connected to the problem of the observed secular acceleration of the Moon and to prizes proposed by the Paris Academy of Sciences between 1760 and 1774, before Pierre de Laplace's provisional solution in 1787. In this context, d'Alembert introduced, in Volume VI, the 200-year inequality now called the Laplace inequality. Memoirs about precession, nutation, and the similar problem of lunar libration exist in Volumes II, V, and VI. They were completed by a memoir in two parts, *Recherches sur les mouvemens de l'axe d'une planète quelconque dans l'hypothèse de la dissimilitude des méridiens,* read in 1769 to the academy (published in 1770).

In parallel, d'Alembert was a mathematician and a philosopher, and he wrote a large number of contributions to the masterpiece of the Enlightenment, the *Encyclopédie*, of which he has been an editor along with Diderot.

Michelle Chapront-Touzé

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