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(*b*. near Strabane, County Tyrone, Ireland, 1809, *d*, Dublin, Ireland, 24 October 1847)

physics.

There is little reliable biographical information concerning MacCullagh. He was the son of a poor farmer and apparently inherited some money from a wealthy grandfather. At any rate, he entered Trinity College, Dublin, as a pensioner in 1824 and went on to take every undergraduate honor in classics and science. In 1833 he became professor of mathematics at Trinity and in 1842 lie succeeded Humphrey Lloyd as professor of natural philosophy. MacCullagh developed the school of mathematical physics that Lloyd had founded to such an extent that in 1845 the *Cambridge Mathematical Journal* became the *Cambridge and Dublin Mathematical Journal* as part of the campaign conducted by Kelvin (its editor), Stokes, and others to upgrade mathematical physics in Britain. In 1833 MacCullagh became a member of the Royal Irish Academy. He held successively higher offices, and in 1838 received the Academy's first gold medal. In 1842 he received the Copley Medal of the Royal Society of London; he became a fellow in the following year.

MacCullagh gave seven courses of lectures on mathematical physics. In one he independently duplicated Poinsot's work on rigid bodies; in another he exploited potential theory. His papers on geometry are generally characterized by depth, taste, and elegance, while a paper on curves of the second order was also highly original.

Pursuing the goal of giving rigor to Fresnel's wave optics, MacCullagh contributed valuable geometrical constructions. He worked steadily toward clarifying the problem posed by Fresnel's theory, and by 1837 had settled on four assumptions: (1) the vibrations of the wave are parallel to the plane of polarization; (2) the density of the ether is constant, but the elastic properties vary; (3) the *vis viva* of the wave is preserved at interfaces; and (4) the vibrations are continuous across interfaces. With these as given, and assuming Fresnel's form for the wave surface, in 1837 MacCullagh set out a phenomenological theory in a paper entitled "On the Laws of Crystalline Reflexion and Refraction." (The simultaneous development of a similar theory by F. E. Neumann led to considerable nationalistic controversy.)

William Rowan Hamilton, in presenting the gold medal of the Royal Irish Academy to MacCullagh for this paper, called MacCullagh's method "mathematical induction" as opposed to "dynamical deduction," indicating that MacCullagh had sought and found a mathematical generalization of the phenomena rather than having sought to derive the phenomena from established dynamical principles. John Herschel seconded Hamilton's praise of the paper and predicted that physical optics was "on the eve of some considerable improvement … [by] searching among the phenomena for laws simple in their geometrical enunciation, …*without (for a while) much troubling ourselves how far those laws may be in apparent accordance with … general principles in dynamics*"

Three theories of physical optics were published in 1839: Cauchy's second theory, Green's elastic solid theory, and MacCullagh's dynamical theory (the first two being read on the same day). Seeking independently to deduce the phenomena from dynamical principles, MacCullagh and Green each proceeded by finding a potential for the presumed luminiferous medium and then deriving a wave equation by means of the Lagrangian variational principle. MacCullagh, in "An Essay Towards a Dynamical Theory of Crystalline Reflexion and Refraction." called this method "dynamical reasoning." Such "dynamical" theories would be "mechanical" if the potential were in turn derived from a complete mechanical structure rather than being postulated from general considerations, MacCullagh, however, admitted failure in his search for such a mechanical basis.

Stokes in 1862 led the way in preferring Green's linear displacement potential to MacCullagh's rotational potential, since the latter involved unbalanced couples. Although both Green's and MacCullagh's theories were more natural than Cauchy's-in that they avoided Cauchy's disposable constants-no theory prevailed until about 1900, when the electromagnetic theory achieved dominance.

In 1880 FitzGerald showed (in "On the Electromagnetic Theory of Reflection and Refraction of Light") that MacCullagh's formulation

could be translated into an electromagnetic one,

(Both MacCullagh's and FitzGerald's formulations are given in vector notation for clarity.) The wave equation studied by MacCullagh, FitzGerald, and later Larmor was for the displacement variable R (which was translated by FitzGerald as being equivalent to).

In a set of papers on "A Dynamical Theory of the Electric and Luminiferous Medium" (1893–1897), Larmor attempted with little success to combine MacCullagh's theory, Maxwell's electrodynamics, and Kelvin's rotationally elastic ethers. (The problem is more tractable with a purely electromagnetic approach, which also avoids the search for a mechanical basis for MacCullagh's displacement variable.)

MacCullagh's 1839 paper was a prototype of the techniques of mathematical physics exploited so successfully by the British in the latter half of the nineteenth century. It is an early example of the growing importance of rotational terms in the dynamics of continuous mediums, of which the curl relations in Maxwell's electrodynamics and Kelvin's theories of vortex motion provide prime later illustrations.

MacCullagh was an Irish nationalist and a strict adherent of the doctrines of the Roman Catholic church. He was modest and sternly moral; despite a keen relish for society, he never married. His disappointment at losing a parliamentary election, in which he had stood as a nationalist candidate, coupled with overwork, resulted in severe dyspepsia and an aggravation of earlier mental illness. He committed suicide at the age of thirty-eight.

BIBLIOGRAPHY

I. Original Works. MacCullagh's writings are gathered in John H. Jellett and Samuel Haughton, eds., *The Collected Works of James MacCullagh* (Dublin, 1880).

II. Secondary Literature. Chief biographical sources are *Encyclopaedia Brittamca*, 9th and 11th eds.; *Proceedings of the Royal Irish Academy*, **4** (1847–1850), 103–116; and *Abstracts of the Papers Communicated to the Royal Society*, **5** (1843–1853), 713–718.

On MacCullagh's work and milieu, see especially W. R. Hamilton, "Address of the President," in *Proceed-trigs of the Royal Irish Academy* 1 (1836–1839), 212–221, on the occasion of the award of the Academy's gold medal to MacCullagh. See also George F. FitzGerald, "On the Electromagnetic Theory of Reflection and Refraction of Light," in *Philosophical Transactions of the Royal Society*, **171** (1880), 691–711; Richard T. Glazebrook, "Report on Optical Theories" in *Report of the British Association for the Advancement of Science* (1885), 157–261, a thorough summary, with references, of the theories of optics available in the late nineteenth century; Joseph Larmor, *Mathematical and Physical Papers*, 2 vols, (Cambridge, 1921), of which the abstract and introduction to the first paper contain valuable historical material and commentary on method consistent with British usage of the period; his *Aether and Matter* (Cambridge, 1900) is a revision of these papers with a greater emphasis on electron theory and relativity; and George G. Stokes, "Report on Double Refraction," in *Report of the British Association for the Advancement of Science* (1862), 253–267 (in his obituary notice of Stokes, in *Scientific Papers*, V [New York, 1964], 180, Rayleigh held that Stokes had treated MacCullagh's theory unjustly). The foregoing represent the main sources for the determination of MacCullagh's place in the historical development of physical optics.

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