Biographical Encyclopedia of Astronomers

Cotes, Roger

Born Burbage, Leicestershire, England, 10 July 1682

Died Cambridge, England, 5 June 1716

Roger Cotes was the editor of the second edition of Isaac Newton's Principia. An innovative educator and popularizer, he brought astronomy, experimental philosophy, and Newtonian physics to half a generation of Cambridge undergraduates. After his early death, Newton said of him, "Had Cotes lived we might have known something."

The second son of Reverend Robert Cotes, rector of Burbage, and Grace, daughter of Major Farmer of Barwell, Cotes was sent to Leicester School. His mathematical ability induced his uncle, Reverend John Smith, to direct his education at home. He later attended Saint Paul's School in London. Cotes matriculated at Trinity College, Cambridge, in 1699, taking his BA in 1702 and his MA in 1706. It is likely that he attended the astronomical lectures of the Newtonian Lucasian Professor William Whiston and possibly the first of Whiston's lectures on Newton's *Principia* (1704). Cotes was elected a fellow of Trinity College in 1705

As an undergraduate, Cotes impressed Richard Bentley, master of Trinity, with his abilities in astronomy and mathematics. Bentley, who early on was keen to establish Trinity College as a leader in the teaching of natural philosophy, introduced Cotes to Newton and his successor Whiston. With support from both Bentley and Whiston, Cotes was elected the first Plumian Professor of Astronomy and Experimental Philosophy in October 1707.

Bentley spearheaded a subscription to build the observatory at Trinity, although it was not completed in Cotes' lifetime. Cotes was assigned rooms in the observatory, which he occupied with his cousin and assistant Robert Smith. The observatory was equipped with astronomical instruments, including a fine brass sextant with a radius of 5 ft., a transit instrument, and a pendulum clock (the latter donated by Newton). Cotes delivered his lectures in the observatory and carried out astronomical observations from its viewing platform

Beginning in May 1707, Cotes and Whiston delivered a course of hydrostatic and pneumatic experiments, with Cotes lecturing on hydrostatics and Whiston on pneumatics. It was the first course of its kind at Cambridge, and it focused on the replication of set-piece experiments such as Boyle's air-pump experiments. Among those who attended were Stephen Hales and William Stukeley, both of whom became prominent Newtonians. After Whiston's expulsion for heresy in 1710, Cotes continued to deliver the lectures on his own.

In 1714, Cotes published a paper in the *Philosophical Transactions* entitled "Logometria." The first part of this paper deals with methods for the calculation of Briggsian logarithms. The remainder of the paper applies integration to problems concerning quadratures, the lengths of arcs, surface areas of revolution, and atmospheric density. This was the only writing by Cotes that was published independently in his lifetime

The total solar eclipse of 22 April 1715 afforded Cotes the opportunity to carry out detailed observations from the observatory. He was able to observe the occultation of three sunspots and the precise conclusion of the period of total darkness and the eclipse. These results were communicated to the *Philosophical Transactions* by Edmond Halley. Cotes also supplied Newton with a detailed sketch of the Sun's corona.

Cotes' observations of the aurora borealis on 6 March 1716 were published in the *Philosophical Transactions* by his cousin in 1720

As Plumian Professor, Cotes also acted as a commissioner of the Board of Longitude, created in 1714 to administer a £20,000 prize for the discovery of an accurate method of determining longitude at sea. Cotes was named a Fellow of the Royal Society in 1711; he took holy orders in 1713. Cotes never married.

At Bentley's suggestion, in 1709 Cotes became the editor of the second edition of Newton's *Principia*, which led to a voluminous correspondence between Cotes and Newton during the next three and a half years. Cotes' enthusiasm helped to energize the author. He was well suited for the task, given his knowledge, his ability to offer advice to Newton, and his diplomatic skills

Cotes' offer to write a preface was accepted by the author. Cotes' chief agenda is the defense of Newton's demonstration of universal gravitation, which had been attacked for reintroducing occult qualities into natural philosophy. Cotes begins by rejecting both ancient Greek and Cartesian approaches to understanding nature. The Newtonian method is one that begins with experiment and observation. Cotes speaks of this approach as "a twofold method, analytic and synthetic." He elaborates on this as follows: "From certain selected phenomena [the Newtonians] deduce by analysis the forces of nature and the simpler laws of those forces, from which they then give the constitution of the rest of the phenomena by synthesis."

Cotes writes eloquently about the power of gravity extending not only to the planets but also to comets outside the planetary system. He concludes that "the earth and the sun and all the celestial bodies that accompany the sun attract one another." It is at this point that he offers his famous argument about the same power of gravity operating in America as in Europe: "For if gravity is the cause of the fall of a stone in Europe, who can doubt that in America the cause of the fall is the same? If gravity is mutual between a stone and the earth in Europe, who will deny that it is mutual in America?" Cotes goes on to declare that "[a]ll philosophy is based on this rule, inasmuch as, if it is taken away, there is then nothing we can affirm about things universally." In response to Cartesian, Cotes affirms, "It is the proof of true philosophy to derive the natures of things from causes that truly exist, and to seek those laws by which the supreme artificer willed to establish this most beautiful order of the world, not those laws by which he could have, had it so pleased him."

In this declaration of empiricist methodology is a hint at natural theology that comes at the end of the preface. Cotes ventures into natural theological apologetics, exclaiming that "[h]e must be blind who does not at once see, from the best and wisest structures of things, the infinite wisdom and goodness of their almighty creator; and he must be mad who refuses to acknowledge them." Cotes then speaks particularly about the role of Newton's magnum opus in promoting natural theology: "Newton's excellent treatise will stand as a mighty fortress against the attacks of atheists; nowhere else will you find more effective ammunition against that impious crowd." This confirms that he agreed with Newton's apologetics that Newton, in the General Scholium, added to the Principia's second edition

After Cotes' death, his cousin Smith succeeded him to the Plumian Professorship and edited and published Cotes' mathematical writings as *Harmonia mesurarum* (1722). The first part of this volume consists of a reprint of Cotes' "Logometria." The second part is made up of elaborations of Newton's fluxions and contains the theorem subsequently known as Cotes's theorem. The third part is a collection of Cotes' other writings on mathematics, including a paper on Newton's differential method that contains an articulation of what has come to be known as the Newton-Cotes formula. Like Newton, Cotes appears to have preferred geometry

to analysis in the presentation of his mathematics. Smith also published Cotes' hydrostatic and pneumatic lectures in 1738.

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