Biographical Encyclopedia of Astronomers

Laplace, Pierre-Simon de

Born Beaumont-en-Auge, (Calvados), France, 23 March 1749

Died Paris, France, 5 March 1827

Pierre-Simon de Laplace developed numerous mathematical techniques, played an important role in the development of the metric system, and made significant contributions to celestial mechanics. His name is remembered in the Kant-Laplace hypothesis for the origin of the Solar System and is a mathematical operator called the Laplacian. His father, Pierre, was a cider merchant, and his mother, Marie-Anne Sochon, came from a landowning family; he had a sister, Marie-Anne, born in 1745. Laplace married Marie Charlotte de Courty de Romanges on 15 May 1788. They had a daughter, Sophie-Suzanne, who died giving birth to a daughter, and a son, Charles-Émile, who died in 1874

His father expected Laplace to make a career in the Church, so he entered the local Benedictine school; at 16, he entered the College of Arts at Caen, a Jesuit school, still intending to study theology, but his interest in mathematics was piqued by two of his teachers, Christopher Gadbled and Pierre le Canu.

Le Canu was acquainted with Jean d'Alembert; when Laplace left the College of Arts without taking his degree, he went to Paris with a letter of recommendation from le Canu. According to legend, d'Alembert sent Laplace away after giving him some mathematical problems, which Laplace solved overnight. In the event, d'Alembert became one of Laplace's great supporters and obtained for him a position at the Military School in Paris

The position meant Laplace could afford to stay in Paris, and he began to bombard the *Académie royale des sciences* with papers, the first one presented on 28 March 1770. Within two years, he presented 13 papers to the academy, of which four were eventually published.

Laplace's brilliance was clear to everyone, including himself. In 1771 and 1772, the academy elected two scientists to membership, older but less capable. Laplace threatened to leave Paris; d'Alembert wrote to Joseph Lagrange, asking on Laplace's behalf if there were any positions available at the Academy of Sciences in Berlin. In the end, Laplace was elected to membership in the academy on 1 January 1773, and stayed in Paris

Laplace developed many important mathematical techniques that informed probability theory, physical science (especially the analysis of heat and sound), cosmology, and celestial mechanics. He was at last able to provide an answer to a query raised by Isaac Newton in his Opticks about the long-term stability of planetary orbits. The mutual gravitation of the planets causes their five orbital parameters to vary; finding the exact nature of these variations (called inequalities) was an important part of celestial mechanics in the years following Newton's triumph. There are two types of variation: first, a periodic variation, whereby an orbital parameter stays close to or oscillates about a mean value, and second, a secular variation, whereby an orbital parameter increases (or decreases) without bound. Determining the periodic or secular nature of a planet's semimajor axis a, eccentricity e, or orbital inclination i would shed light on the long-term stability of the Solar System

On 10 February 1773, only a month after his election to the academia, Laplace read the first part of a paper on the secular inequalities of the planets; the second part, probably read before 27 April 1774, examined the secular variations of the semimajor axis, and through a variety of *ad hoc* methods, Laplace claimed to show that the variations were purely periodic. Shortly afterward, Lagrange submitted a paper concerning variations in the line of nodes and the orbital inclination, showing that the latter were periodic, not secular. Lagrange's paper was given to Laplace to referee. Laplace immediately applied Lagrange's method, analyzed the eccentricity and (in modern parlance) the argument of perihelion, and showed that the variations of the eccentricity were likewise periodic. Laplace presented his own work in several parts between 14 July 1773 and 17 December 1774, and managed to include his work in the Mémoirs of the academy for 1772, all before Lagrange's paper appeared. In 1776, Lagrange demonstrated that the semimajor axes of the planets underwent only periodic variations. Thus, Lagrange and Laplace showed that orbital parameters remain bounded, though they still needed to establish that the variations were not only periodic but also small. In 1784, Laplace provided that result.

Today, credit is often given to Laplace alone for having proven the long-term stability of the Solar System. This stems in no small part from Laplace's popular publications, beginning with Exposition du système du monde (1796), a popular account of celestial mechanics. In it, Laplace presented the nebular hypothesis of the origin of the Solar System. Laplace noted five key observations about the Solar System:

(1) planets orbit the Sun in the same direction and in roughly the same plane;

(2) planetary satellites likewise revolve around their primaries in the same direction and in the same plane;

(3) planets, satellites, and the Sun all rotate about their own axes in the same direction and in roughly the same plane (or so Laplace thought, though today we know it to be untrue);

(4) orbital eccentricities of planets and satellites are very small; and

(5) comets disobey all of the above and appear to have their orbits randomly distributed

Laplace noted that the only person to put forward an origin of the Solar System since Newton's discoveries was Georges Leclerc, who had suggested that a coetary collision with the Sun yielded parts that later coalesced to form the planets. Laplace offered a new hypothesis: The Solar System began as a vast cloud, which began to collapse under its own gravity, with portions of the cloud condensing into planets and their satellites. Laplace pointed to the Pleiades as examples of a case where a cloud might condense into a multiple star system. Although the nebular hypothesis as Laplace presented it is no longer considered valid, the current theory of the formation of the Solar System incorporates many of Laplace's ideas

Système du monde was a mere prelude to a more ambitious and more mathematical work, *Mécanique céleste*, in which Laplace summarized everything known about celestial mechanics in five dense volumes. The work provided the first fully analytical solution to calculations of the orbital elements for a celestial body from three observations. The technique assumed that the second (middle) observation was exact, and that the first and third observations were to be approximated (via truncated series expansion) to a high degree of accuracy

Laplace sent *Mécanique céleste*'s first two volumes, which appeared in 1799, to a rising star of French politics, Napoleon Bonaparte. Napoleon had been a student at the Military School, and in September 1785 Laplace had tested Napoleon in mathematics. Napoleon installed Laplace, though only briefly, as Minister of the Interior (1799), and later made him a Grand Officer of the Legion of Honor (1802), a Chancellor of the Senate (1803), and a Count of

the Empire (1806). Laplace actively participated in the Institut de France, the *École Polytechnique*, and the *Bureau des longitudes*.

Jeff Suzuki

Selected References

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Whittaker, Sir Edmund (1949). "Laplace." *American Mathematical Monthly* 56: 369-372.