Friedrich Wilhelm Bessel

Born: 22 July 1784 in Minden, Westphalia (now Germany)
Died: 17 March 1846 in Königsberg, Prussia (now Kaliningrad, Russia)

Wilhelm Bessel's father was a civil servant in Minden. Bessel attended the Gymnasium in Minden for four years but he did not appear to be very talented, finding Latin difficult. The fact that he later became proficient in Latin, teaching himself the language, probably suggests that the Gymnasium failed to inspire Bessel. In January 1799, at the age of 14, he left school to become an apprentice to the commercial firm of Kulenkamp in Bremen. The firm was involved in the import-export business.

At first Bessel received no salary from the firm but, as his accounting skills became appreciated by the firm, he received a small salary. Interest in the countries his firm dealt with led Bessel to spend his evenings studying geography, Spanish and English. His interests turned towards navigation and he considered the problem of finding the position of a ship at sea. This in turn led him to study astronomy and mathematics and he began to make observations to determine longitude.

In 1804 Bessel wrote a paper on Halley's comet, calculating the orbit using data from observations made by Harriot in 1607. He sent his results to Heinrich Olbers, the leading comet expert of his time, who recognised at once the quality of Bessel's work and Olbers gave Bessel the task of making further observations to carry his work further. The resulting paper, at the level required for a doctoral dissertation, was published on Olbers' recommendation. From that time on Bessel concentrated on astronomy, celestial mechanics and mathematics.

Olbers suggested to Bessel, who was still an apprentice to the import-export firm, that he should become a professional astronomer. In 1806 he accepted the post of assistant at the Lilienthal Observatory, a private observatory near Bremen. It was only after some considerable thought that Bessel left the affluence that was guaranteed in his commercial job choosing instead the near poverty of the Observatory post. However the Lilienthal Observatory gave him valuable experience observing planets, in particular Saturn, its rings and satellites. He also observed comets and continued his study of celestial mechanics. In 1807 he began to work on reducing James Bradley's observations (Bradley was English Astronomer Royal from 1742 to 1762) of the positions of 3222 stars made around 1750 at Greenwich.

Bessel's brilliant work was quickly recognised and both Leipzig and Greifswald offered him posts. However he declined both. In 1809, at the age of 26, Bessel was appointed director of Frederick William III of Prussia's new Königsberg Observatory and professor of astronomy. It was not possible for Bessel to receive a professorship without first being granted the title of doctor. A doctorate was awarded by the University of Göttingen on the recommendation of Gauss, who had met Bessel in Bremen in 1807 and recognised his talents.

Although the Observatory at Königsberg was still under construction, Bessel took up his new post on 10 May 1810. He continued to work on Bradley's observations while work continued on the observatory from 1810 to 1813. Bessel's work had now become known internationally and he was honoured with the award of the Lalande Prize from the Institut de France for his tables of refraction based on Bradley's observations. Also during this period, in 1812, he was elected to the Berlin Academy.

The Königsberg Observatory was completed in 1813 and Bessel began observing there. Fricke writes in [1]:-

Bessel remained in Königsberg for the rest of his life, pursuing his research and teaching without interruption, although he often complained about the limited possibilities for observations because of the unfavourable *climate. He declined the directorship of the Berlin Observatory, fearing greater administrative and social responsibilities...*

It was in Königsberg that Bessel undertook his monumental task of determining the positions and proper motions of over 50000 stars which led to the discovery in 1838 of the parallax of 61 Cygni. However his life did not run very smoothly although he made a happy marriage in 1812 ([1]):-

... they had two sons and three daughters. [*The marriage*] *was clouded by sickness and by the early death of both sons. ... From* 1840 *on, Bessel's health deteriorated. His last long trip, in* 1842, *was to England, where he participated in the Congress of the British Association in Manchester. His meeting with important English scientists, including Herschel, impressed him deeply and stimulated him to finish and publish, despite his weakened health, a series of works. After two years he died of cancer...*

Let us examine Bessel's work in more detail. He used Bradley's data to give a reference system for the positions of stars and planets and also to determine the positions of stars. He had to deduce errors in Bradley's instruments and errors caused by refraction. He had to reduce the positions to one fixed date and eliminate the effects of the Earth's motion, the precession of the Earth and other effects. The authors of [5] write:-

Bessel was one of the first astronomers to realise that, before a positional observation could be fully relied upon, one must have quantitative knowledge of every possible error that might enter into the finished result. He came to use Bradley's and Maskelyne's eighteenth-century Greenwich observations because these two astronomers were the first to provide exhaustive analyses of their own instrumental errors, along with temperature and pressure of the atmosphere through which the measurements had been made. By eliminating all sources of error - optical, mechanical and meteorological - Bessel was able to obtain astronomical results of astonishing delicacy from which a great deal of new data could be extracted.

Bessel's work in determining the constants of precession, nutation and aberration won him further honours, such as a prize from the Berlin Academy in 1815. Bessel published Bradley's stellar positions in 1818 in a work which gives the proper motion of stars. In 1825 he was honoured by election as a Fellow of the Royal Society.

In 1830 Bessel published the mean and apparent positions of 38 stars over the 100 year period 1750-1850. These 38 stars were the 36 'fundamental stars' of Maskelyne together with two further polar stars. From periodic variations in the proper motions of Sirius and Procyon, two of Maskelyne's 36 fundamental stars, Bessel deduced that they had companion stars in orbit which had not been observed. He announced that Sirius had a companion in 1841 thus being the first to predict the existence of 'dark stars'. Ten years later the orbit of the companion was computed and it was observed in 1862.

Bessel used parallax to determine the distance to 61 Cygni announcing his result in 1838. Clearly to succeed it was important to choose a star which was close to the Sun. His method of selecting a star was based on his own data for he chose the star which had the greatest proper motion of all the stars he had studied, correctly deducing that this would mean that the star was nearby. Since 61 Cygni is a relatively dim star it was a bold choice based on his correct understanding of the cause of the proper motions. Bessel, using a Fraunhofer heliometer to make the measurements, announced his value of 0.314" which given the diameter of the Earth's orbit, gave a distance of about 10 light years. The correct value of the parallax of 61 Cygni is 0.292".

John Herschel, when he learnt of Bessel's achievement, wrote to him describing it as:-

... the greatest and most glorious triumph which practical astronomy has ever witnessed.

Olbers, told of Bessel's achievement on his 80th birthday, said it was a gift that:-

... put our ideas about the universe for the first time on a sound basis.

The Royal Astronomical Society awarded him their gold medal to mark this achievement.

Bessel also worked out a method of mathematical analysis involving what is now known as the Bessel function. He introduced this in 1817 in his study of a problem of Kepler of determining the motion of three bodies moving under mutual gravitation. This mathematical achievement is described in [1] as follows:-

Bessel was also an outstanding mathematician whose name became generally known through a special class of functions that have become an indispensable tool in applied mathematics, physics and engineering. The interest in these functions ... arose in the treatment of the problem of the perturbation in the planetary system.

Bessel functions appear as coefficients in the series expansion of the indirect perturbation of a planet, that is the motion caused by the motion of the Sun caused by the perturbing body. In 1824 he developed Bessel functions more fully in a study of planetary perturbations and published a treatise on them in Berlin. It was not the first time that special cases of the functions had appeared, Jacob Bernoulli, Daniel Bernoulli, Euler and Lagrange having studied special cases of them earlier. In fact it was probably Lagrange's work on elliptical orbits that first suggested to Bessel to work on the Bessel functions.

This remarkable man who left formal education at the age of 14 made contributions beyond astronomy and mathematics. His contributions to geodesy include [2]:-

... a correction in 1826 *to the seconds pendulum, the length of which is precisely calculated so that it requires exactly one second for a swing. During* 1831-32 *he directed geodetical measurements of meridian arcs in East Prussia, and in* 1841 *he deduced a value of* 1/299 *for the ellipticity of the Earth, the amount of elliptical distortion by which the Earth's shape departs from a perfect sphere.*

Bessel also had a very significant impact on university teaching despite the fact that he never had a university education. In [8] Klein describes how the name of Bessel, together with the names of Jacobi and Franz Neumann, is intimately linked to the reform of teaching at universities, first in Germany and then throughout the world.

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