

Pierre Simon Laplace - Biography Paper

MATH 4010

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Many people contributed to the scientific fields of mathematics, physics, chemistry and astronomy. According to Gillispie (1997), Pierre Simon Laplace was the most influential scientist in all history, (p.vii). Laplace helped form the modern scientific disciplines. His techniques are used diligently by engineers, mathematicians and physicists. His diverse collection of work ranged in all fields but began in mathematics.

Laplace was born in Normandy in 1749. His father, Pierre, was a syndic of a parish and his mother, Marie-Anne, was from a family of farmers. Many accounts refer to Laplace as a peasant. While it was not exactly known the profession of his Uncle Louis, priest, mathematician or teacher, speculations implied he was an educated man. In 1756, Laplace enrolled at the Beaumont-en-Auge, a secondary school run the Benedictine order. He studied there until the age of sixteen. The next step of education led to either the army or the church. His father intended him for ecclesiastical vocation, according to Gillispie (1997 p.3). In 1766, Laplace went to the University of Caen to begin preparation for a career in the church, according to Katz (1998 p.609). Cristophe Gadbled and Pierre Le Canu taught Laplace mathematics, which in turn showed him his talents. In 1768, Laplace left for Paris to pursue mathematics further. Le Canu gave Laplace a letter of recommendation to d'Alembert, according to Gillispie (1997 p.3). Allegedly d'Alembert gave Laplace a problem which he solved immediately. This prompted d'Alembert to send a more difficult problem which Laplace also solved immediately. Fact or fiction, d'Alembert was very impressed by Laplace.

Laplace became a professor of mathematics at the Ecole Militaire through d'Alembert. He taught geometry, trigonometry, elementary analysis and statics to young cadets. During this time, Laplace wrote thirteen papers in under three years. According to Gillispie (1997), "the topics were extreme-value problems; adaption of the integral calculus to the solution of

difference equations; expansion of difference equations in a single variable in recurrent series and in more than one variable in recurro-recurrent series; application of these techniques to theory of games of chance; singular solutions of differential equations; and problems of mathematical astronomy, notably variation of the inclinations of the ecliptic and of planetary orbits, the lunar orbit, perturbations produced in the motions of the planets by the action of their satellites” (p.4). Only four from the large list were actually published. He read the first paper, “Recherches sur les maxima et minima et des lignes courbes”, before the Academy of Sciences in 1770. In this paper, he concludes the same result as Lagrange in discussion of Euler’s assumption of a constant difference. Laplace proceeded to make a general criterion for finding the true maximum and minimum for a particular case. He regarded this as his chief contribution, according to Gillispie (1997 p.5). However, his second paper was published first. This paper, “Disquisitiones de calculo integrale,” gave a particular solution for a differential equation of one class. In 1773, Laplace corrected that publication. This was the year he finally was elected to the Academy of Sciences, after being passed over two years in a row. He continued to be in correspondence with d’Alembert. D’Alembert was a big influence in Laplace’s work and was seen in the style of many of his publications. Laplace continued to produce many memoirs. “Recherches sur le calcul integral aux differences infiniment petites, et aux differences finies” marked the start of a major contribution. Lagrange proved that the integration of equation,  $X = y + H \frac{dy}{dx} + H' \frac{d^2y}{dx^2} + H'' \frac{d^3y}{dx^3} + \dots + H^{n-1} \frac{d^ny}{dx^n}$ , can always be integrated if the  $X=0$  case integration is possible, according to Gillispie (1997 p.8). Laplace again approached it more generally and modified it so that all steps could be modified to conform to the rules of algebra. Laplace was in competition with Lagrange. It pushed Laplace to work harder. They continually jumped between publications on the various topics of integral calculus. Laplace began work on

“recurro-recurrent” series. It was there he encountered probability. Used the principle of inverse probability to convince astronomers that their normal practice for obtaining an average was in error, according to Gillispie (1997 p.21). Laplace broadened probability to include all ranges from hypothetical containers, philosophic causality, scientific error to credibility of evidence. Laplace gave warning that “the science of chances must be used with care and must be modified when we pass from the mathematical cast to the physical” (Gillispie 1997 p.23). These investigations led Laplace to celestial mechanics. Laplace wanted to modify the law of gravity. He felt that gravity was a force propagated in time instead of instantaneously. He looked at the inverse-square law of attraction, especially connecting to the solar system. He concluded that the force of gravity was astonishing in its activity but finite in velocity, according to Gillispie (1997 p.35). Laplace wrote a dual memoir on probability and gravitation. Once again he interacted with Lagrange. The topics leaned more towards planetary theory now. Lagrange and Euler disagreed on the secular inequalities of the mean motions of Jupiter and Saturn. According to Gillispie (1997), Laplace agreed with Lagrange in values for apsides, eccentricities and inclinations but drastically disagreed for the mean motions (p.38). Laplace introduced a method for solving a collection of simultaneous differential equations suited for planetary perturbation theory. This became known as successive approximations. Laplace and Lagrange analyzed the orbits quite frequently. They wanted to prove that no planet would drift off into space or that any would move out of the ecliptic plane. Laplace developed a technique, now called the Laplace expansion in the theory of determinants, to eliminate any given quantity in a set of linear equations. Laplace also took on the question of how the law would be derived on the motions of tides due to gravitational forces. He decided the molecules will slide over each other as if isolated, with no detectable loss from internal collisions in the system, according to Gillispie

(1997 p.61). That solution became useful since when dealing with the physical sea, volume was not symmetrical. Laplace accomplished many feats while still early in his career.

By late 1780s, Laplace was recognized as one of the leading figures of the Academy, according to Gillispie (1997 p.67). In 1788, he married Marie-Charlotte. She was twenty years younger than him. They had two children, a son, Charles-Emile, and a daughter, Sophie-Suzanne. Laplace developed an ego by his time, claiming he was the best mathematician in France. In 1784, the government appointed him to examiner of cadets in Royal Artillery. Many accounts stated that Laplace examined and passed Napoleon Bonaparte. Due to the reorganization of the Academy in 1785, Laplace was promoted to the senior rank of pensioner. Laplace still kept in close correspondence with Lagrange. Focusing again on probability, he concentrated on the inverse probability. According to Gillispie (1997), his calculus of generating functions is, in a sense, a calculus of exponents and characteristics as well as of coefficients and variable quantities, (p.87). He then developed a technique for evaluating integrals of differential equations containing very large exponents. The Academy decided to include the summaries of birth, marriage and death in the published memoirs. Laplace addressed demography and equations to determine the probability of these natural events. Even though, Laplace found this topic to be very useful, he returned his interest to the curvature of comet orbits. He had publically criticized Boskovic and Lalande on the flaws in their approach. Laplace characterized his methods with rigorous analysis and observations known to be approximations. According to Gillispie (1997), the second order differential equations of the motion of a comet around the sun at the focus of a conic section yielded directly seventieth degree determining the distance of the comet from the earth. Coincidentally this computation was made the same time Herschel discovered the new planet Uranus in 1781. At the time, it was not certain that this discovery was

in fact a new planet. Laplace used his method to determine the comet's measurable motion. He found that neither his nor Lagrange's method worked on the present object. In 1783, Laplace finally made reference to "Herschel's planet." Laplace entered into another aspect of science, physics. Laplace began working with Lavoisier. The collaboration involved experiments on the effects of varying temperature and pressure on water, ether and alcohol. While trying to verify a barometer design, they determined thermal expansibility of glass, mercury and other metals. The joint memoir consisted of four articles: Nature of heat and its quantification; Determination of specific heats; Theoretical consequences and a program for a chemical physics; Application of the techniques to the study of combustion and respiration, according to Gillispie (1997 p.102). In 1793, The Academy managed to print their final Laplace memoir before their demise. "Sur quelques points du systeme du monde" discussed the variations on the figure of earth. According to Katz (1998), the French Revolution caused most schools to close by 1794, (p.639). Although short lived, the Ecole Normale was also constructed. Laplace taught mathematics as an assistant to Lagrange there. During this time, France wanted to standardize weights and measures. Laplace worked on this committee and helped form the length of a meter. Laplace's first book, *Exposition du systeme du monde*, published in 1776 had two distinct parts. The first part consisted of rational mechanics of the solar system limited to the celestial bodies' motion. The first part was formulated like a textbook. The second part investigated the laws of gravitational attractions. The second part was in more abstract manner than previous memoirs. Similarly to the Laplace-Lagrange interaction of integral calculus, Laplace and Legendre competed on attraction. This period marked the change in scientific ways. Laplace began work on his *Mecanique celeste* and would remain focused on the problems of planetary astronomy for the next twenty years.

Napoleon was rising to power during this time frame. In 1796, Laplace was elected president of the new Academy, the Institute de France. While Napoleon was away, Laplace became the predominant personality at the Ecole Polytechnique. For the first time in history, leading scientists were the teachers, according to Gillispie (1997 p.168). In 1799, Napoleon came to power. Laplace also published Book I and II of the *Mecanique celeste*. The *traite de mecanique celeste* was a composite work. It had the aspects of a textbook, a collection of research papers, reference book and an almanac that contains both theoretical and applied science, according to Gillispie (1997 p.184). Book I was a mathematical account of the laws of statics and dynamics in astronomical problems. Book II continued the work outlined in Laplace's first book, *Exposition du systeme du monde*, on the motion of celestial bodies. Napoleon named Laplace Minister of Interior; while only for a short six weeks it marked the beginning of the Napoleon influence over science. Napoleon appointed Laplace to the Senate and made him Chancellor. The honors and political positions continued. Laplace was named to the Legion of Honor and ennobled with the title of Count of the Empire. According to Crosland (1967), Laplace's status and wealth depended on Napoleon, (p.103). All of his given positions were equivalent to a state pension. In return, Laplace dedicated Volume three of *Mecanique celeste* and *Theorie analytique des probabilities* to Napoleon. The different volumes of *Mecanique celeste* were continually published. Book III based on the figure of planets. Book IV dealt with the motions of the sea and atmosphere. Book V discussed rotational motion. Book VI discussed the theory of planets, while Book VII was the theory of the moon. Book VIII focused on the moons of Jupiter. Book IX developed formulas for calculating cometary perturbations. Book X marked the shift of interest to problems of physics. The Society of Arcueil was formed. Most members were personal friends of Napoleon. The main group revolved around Berthollet

and Laplace. According to Crosland (1967), the Arcueil Circle was Newtonian in two ways, in its choice of problems and its method of tackling them, (p.302). During this time, Laplace had a dominating influence on French physics. According to Fox (1997), Laplace's work in physics was characterized by an interest in outstanding problems of the Newtonian tradition, (p.203). Biot, another member of the Arcueil society, became Laplace's protégé. Napoleon described Laplace as the "mathematician of the highest rank" (Crosland 1967 p.64) and Laplace addressed him as "Napoleon the Great" (Crosland 1967 p.65). This did not mean their relationship was always civil. Napoleon was not always considerate or even kind to Laplace. Eventually, Laplace voted in the Senate to overthrow Napoleon. As the changing of the guards, this change in power marked another change in science.

The Arcueil Society was no longer the powerhouse it once was. Laplace's influence was also starting to wane. Sophie Germain won the award in 1816 on her "Memoir on the vibrations of elastic plates." She went against Laplace's guidelines. This, of course, was not the only sign his power was fading. He received direct and indirect criticism on his style of physics. Few even used his approach to physics anymore. Poisson carried on the Laplacian physics into the late 1820s and 1830s. According to Fox (1997), Poisson even criticized and corrected a number of shortcomings in the theory of capillarity (p.249). His influence on classical physics was not measured by the eventual failure of some topics. With the death of his close friend, Berthollet, in 1822, Arcueil became very different. Laplace remained active there until his own death in 1827. Laplace died the same month as Newton a century later. This was very fitting considering he was called "the Newton of France" (Katz 1998 p.609). According to Crosland (1967), Biot made a short speech at the funeral. There was a eulogy given by Fourier for the Academy, Pastoret for the Chambre des Paris, Royer-Collard of the Academy Francaise and Poisson from the Bureau

des Longitudes (p.424). Fourier stated in his eulogy: "It cannot be said that it was given to him to found an entirely new science, ... but Laplace was born to perfect everything, to deepen everything, to push back all the boundaries, to solve what was thought to be insoluble. He would have completed the science of the heavens if that science could be completed."

It seemed vital to return to the Laplace transform. Laplace transform was a method of solving differential, difference and integral equations. According to Grattan-Guinness (1997), a strong controversy ensued at the Institute about this work but Laplace held strong (p.263). The use of linear differential became necessary and most common to describe engineering problems. The Laplace transformation techniques became the way to solve them. According to Nixon (1965), this mathematical tool enables differential equations to be transformed into relatively simple algebraic equations that can be manipulated until desired form was obtained (p.21). The most practical part of this method became the extensive solutions for reuse. Most problems fell into similar patterns therefore the solutions are stored in tables for later use.

Laplace made major contributions in mathematics, celestial bodies and physics to name a few. He proved to be among the greatest scientists of all time. According to Gillispie (1997), Laplace came to appreciate, what proved to be the case in the next generation, that the major contributions of probability in the foreseeable future would lie in its applicability to political and social sciences and practices (p.274). As Laplace proposed in the opening statement of *Exposition du système du monde*: "If on a clear night, and in a place where the whole horizon is in view, you follow the spectacle of the heavens, you will see it changing at every moment." Laplace changed science so it would be what it is today.

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