Urbain Jean Joseph Leverrier | Encyclopedia.com

(*b*. SaintLô, France, 11 March 1811; *d*. Paris France, 23 September 1877),

astronomy, celestial mechanics, meteorology.

Le Verrier, whose family came from Normandy, attended secondary school in his native city and then in Caen. The family's finances were modest; and his father, an estate manager, sold his house in order to send Le Verrier to Paris to prepare for the École Polytechnique. Admitted in 1831, he graduated as *élève-ingénieur* of the state tobacco company and for two years studied at the specialized school of tobacco manufacture. He then resigned to pursue chemical research under Gay-Lussac.

In 1837 Le Verrier married the daughter of his former mathematics professor. He gave private lessons to support himself and applied for the position of *répétiteur de chimie* at the École Polytechnique. Having already published two well-received memoirs on combinations of phosphorus, he was accepted— as *répétiteur d'astronomie*.

Le Verrier was already interested in astronomy; his first publication (1832) had dealt with shooting stars and had led to his first contact with the astronomer royal, George Airy. Henceforth, Le Verrier devoted himself exclusively to astronomy. In 1837 he began to study the most general problem of celestial mechanics, the stability of the solar system. The perturbations of major axes of the orbits had been treated, but Laplace had failed to obtain significant results for the eccentricities and inclinations. Extending Laplace's calculations by carrying the approximations much further and by making a more complete analytical study, Le Verrier derived in 1839 and 1840 precise limits for the eccentricities and inclinations of the seven planets, given the masses accepted at the time. For Jupiter, Saturn, and Uranus he demonstrated that stability is acquired without restriction.

Le Verrier next turned to the theoretical study of Mercury, the existing tables of which did not agree well with observation, and then to the identification of periodic comets. His progress in the analytic theory of perturbations was recognized by the Académie des Sciences; he became a member in January 1846, while engaged in the work that led him to the discovery of Neptune.

Until 1846 there was no theory of Uranus that permitted its movements to be represented satisfactorily. In 1821 Bouvard had constructed tables that, abandoning the older positions, adhered very closely to recent observations. Yet twenty years later a discrepancy of two minutes had already been observed, and several astronomers suggested that it might result from the attraction of an unknown planet. In 1845 Arago presented the problem to Le Verrier, who began by establishing a precise theory of Uranus. He then demonstrated that its observed perturbations could not be explained as the effect of the actions of Jupiter and Saturn, whatever modifications might eventually be made in the values assigned to the masses of those planets. He began to search for signs of an unknown disturbing planet. Finally, in a third memoir on the subject, appearing on 31 August 1846, Le Verrier fixed the exact position of the unknown planet and gave its apparent diameter.

Le Verrier communicated the result of his investigations to several astronomers who had powerful instruments at their disposal. Among them was J. G. Galle, at the Berlin observatory, who was notified by the Le Verrier on 23 September. Two days later he wrote to the Le Verrier: "The Planet whose position you indicated *really exists*. The same day I received your letter I found a star of the eighth magnitude that was not recorded on the excellent Carta Hora XXI (drawn by Dr. Bremiker).… The observation of the following day confirmed that it was the planet sought." The map to which Galle referred had just reached him. The object observed was fifty-two minutes from the position predicted by Le Verrier. First called Le Verrier's planet, it was eventually named Neptune.

The English astronomer J. C. Adams had independently carried out a study essentially equivalent to Le Verrier's, although less elaborate, and had sent it to Airy. Having disregarded it until apprised of le Verrier's second memoir on the subject, Airy then initiated a series of similar observations. Unfortunately, the Greenwich observatory did not posses a sufficiently accurate star map; thus identification of the planet required an effort that was not made until after the announcement of Galle's observation.

While Le Verrier, Airy, and Adams were establishing friendly relations at this period, a sharp polemic over the priority in this discovery was being conducted by French and English journalists. A short while later French and American scientists contested the role of Le Verrier's work and claimed that the discovery was due solely to chance. This assertion was based on the fact that at the end of several months, observations had shown that the elements of Neptune's orbit were quite different from those predicted by Le Verrier. Sir John Herschel explained the error of Le Verrier's opponents as follows: "The axis and excentricity are intellectual objects …, useful to represent to the mind's eye the general relations of the enquiry was to say whereabouts in space at the present moment is disturbing body…." In fact, the perturbations of Uranus by Neptune are great only when these planets are at least approximately in heliocentric conjunction; and, for these occupied by Neptune but not the totality of its orbit.

This successful application of mathematical analysis helped to make the public and governments aware of the importance of scientific research in general. Encouraged, in 1847 Le Verrier conceived the project "of embracing in a single work the whole of the planetary system," that is, of constructing theories and tables of the planets and determining their masses in a uniform manner while simultaneously taking into account all the mutual perturbations. This work, which he did not complete until a month before his death, occupies more than 4,000 pages of the *Annales de l'Observatoire de Paris*.

Le Verrier began by establishing the expansion of the perturbing force in its most general form—an expansion extended to the seventh power of the eccentricities and inclinations, and including 469 terms dependent on 154 special functions. This work, carried out in 1849, was the basis of later investigations. Le Verrier then turned to the first four planets, from Mercury to Mars, the theory and tables of which he completed in 1861. Between 1870 and 1877 he treated the other four planets.

Le Verrier's theories are literal and therefore permit interpretations of broad scope. But in elaborating them he did not adhere rigorously to his initial plan: the mutual perturbations of the big planets were too large for them all to undergo complete analytical expansions, and it was necessary to resort to interpolation procedures; for the other planets a uniform treatment was not possible, and certain constants had to be determined separately on the basis of isolated effects in which they played a preponderant role. On the whole, the ensemble represents a considerable advance in the determination of both the masses of the planets and their orbits.

Le Verrier hoped that his work would lead to further discoveries analogous to that of Neptune. His project of 1847 states that he wished to "put everything in harmony if possible and, if it is not, to declare with certainty that there exist still unknown causes of perturbations, the sources of which would then and only then be recognizable." He knew by 1843 that the observed motion of Mercury would not agree with theory. In 1859 he showed that Mercury moves as if an unknown agent produced an advance of its perihelion of about thirty-eight seconds per century. He then put forth the hypothesis of the perturbing action of an intramercurial planet—or, rather, of a group of such planets; the dimensions of a single perturbing body—on the order of those of Mercury—ruled out the possibility of this body having remained unobserved. The hypothesis was not confirmed by the observations conducted for this purpose. No satisfactory explanation was found until 1916, when Karl Schwarzschild, applying the theory of general relativity to celestial mechanics, demonstrated that the only notable correction in the orbits in relation to the Newtonian theory was an advance in the perihelia. This advance is very slight, except in the case of Mercury where it attains fortythree seconds per century. Hence the disagreement pointed out by Le Verrier ultimately became the most celebrated proof of the validity of Einstein's theory.

Le Verrier was one of the founders of modern meteorology. In 1854 the minister of war requested him to study the cyclone that struck the fleets besieging Sevastopol. His systematic inquiry in Europe and Asia enabled him to determine the path of the cyclone. Occupied during this period with the reorganization of the meteorological observation service of the Paris observatory, Le Verrier conceived "the project of a vast meteorological network designed to warn sailors of approaching storms." The greatest difficulty lay in securing the cooperation of the various telegraphic services. By 1857 the project was sufficiently advanced for distribution of a daily bulletin giving the atmospheric conditions at fourteen French and five foreign stations. In England, Robert Fitzroy took the lead in the practical application of the method, and succeeded in 1859 in establishing a storm warning and signaling center for British ports, something that Le Verrier obtained for France and continental Europe in 1863. The predictions were based on the examination of wind charts and isobars. The bulletin prepared by the Paris observatory, which became international in 1872, was sent to all European capitals; it was furnished twice a day when the situation was unsettled, and special telegrams were sent in case of severe storms. Le Verrier also organized a network of stations to report on thunderstorms. When he died, the various meteorological services were reorganized as the Bureau Central Météorologique de France.

Authoritarian and easily offended, but possessed of absolute integrity in scientific matters. Le Verrier conducted his projects like battles—in which, however, he displayed more emotion than strategy. As a result, in the course of his career he acquired the friendship and often the admiration of the greatest foreign scientists while quarreling with most of his French colleagues, who were in more direct contact with him. His dispute with Arago began, paradoxically, because the latter wished to name the new planet for Le Verrier.

Appointed director of the Paris observatory in 1854, following the death of Arago, Le Verrier successively lost the confidence of all its members. They reproached him especially for prohibiting them from taking the initiative and doing private work and for devoting to astronomy only a tenth of the available funds. His management was so contested that he was dismissed in 1870. Reinstated in 1873, after the death of his successor and enemy Charles-Eugène Delaunay, he was then prudent enough to devote all his activity to celestial mechanics. For the first time in his life he trained a student, J. B. Gaillot, who completed the theories of Jupiter and Saturn, which Le Verrier had not had the opportunity to treat thoroughly.

Le Verrier succumbed to the effects of a liver disease that caused him great discomfort during his last five years and affected his already difficult disposition. The fatal progress of this disease has been attributed to the intensity of his scientific work. His other responsibilities included a chair of celestial mechanics at the Sorbonne, created for him after the discovery of Neptune, and, beginning in 1849, a chair of astronomy. He occupied himself as well with the observatory of Marseilles, which was established at his initiative as a branch of the Paris observatory. In 1849 Le Verrier was elected deputy from La Manche, after a campaign in which he affirmed his Catholic faith and his conservative ideas. Three years later he was named to the Imperial Senate, and he remained a senator until the end of the Empire. He was a member of most of the scientific academies of Europe and had the distinction of twice receiving the gold medal of the Royal Astronomical Society of London (1868, 1876).

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