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Focus: Fitzgerald and the Maxwellians

Mentor and Constant Friend: the Life of George Francis Fitzgerald (1851–1901)

D. WEAIRE and J. M. D. COEY

School of Physics, Trinity College, Dublin 2, Ireland. Email: dweaire@tcd.ie

George Francis Fitzgerald is known to most students of physics for his proposal of the Fitzgerald (-Lorentz) Contraction, but this is a minor episode in a remarkable life. Many of his ideas found expression through others. His powerful influence on the physics of his time has been reconstructed from his correspondence, as leader of the Maxwellians.

Scientific Saint

As historians continue to dig over the period in which classical physics came to a climax of fruition and failure, the modern reputation of George Francis Fitzgerald (or in the more aristocratic spelling, FitzGerald, which appears on his bookplate and elsewhere), grows steadily, almost to the proportions that it enjoyed in 1901 when he died and was accorded the rare distinction of a fulsome obituary and portrait in the new American journal *Physical Review*.

Lord Kelvin[1] said then: 'it seems to me that no one ever attained more nearly than Fitzgerald to the chief aim of man as defined by the shorter catechism of the Church of Scotland, to glorify God and enjoy him for ever.' He was indeed, as John Bell[2] declared, 'some sort of scientific *saint*'. Bell was probably unaware that Ramsay, Fitzgerald's correspondent on matters spectroscopic, declared that he was 'as good as St Gabriel in giving help'. His generous (though betimes impatient and intemperate) personality did not lend itself to compiling monumental works. Instead he left scattered traces of his influence in short

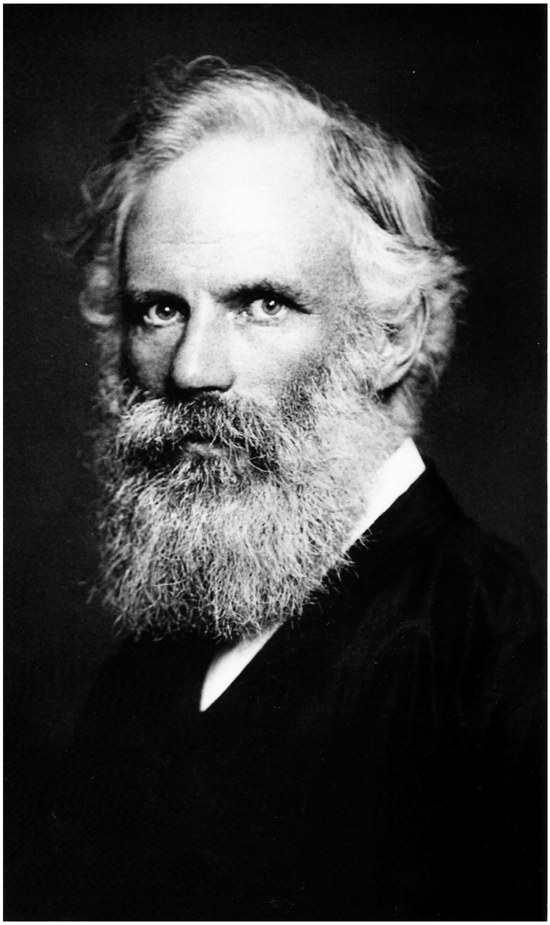

Figure 1. Fitzgerald.

publications and a voluminous correspondence, often consisting of questions to and answers from Fitzgerald. It is yet to be fully analysed.

Michael Purser[3] has described the inbred coterie of professional and academic families, clustered around Trinity College Dublin, out of which Fitzgerald emerged, as did many other notable figures of his century, from the Duke of Wellington to Oscar Wilde.

From that upbringing, privileged both in social and intellectual terms, he embarked on the obvious career for a man of his egregious talents, entering Trinity College and soon becoming Fellow and Erasmus Smith Professor of Natural and Experimental Philosophy. He did so in the same year that John Hewitt Jellett, a versatile scholar who presided over the mathematical and physical section of the British Association, became Provost of the college, in succession to yet another notable Trinity physicist, Humphrey Lloyd. He never left.

Comfortably established at Trinity College (or at least initially so), he was nevertheless a restless figure, and constantly in touch with the wider world of physics – often as a conspicuous participant in the meetings of the British Association, which greatly stimulated him. For example, at the 1897 meeting of the BA that was held in Toronto (requiring a Transatlantic crossing that seems to have bonded a lot of close friendships by enforced leisure, which we might envy today), Oliver Lodge raised a question: should one expect the spectral lines of an atom to be doubled by a magnetic field, or simply broadened? Lodge took the boat home to Liverpool straight after the meeting, but Fitzgerald availed of a post-conference trip laid on by the Dominion government to take delegates by special train across the prairies to the Rockies and British Columbia. There he had time to think, and he came to the correct conclusion that the lines should be doubled (the Zeeman Effect). He explained this conclusion, which was very relevant to the work of his former pupil Thomas Preston, in a letter to *Nature*[1].

He became a favourite source of advice for many colleagues. Monsignor Molloy, who assisted Marconi in his marine trials, asked him how the coherer (Marconi's detector) worked, when travelling with him on the railway. John Perry approached him with a tricky point in rotational dynamics, being engaged in writing a book on spinning tops, and stuck at one point. This was any easy one: Fitzgerald's father-in-law had solved the problem and published it his book *Theory of Friction*. The most persistent questions came from the Maxwellians.

The Maxwellians

Fitzgerald became the acknowledged leader of an international invisible college, the Maxwellians,[4,5] the apostles of James Clerk Maxwell. He was their Saint Paul, a constant source of advice, encouragement and bold ideas for them all, as well as a wider circle of correspondents. They included principally Hertz, Lodge, Larmor and especially Heaviside.

Heaviside's relationship with Fitzgerald was an attraction of opposites: the prestigious public figure and the reclusive eccentric, linked in mutual admiration by a shared obsession with electromagnetic theory, and interacting at a distance. It was Fitzgerald that led the representations that brought the impoverished Heaviside a small state pension in recognition of his extraordinary individual contributions to science and technology.

Richard Feynman remarked that 'from the long view of the history of mankind 10,000 years from now, there can be little doubt that the most significant event in the 19th century will be seen as Maxwell's discovery of the laws of electrodynamics'. Not Napoleon, not Marx, not Freud, not the abolition of slavery and serfdom, not the convulsions of the Commune, the Indian mutiny or the American civil war, but the fruitful fundamental theory that was brought to its final perfection by the Maxwellians.

Fitzgerald never actually met Maxwell, nor did he correspond with him directly. Their closest contact came after Fitzgerald submitted his first important paper to the Royal Society and received from its Secretary (George Gabriel Stokes) a referee's report written by Maxwell. It arrived just two days after Maxwell had died. The report contains detailed criticisms of the work, and a plea to justify the physical basis of his equations. Stokes comments 'The physical bent of Maxwell's mind would naturally lead him to picture himself a physical state, and then set himself to work out the mathematics of it. The bent of your mind is rather to look at the mathematical expressions and then seek for the physical interpretations, or perhaps even in great measure leave that alone.' Fitzgerald was to prove this characterization utterly wrong – or did the young man take Stokes' advice to heart?

Mathematician at large

Fitzgerald had much in common with another imposing natural philosopher of his time, William Thomson, Lord Kelvin. They were both Irish Protestants (of different sorts), both Irish Unionists, and they were both fascinated by the 'all-pervading ether' (albeit from different and sometimes conflicting perspectives). They shared a realistic, practical attitude to science, together with a belief in its economic importance. Both had the advantage of an excellent grounding in the modern (i.e. French) mathematics of their time, and upon that confident analytical base they were both able to explore a wide range of physical science. Despite their high mathematical competence, they both distrusted mathematical sophistication. Symbols were no substitute for facts, as Thomson and Tait warned in their textbook, and Fitzgerald inveighed against Continental natural philosophers who over-elaborated their theories. Even Boltzmann came in for this treatment, when he ventured into Fitzgerald's favourite territory [1].

Pupils and protégés

In his college Fitzgerald was regarded as the 'idol of the undergraduates and the hope of the older men'.[1] He drew around him a circle of talented pupils and protégés – often very literally in the local tea rooms, as recounted by Robert Lloyd Praeger. Among them were:

> *Thomas Preston (1865–1900)*, a tenacious young researcher and scholar who wrote influential textbooks and discovered the Anomalous Zeeman Effect.
> *John Townsend (1868–1957)* who, with Ernest Rutherford, studied under J. J. Thomson at Cambridge, and became Professor at Oxford. Discoverer of Ramsauer–Townsend Effect.

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Frederick Trouton (1863–1927) who assisted Fitzgerald in his experiments and is known for 'Trouton's Rule' in materials science. He went to University College London in 1902.
Edmund Fournier d'Albe (1868–?), versatile inventor (the first to transmit a picture by wireless), linguist and writer, author of the first popular work on the electron theory, and the first to use a fractal construction in a physical model.
Thomas Ranken Lyle (1860–1944), founder of the first physical laboratory in the southern hemisphere, in Melbourne.
John Joly (1857–1933), energetic inventor and pioneering geophysicist as Professor of Geology, and early advocate of radiotherapy.

Alone among these examples, Joly remained in Trinity (leading its volunteer defence force against possible attack in the 1916 Easter Rebellion, and reconciling himself to its eventual consequences). Fitzgerald's disciples scattered far and wide, as did the Anglo-Irish in general, and his legacy can be found in distant places, from Melbourne to the Punjab.

Scientific writings and less tangible influence

It fell to Joseph Larmor in Cambridge to gather up the 'Scientific Writings of the late George Francis Fitzgerald'.[1] He missed quite a few (some dozens) in the process, as Fitzgerald himself would surely have done. Even with due allowance for omissions and unfinished works, this collection does not come close to matching the collected works of comparable contemporaries, such as Kelvin and Stokes. He often offered his best thoughts immediately to others – in private chat or in correspondence, in public at the BA, in tea rooms, or even closer to home at the meetings of the Dublin University Experimental Science Association. He was the dominant figure in that remarkable club, which avidly pursued all the latest experiments and inventions. They had to change the rules to confer legitimacy on his domination of the entire proceedings.

DUESA was founded in the year after Fitzgerald was elected to Fellowship in Trinity. It was to comprise undergraduates and senior members and meet once a month for tea, short presentations and demonstrations, followed by discussion. Its aim was to encourage 'investigations and interesting experiments in all branches of experimental science – physics and chemistry'. At the first meeting, on 13th March 1878, the first communication 'On the Relations between the Radiometer and the Spheroidal State' was by Fitzgerald. He continued to play the leading role in the Association over the next ten years, submitting as many communications and exhibits as there were meetings (49). Their range spanned fresh and salt water rainbows, the deposition of metallic thin films, Crooke's molecular shadows, his model of the ether, the analogy between heat and electricity, the thermal resistance of clothes, the relation of surface tension to muscular contraction, photographs of the solar spectrum, electric light and power and much more. Other prominent figures in the association at that time were John Joly (37 presentations), Emerson Reynolds (30), Fred Trouton (15) and George Coffey (14). Four out of these five became Fellows of the Royal Society, as did Fitzgerald himself and several others among his Dublin associates.

When he did set out to publish his ideas and theories, they were often dashed off in haste: 'I rush out with all sorts of crude notions […]' Many important ideas were launched in a tentative or fragmentary form, mere straws in the wind or seeds broadcast in the history of physics.

Straws in the wind

The most famous example of his sporadic style is that of the Fitzgerald Contraction. This bold idea, to the effect that bodies should contract in the direction of their motion through the ether, undoubtedly drew its inspiration from the sophisticated Maxwellian correspondence on properties of the electromagnetic field, as Hunt explains,[4] but Fitzgerald misled posterity by appearing to pluck it out of thin air – or perhaps we should say out of the *ether*. It is not to be found in the Scientific Writings. Perhaps Larmor grew exasperated by having to dig such things out of obscure sources, in this case a short note in the American journal *Science*.[4]

His name survives in relativity on account of this brilliant suggestion, which was not 'baseless' as some historians have thought, but rather was founded on Maxwellian theory.[4]

Asked what happens when the velocity of a body exceeded the speed of light, a case which the theory seemed not to encompass, he replied that this may well be impossible. We can only wonder what he would have made of Einstein's theory, which arrived a few years after his death. A mere play of symbols? More likely, he would have rejoiced in another grand synthesis, like that of Maxwell.

J. D. Jackson has recently pointed out[6] that Fitzgerald, rather than Tesla, was the first to envisage the Earth as surrounded by an electromagnetic resonator, which could be excited by thunderstorms. This was merely presented to the British Association in 1893, and briefly recorded:[1] there were no equations, hardly any numbers or references, no follow-up articles …

A few other examples, none of them very well known, follow in brief.

- According to Abraham Pais,[7] he advanced with the first conception of the spin of the electron, in connection with magnetism – but the brief note in question makes only an ambiguous reference to 'rotation'.
- He certainly attributed mass to a change in the structure of space itself, but failed to develop this notion.[1]
- He gave the correct explanation of the origin of the tails of comets in another brief paper.[1]

- He was involved with Monck and others in the first use of photoelectric measurement in astronomy.[8]
- He made (with Wilson) an important contribution to the development of the electric arc as a source of illumination.[1]

The Hertz experiment

So far we have spoken of isolated contributions, quickly conceived and left behind. But underneath this restless activity lies a steadily accumulating understanding of Maxwell, leading to a climax in 1887–88. Hertz's 1887 experiment[9,10] – the emission of radio waves by an electric circuit – was the most dramatic vindication of Maxwell's theory. Fitzgerald thought long and hard about this experimental possibility, but failed to promote an experiment close to home. In part this was because he could not see a way to *detect* the waves that he thought could be generated

And so it was that the young Heinrich Hertz, surrounded in Germany by sceptics (as regards the theory of Maxwell) made the breakthrough, using a spark detector.

Fitzgerald was elated. It was the crowning moment of his career when his address[1] to the 1888 British Association meeting gave him the opportunity to expand lyrically upon the implications of the Hertz experiment. 'We have snatched the thunderbolt from Jove himself, and enslaved the all-pervading ether.'

Later he must have felt at least a pang or two of regret, especially when Marconi commercialised radio communication.[10] Fitzgerald could have been to radio what Kelvin was to telegraphy at an earlier stage – and so become Baron Liffey?

Industrial and educational policy

Fitzgerald's impassioned speeches in later life, advocating proper support for applied research in universities and government laboratories, would be entirely orthodox today but were radical in their time. Attis has recounted their content against the background of late nineteenth-century Ireland.[10] He made little headway in this crusade, and his polemics grew increasingly bitter.

Keen interest in the practical applications of science naturally translated into concern for technical education.[11] At the same time he was a stern defender of the ideal of university education as self-motivated study. It was no part of the business of the universities to teach, but rather: 'The business of Universities is to advance culture and knowledge, and to afford students an opportunity of learning how to do this.'

Furthermore (and despite his advocacy of applied science): 'If Universities do not study useless subjects, who will?' He was appointed to the Board of National Education in 1888, and offered his blunt opinions of the quality of the readers used in National Schools – cheap and bad. But it was for the areas of technical and practical education that he felt most concern. ‘Why are we so far behind in all this in Ireland? Is it the fault of the farmers – of the industrial classes?’ ‘No. It is the fault of our educational system. …. How can we expect any other result when the educational machinery of the country is controlled by a lot of very worthy old bookworms with more sympathy with the theory of equations and Greek verse than with the industrial welfare of the country? [… .] Blind leaders of the blind, we will soon all be in the ditch together.’ ‘The people are starving of bread and you have given them educational stones, and their blood cries out against you.’

For his pains, he found himself Commissioner for Intermediate Education and member the Board for Technical Education as well. The latter was responsible for a new technical institute, eventually to become today’s Dublin Institute of Technology.

He was ever concerned that scientific discourse should be clear and intelligible, as much for the benefit of students as for the practitioners themselves. Meaningless definitions earned his contempt. ‘When a student is told, as an explanation of the term mass that it means the quantity of matter, there in an appeal made from the obscure to the more obscure. It is a case of huggermugger. He is demoralized by having to swallow a term of which neither he nor his teacher has a distinct idea, and he naturally concludes that the whole subject is one which no fellow can understand.’

He believed that young children should be introduced to physical reasoning by working out the consequences of simple experiments, and he was influential in the introduction of the new ‘heuristic’ methods of science education in Ireland,[12] which took this attitude quite far. Heuristic textbooks had sealed pages of theory, to be opened only by the student after an experimental investigation. As with most educational fashions, this doctrine recurs from time to time.

Conclusion

What is it about our history that slights Irishmen and Danes, asked Jackson in his note[6] on one of Fitzgerald’s forgotten accomplishments. We have been unable to fathom the meaning of the inclusion of Danes here – Oersted has a secure seat in the scientific pantheon – but the great man did share some characteristics of Hamlet, it is true. He was eloquent, he drew close friends and widespread admirers, he was resentful of authority – and there was a self-destructive element in his denouncements of even his own college. A lot of his anguished frustration was surely was of his own making. But he was a truly inspiring influence on those who knew him, their ‘mentor and constant friend’, as Mrs Preston wrote for her dying husband.[13]

The teaching of physics can become desiccated and dispirited if we entirely neglect its vital human element. We too can be inspired by this energetic and expansive Victorian and his many friends. As Lodge said, 'Ay, he was a man worth knowing'.

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About the Authors

Denis Weaire, a Vice-President of the Academia Europaea, is Professor of Natural and Experimental Philosophy (1727) at Trinity College Dublin, as was Fitzgerald. His research is concerned with soft condensed matter. He is active in promoting the history of physics throughout Europe.

Michael Coey is Professor of Experimental Physics in Trinity College Dublin. His research is in magnetic materials and their applications.