

Newton and the history of optics

The 25th of December 1942 is the three-hundredth anniversary of the birth of Isaac Newton, discoverer of the law of universal gravitation and one of the greatest figures in the history of science. Newton's fame rests most securely on his great work "*Principia Mathematica Philosophiae Naturalis*". In this work Newton developed a system of mechanics on broad foundations and opened up many new fields of knowledge. In particular, he laid the basis of dynamical astronomy including especially planetary and lunar theory, the theory of the figure of the earth and the theory of the tides, as also of hydrodynamics and the theory of sound. The magnitude of the scientific achievements embodied in the *Principia* of Newton has been described by Lenard in the following words:

"If we open the book in order to examine it in detail, we are astonished, quite apart from the main discovery, by every part of it, and overwhelmed with admiration for the greatness, the extent, the power, as well as the fineness of structure of what he erects upon the foundations given by Pythagoras, Archimedes, Leonardo, Stevin, and in particular Galileo and Huygens using the material afforded by Copernicus, Tycho and Kepler, and the tools provided by mathematicians from Euclid to Descartes, with very essential additions of his own. We are not less astonished and almost overwhelmed, by the countless number of single achievements, which, from whatever side the work is regarded and studied, are revealed to any one capable of comprehending them. The whole, when we consider the richness of its contents, the general and detailed form, and the impression it makes of towering greatness, can only be compared to a grand old Gothic cathedral: one stands in front of it filled with astonishment, absorbed in gazing at it, and without words to express one's impressions. Great cathedrals were built in numbers by the masters of Gothic, but among the works of men of science, Newton's *Principia* is unique of its kind."

The two years 1665 and 1666 which Newton spent at his country home of Woolsthorpe after taking his Bachelor's degree at Cambridge appear to have been the formative period of his youthful genius. To these two years have been traced back his fundamental discovery of the spectral character of white light, his invention of the fluxional calculus, and his first conception of the universal law of gravitation. The recognition of Newton's transcendent abilities fortunately also came quickly, for in 1669 when he was only twenty-seven years of age, he was called to the Lucasian Professorship of Mathematics at Cambridge. In the years that followed and which were passed quietly at Cambridge, Newton published much of his work on optics and developed his thoughts on gravitation. The writing of the *Principia* was completed in 1684 and the work appeared in print in

1686. Newton's major scientific activities practically terminated in 1692. The later years of his life were spent in London in the discharge of his official duties as Warden and later as Master of the Mint. He was President of the Royal Society of London from 1703 till his death on the 20th of March 1727. Newton was buried in Westminster Abbey.

While Newton appears as a mathematical philosopher in his *Principia*, he is essentially the practical experimentalist and observer in his optical investigations which had as their starting point his desire to construct improved forms of astronomical telescope. Newton's approach to the subject is clearly stated in the opening words of the first book of his *Optics* which disclaim any desire to explain the properties of light by the aid of hypotheses. The reprint of the fourth and final edition of the book issued in 1931 makes Newton's work on the subject conveniently accessible to readers of the present day. The first book in the treatise sets out in full detail his observations on the spectral composition of white light and its consequences. The second book deals with the colours of thin and thick plates and their interpretation. The third book contains some evidently incomplete observations on what we would today call the diffraction of light by obstacles and narrow slits. The work terminates with the famous queries, thirty-one in all, in which Newton wrote down his thoughts on a wide range of topics.

As is well known, Newton favoured a corpuscular view of the nature of light. Indeed, he made it quite clear in his treatise that he rejected the wave-concepts of light advanced by Robert Hooke in his *Micrographia* (1665-67) and by Christian Huygens in his celebrated *Traite de la Lumiere* (1690). As is also well known, this had unfortunate consequences for the progress of optical science, Newton's great authority having kept back the inevitable triumph of the wave-theory of light by well over a century. The specific objection raised by Newton to the wave-theory of light in his query 28, namely that light does not bend into the region of shadow of an obstacle, was clearly based on an incomplete knowledge of the facts. This would, no doubt, have become evident to Newton himself if he had continued the experiments described in the third part of his book and approached the subject with an open mind. There has been a tendency in recent times to find some support for Newton's attitude towards the wave-theory of light in the recent revival of corpuscular idea and even to find in his hypothesis of "fits" of easy reflection and transmission, a resemblance to the ideas of the quantum mechanics. It is sufficient to remark that it is precisely the phenomena of the kind described in the second and third books of Newton's optics that form the strongest bulwarks of the wave-theory of light, and that the corpuscular aspects of the behaviour of light do not enter in the interpretation of these phenomena. Indeed, it does not seem easy to discover any real justification for Newton's rejection of the ideas advanced by his contemporaries Hooke and Huygens in explanation of the facts of optics known in their day.