Challis, James (1803–1882), astronomer and physicist

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- A. M. Clerke
- , revised by David B. Wilson

Challis, James (1803–1882), astronomer and physicist, was born on 12 December 1803 at Braintree, Essex, the fourth son of John Challis, a stonemason. After attending Braintree School, the Revd Daniel Copsey's school, Braintree, and Mill Hill School, Mill Hill, Middlesex, Challis matriculated at Trinity College, Cambridge, in 1821. Elected scholar of Trinity in 1824, he graduated in 1825 as senior wrangler and first Smith's prizeman, and was elected a fellow of Trinity in 1826. Ordained in 1830, he then held the college living at Papworth Everard, Cambridgeshire, until 1852. In 1831 Challis married Sarah Copsey of Braintree, the second daughter of Samuel Chandler of Tyringham, Buckinghamshire, and the widowed daughter-in-law of his former schoolmaster.

Plumian professorship

Challis examined for the mathematical tripos in 1831 and 1832, and on Airy's appointment as astronomer royal Challis was elected in February 1836 to succeed him as Plumian professor of astronomy and experimental philosophy. He became director of the Cambridge observatory at the same time. In April 1836 he was admitted a fellow of the Royal Astronomical Society (RAS), and in 1848 he was elected a fellow of the Royal Society of London. He and his wife lived at the Cambridge observatory, exercising a genial hospitality for twenty-five years. Challis once left his wife to guard an intruder at the observatory while he went for help. Stress, due to arrears of reductions derided by Airy, compelled him to resign direction of the observatory in 1861. He was replaced by J. C. Adams. Challis remained as Plumian professor, however, and in 1870 was re-elected to the Trinity fellowship which he had vacated upon his marriage.

As Plumian professor, Challis lectured on physical subjects covered by the mathematical tripos. By the time of his appointment in 1836 he had published some twenty papers on these subjects. His expertise in the area of hydrodynamics led the British Association for the Advancement of Science to invite him to write a report of the current state of research on the subject, which was published in the 1833 volume of the association's *Reports* and which he followed with a substantial 'Supplementary report' in 1836. In 1838 Challis published a syllabus for his course of experimental lectures on the equilibrium and motion of fluids and on geometrical and physical optics. Accepting the relatively new undulatory theory of light, the syllabus explained that light was transmitted through an unlimited elastic ether just as sound was conveyed through air. Challis rejected, however, the theory that light consisted of transverse ethereal vibrations. This theory was suggested by the phenomenon of the polarization of light and, in turn, implied that the ether (unlike air) possessed characteristics of a solid. Challis's views of the 1830s were central to his lifelong theoretical research, which mainly applied hydrodynamical principles to the physics of a fluid ether. Challis yielded teaching the subjects of light and fluids to Stokes in 1849 when the latter became Lucasian professor. Challis continued lecturing on practical astronomy, that is, on astronomical instruments and their use in making observations. He had published a syllabus for the lectures in 1843, and the lectures themselves appeared in 1879 as *Lectures on Practical Astronomy and Astronomical Instruments*. They emphasized instruments in the Cambridge observatory, some invented by Challis. The Plumian professor was one of four examiners for the Smith's prizes, and in that role Challis evaluated the likes of Stokes, Cayley, Adams, William Thomson, Tait, and Maxwell. He wrote letters supporting Thomson's and Stokes's applications for professorships at Glasgow University in the 1840s and, in 1856, Maxwell's for the professorship of natural philosophy at Marischal College, Aberdeen. Challis published fourteen papers in the *Transactions of the Cambridge Philosophical Society*, mostly in the 1830s and 1840s, and was president of the society from 1845 to 1847. With Thomson, he set the subject and examined for the Adams prize which Maxwell won in 1857 with his groundbreaking analysis of Saturn's rings.

Observational astronomy

Challis was best known as an observational astronomer. In his quarter century at the Cambridge observatory he emphasized determinations of the places of sun, moon, and planets, both to increase tabular accuracy and to test Newton's law of gravitation. He was the first in Britain to notice the division of Biela's comet on 15 January 1846, and he reobserved both nuclei in 1852. In fact, from the mid-1840s until the end of his directorship, he published some sixty papers reporting observations of comets and asteroids. He followed Airy's methods in his observations but improved the observatory's instrumentation. In 1848 he invented the meteoroscope, a kind of altitude-and-azimuth instrument in the form of a theodolite, designed for ascertaining the varying dimensions and positions of the zodiacal light, for measuring auroral arches, and for determining rapidly the points of appearance and disappearance of shooting stars. The next year he invented the transit-reducer, which was distinguished with a bronze medal at the Great Exhibition of 1851. Challis introduced the collimating eyepiece in 1850, and it was soon adopted at Greenwich and elsewhere. It was amended from Bohnenberger's design at his request by William Simms. From 1832 to 1864 Challis published twelve volumes of *Astronomical Observations Made at the Observatory of Cambridge*. Each volume contained an elaborate introduction, and the first two described instruments and methods.

In 1846 Challis failed to discover Neptune. Discussions of the episode, then and since, have often revealed more about the pride of nations and the wisdom of hindsight than about Challis as an observational astronomer. Adams communicated his unpublished theoretical prediction of the existence and location of an unknown planet to Challis and Airy in the autumn of 1845. Evidently, neither was entirely convinced by Adams's results, and both already had full workloads. Things changed only in June 1846 when Airy read U. Le Verrier's just published results that were similar to Adams's. By the end of July, Airy had persuaded Challis to use the Cambridge observatory's Northumberland telescope to search for the new planet. Lacking charts, Challis began plotting the positions of a few thousand stars in the appropriate part of the sky to determine which ‘star’ was moving and was therefore actually a planet. Before he finished, J. G. Galle at the Berlin observatory, using Le Verrier's prediction and an existing map of the stars in question, made the discovery in September 1846. Reviewing his observations, Challis found that he had observed the planet twice during August and once on 29 September, before learning on 1 October of its discovery. In November, Adams, Airy, and Challis read papers on the matter before the RAS, which published them in its *Memoirs*. Adams's was the first publication of his mathematical investigation; Airy's and Challis's explained their roles in the search for the new planet. Airy thought, given the simultaneous but independent theoretical and observational investigations in England and on the continent, 'that it will be found that the discovery is a consequence of what may properly be called a movement of the age' (Airy, 386). Challis's paper sounded the same theme as his report later that year to the Cambridge observatory syndicate, in which he stated: 'I lost the opportunity of announcing the discovery by deferring the discussion of the observations, being much occupied with reductions of comet observations, and little suspecting that the indications of theory were accurate enough to give a chance of discovery in so short a time' (Glaisher, 171). Airy's and Challis's accounts failed to disperse the cloud that shadowed their remaining careers for allowing such scientific glory to escape England.

Progress in physics

In numerous papers and books Challis developed a comprehensive physical theory that was both unique and characteristic of Victorian physics. His earliest publications were mathematical studies of subjects he lectured on: hydrodynamics, light, and sound. His articles in the *Philosophical Magazine* in the 1840s brought him into conflict with Airy and Stokes. Challis later extended his investigations of fluids into a *Newtonian* theory of all physical phenomena. He followed Newton's rejection of the concept of action-at-a-distance forces, his insistence that nature's unobservable qualities resemble those that could be sensed, and his advocacy of 'a certain most subtle spirit which pervades and lies hid in all gross bodies' (*Sir Isaac Newton's Mathematical Principles*, 2.547). Newton's subtle spirit became Challis's ether. Challis's resultant vision pictured nature as consisting of two ultimate components: inert, spherical atoms and an elastic, fluid ether. Challis regarded these as a priori hypotheses whose truth was made highly probable through their predictions' agreement with quantitative observation. Mind acted through ether to cause bodily activity. Ethereal oscillations acted on atoms to cause the observable phenomena of gravity, light, electricity, magnetism, and heat. Though broadly similar to Victorian field theory, Challis's specific ideas gained no discernible support. He, however, regarded his theories as the only proper development of Newton's insights. Because they were so original, Challis thought that his theories' acceptance would take time, perhaps considerable time. In 1869 he published *Notes on the principles of pure and applied calculation; and applications of mathematical principles to theories of the physical forces*, which at nearly 700 pages was by far the fullest statement of his views. *An Essay on the Mathematical Principles of Physics* (1873) and *Remarks on the Cambridge Mathematical Studies* (1875) were much shorter summaries. In both he urged Cambridge's mathematical students to use the resources of the new Cavendish Laboratory to combine theory and experiment in pursuing physical research. He seemed to be in search of disciples.

Religious studies

Challis's religious writings sought to harmonize modern science with a conservative view of the Bible. *Creation in Plan and Progress* (1861) responded to Goodwin's chapter in *Essays and Reviews*. Challis argued that Genesis was essentially God's 'antecedent plan' for creation, not a chronology of how he executed it. Even so, Genesis and science largely agreed. Light and heat from the primordial, self-luminous earth accounted for the light created on the first day as well as thick clouds of water vapour that constituted the water above the firmament that Genesis mentioned. As the earth cooled, rain fell, clouds dissipated, and the sun, moon, and stars appeared (on the fourth day). Genesis also agreed with much of the chronology of the appearance of plants and animals evident in the geological record. Though the geological record may have documented a vast period of time, human history extended only about 6000 years, back to Adam and Eve. *A Translation of the Epistle of the Apostle Paul to the Romans* (1871) maintained that Paul's use of the word 'law' was like modern science's use of the word. Hence, only now was it possible to realize what Paul meant by phrases like 'the law of faith' and 'the law of sin'. The inductive method of science guided Challis's close biblical exegesis in his *Essay on the Scriptural Doctrine of Immortality* (1880). He concluded, for example, that the eternal punishment of the Bible meant the eternal *effect* of punishment, that is, immortality. As needed, punishment would eventually make all men righteous and thus eligible for salvation.

Achievements

Challis's genuine abilities won him a senior wranglership, a Cambridge professorship, a firm position in Cambridge's school of mathematics and mathematical physics, and undeniable accomplishments in observational astronomy. Thus assured a hearing, he articulated an elaborate physical theory as well as an intricate blend of religion and science. His desire to combine conservative religion and modern science was, in fact, not unlike that of Stokes. His unified physical theory mirrored the unifying aspects of Thomson's thermodynamics and Maxwell's electromagnetic theory of light. Even Challis's persistence in the face of stern opposition resembled that of Thomson, the difference being that Thomson was right often enough—and profoundly enough—that he enjoyed enormous acclaim. Challis's particular configuration of widespread Victorian ideas, by contrast, made little mark.

In the 1870s Challis continued his stream of articles, which numbered nearly 250 altogether, including four co-authored with Adams. He even pitted his version of physics against the striking phenomena of Crookes's radiometer, once again providing a peculiar explanation that he proclaimed a great success. He published books that summarized his physical theories and set forth his religious views. He hoped that his originality in physics would bring an appointment as emeritus professor, leaving lectures to younger men and more time to himself for research. That did not happen, however. Ill health prevented his lecturing towards the end of his life, and in 1880 he appointed Alexander Freeman of St John's College as deputy to lecture for him. Challis died at his home, 2 Trumpington Street, Cambridge, on 3 December 1882 and was buried on 8 December beside his wife at Mill Road cemetery in Cambridge. A son and daughter survived him.

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