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(*b*. Magheragall, County Antrim, Ireland, 11 July 1857; *d* Holywood, County Down, Ireland, 19 May 1942),

theoretical physics.

Larmor was the eldest son in a large family. His father gave up farming to become a grocer in Belfast in 1863 or 1864. A shy, delicate, precocious boy, Larmor attended the Royal Belfast Academical Institution; received the B.A. and the M.A. from Queen's University, Belfast; and entered St. John's College, Cambridge, in 1877. In 1880 he was senior wrangler in the mathematical tripos (J. J. Thomson was second), was awarded a Smith's Prize, and was elected fellow of St. John's. For the next five years Larmor was professor of natural philosophy at Queen's College, Galway, then returned as a lecturer to St. John's in 1885. He succeeded Stokes as Lucasian professor in 1903 and retired from the position in 1932. His health deteriorating, he returned to Ireland to spend his final years. He never married.

Larmor became a fellow of the Royal Society in 1892 and served as a secretary from 1901 to 1912. From 1887 to 1912 he served on the council of the London Mathematical Society; he was president of this society in 1914-1915, having been at times vice–president and treasurer. The Royal Society awarded him its Royal Medal in 1915, and its Copley Medal in 1921, and he received the De Morgan Medal of the London Mathematical Society in 1914. Larmor was also awarded many honorary degrees and became a member of various foreign scientific societies. He was knighted in 1909. He represented Cambridge University in Parliament from 1911 to 1922. In his maiden speech in 1912 he defended the unionist position in the debate on Irish home rule. His major concern then and later was for education and the universities. Those who knew him report that Larmor was an unassuming, diffident man who did not readily from close friendships and whose numerous acts of generosity were performed without publicity. In the words of D'Arcy Thompson, "Larmor made few friends, perhaps; but while he lived, and they lived, he lost none."

Larmor's lectures and writings were often obscure, in that he would sketch the broad outlines of his thought without filling in the mathematical details, but this thought was stimulating and creative. He was concerned to stress the physical and geometrical characteristics of a problem rather than the analytical niceties. Of interest in this connection is his "Address on the Geometrical Method," delivered in 1896. In dynamics Larmor was a champion of the principle of least action. An early paper (1884) showed the analogies between diverse physical problems that it can bring to light. The use of the method of least action enables the compression of the basic assumptions involved in constructing a theory into a single function, from which results may be deduced with some guarantee of consistency and completeness. Larmor employed this method in his fundamental works, particularly in electron theory.

Larmor's scientific work centered on electromagnetic theory, optics, analytical mechanics, and geodynamics. As one of the great completers of the edifice of classical mathematical physics he bears comparison with H. A. Lorentz. Like Lorentz, his major work concerned electron theory, that is, the interaction of atomically charged matter and the electromagnetic field. Unlike Lorentz, Larmor did not participate to a large extent as a guide to the newer generation of physicists developing quantum theory and relativity. In general, he maintained a conservative, critical attitude toward the new ideas, particularly examining the possible limitations of the relativity theories.

Larmor's electron theory was a new fusion of electromagnetic and optical concepts. His first paper on electromagnetism, written in 1883, dealt with electromagnetic induction in conducting sheets and solids. In this work he encountered the problem of the effect of the motion of matter through the ether, the central problem leading to relativity and the key concern of his famous book, *Aether and Matter*. Larmor reported on the action of magnetism on light to the British Association for the Advancement of Science in 1893. In this report he discussed the dynamical theory of wave optics which the Irish physicist James MacCullagh had perfected in the 1830's. MacCullagh's treatment had avoided the flaws of other more or less contemporary theories, but MacCullagh had been unable to supplement his mathematical work with a specific mechanical model of the luminiferous ether. His expression for the action function of the ether corresponded to a medium possessing rotational elasticity, however, so that any element of it would resist rotation but otherwise would behave like a liquid. Kelvin's gyrostatic model of the ether, which had been the subject of an article by Larmor, removed the major objection to MacCullagh's theory on grounds of physical unrealizability. Furthermore, in 1880 G. F. FitzGerald had translated MacCullagh's analysis of optical reflection into the language of electromagnetic theory.

Inspired particularly by this last work, Larmor presented his electron theory in three important papers entitled "A Dynamical Theory of the Electric and Luminiferous Meduim" in 1894, 1896, and 1898. He combined MacCullagh's tyhpe of ether with the electromagnetic field theory by identifying the magnetic force with the rate of displacement of the ethereal medium, and the electric displacement with the absolute rotation of the medium (the curl of the displacement of the ether). At first the permanent Amperian electric currents of material atoms were treated as vortex rings in the ether, thereby introducing Kelvin's vortex theory of the atom, while electric charge was not included integrally in the theory. Two months after the first article in the series was written, however, Larmor added a section incorporating "electrons" into the theory as mobile centers of rotational strain in the ether. In the MacCullagh type of ether such centers of strain would be permanent, possess inertia, and act upon one another as charged particles do.

The second article in the series (written in 1895) developed the theory of electrons foreshadowed in the addendum to the first. The only interaction between the ether and ordinary matter was assumed to be via the discrete electrons (of both signs of charge), and Larmor discussed the relation between a microscopic theory treating the dynamics of the electron and a macroscopic theory in which the current and other variables are treated as statistical averages. The influence of the motion of the matter through the ether on ligh propagation and the null result of the Michelson–Morely experiment were treated in a fashion similar to that of Lorentz in the same year. A standard of time varying from point ot point was introduced, and it was shown that the FitzGerald–Lorentz contraction would arise out of the theory of the equilibrium of charges in a moving ether. Part 3 (written in 1897) dealt further with the effects involving material media, including motion through the ether, optical dispersion, and particularly electrical stresses. Much of this work was incorporated in *Aether and Matter* (published in 1900), which won the Adams Prize at Cambridge in 1898. This book concentrated mainly on the problem of motion of matter through the ether; here we find, perhaps for the first time, the full Lorentz transformations for space and time and for the electromagnetic field in *vacuo*.

Aside from his general version of the electron theory, constructed from a rotationally elastic ether, Larmor is noted for two specific contributions to electrodynamics. He introduced the Larmor precession, which orbiting charges undergo when subjected to a magnetic field, in 1897 in connection with a discussion of the Zeeman effect. In the same article he treated the radiation of an accelerating charge, obtaining the well–known nonrelativistic formula expressing the power radiated as proportional to the square of the product of charge and acceleration.

Larmor was interested in the dynamics of the earth's motion from 1896, when he published a work on the earth's free precession. In 1906 and 1915, with E. H. Hills, he analyzed possible causes of the irregular motion of the earth's axis; among his other articles one concerns irregularities in the earth's rotation and the definition of astronomical time(1915). Among the 104 articles included in Larmor's *Papers* is "Why

Wireless Electric Rays Can Bend Round the Earth" (1924), which was of importance for radio communications. He edited several collections of scientific papers besides his own; and he contributed valuable biographical notices of scientists, particularly one of Kelvin (1908). Strongly interested in the history of his subject, he included in his longer papers and as appendixes to his *Papers* very interesting critical summaries of the work that preceded and led to his own research. His own work owed much to "that Scoto–Irish school of physics which dominated the world in the middle of the last century," particularly to W. R. Hamilton, J. MacCullagh, J. C. Maxwell, Kelvin, and G. FitzGerald; and there is little doubt that he considered himself the last follower of this tradition.

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Original Works. Most of Larmor's papers were published in his *Mathematical and physical papers*, 2 vols. (Cambridge, 1929). Not included are his later papers on relativity, which are listed in vol. II, and most of his biographical notices. His biography of Kelvin appears in *Proceedings of the Royal Society*, **81A** (1908), i–1xxvi, *Aether and Matter* (Cambridge, 1900) was published separately.

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