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GEORGE GABRIEL STOKES 1819-1903
AN IRISH MATHEMATICAL PHYSICIST

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The name of Stokes, a contemporary of Kelvin and Maxwell, has become well known to generations of international scientists, mathematicians and engineers, through its association with various physical laws and mathematical formulae. In standard textbooks of mathematics, physics and engineering we find Stokes' Law, Stokes' Theorem, Stokes' Phenomenon, Stokes' conjecture and the Navier-Stokes equations. George Gabriel Stokes has long been associated with the University of Cambridge, where he spent all of his working life, occupying the Lucasian Chair of Mathematics from 1849 until his death in 1903. This prestigious chair was once held by Isaac Newton, and is currently occupied by Stephen Hawking, who has reached a wide audience outside mathematics with his "Brief History of Time". What is not well known is that Stokes was born in Skreen, County Sligo, where his father was Rector of the Church of Ireland, and received his early education there and in Dublin. Like William Thomson, later Lord Kelvin, who is often associated with Scotland (he occupied the chair of Natural Philosophy in Glasgow University) rather than with Belfast, where he was born, the contribution of Stokes has not been fully recognized in Ireland. Kelvin at least had a statue outside Queen's University, but Stokes lacked any memorial in the land of his birth. Perhaps this is a commentary on the importance which Irish society attaches to scientific vis-a-vis literary achievement. The situation was rectified, however, with the unveiling by former EU Commissioner for Agriculture, Mr Ray MacSharry, of a memorial at Stokes' birthplace in Skreen on Saturday 10th June 1995 as part of a meeting organized at Sligo RTC by the Institutes of Physics and of Mathematics and its Applications,

under the auspices of the Royal Irish Academy, as part of the Sligo 750 celebrations.

The first of the Stokes family to be recorded in history was Gabriel Stokes, born in 1682, a mathematical instrument maker residing in Essex Street, Dublin, who became Deputy Surveyor General of Ireland. Among his concerns was the use of "hydro-static balance" to ensure a piped water supply to Dublin. His great grandson, George Gabriel, returned to this problem in one of his earliest papers "The internal friction of fluids in motion" where he discussed an application to the design of an aqueduct to supply a given quantity of water to a given place. Gabriel's elder son, John, was Regius Professor of Greek and his younger son, another Gabriel, was Professor of Mathematics, both in Dublin University.

The descendants of this professor of mathematics became an important medical family in Ireland and internationally (see the article by J. B. Lyons). The first of the medical Stokes was Whitley (1763-1845), a medical Fellow of Trinity College, Dublin, whose career was temporarily interrupted from 1798 to 1800 when he was suspended for his association with the United Irishmen. Besides holding, at various times, medical chairs in Dublin University and the College of Surgeons, Whitley was Donegall Professor of Mathematics for one year (1795) and published in 1821 "Observations on the population and resources of Ireland", charging Malthus with errors. The name of his son, William Stokes (1804-1878), is preserved in medicine through Cheyne-Stokes respiration and the Stokes-Adams syndrome in cardiology. His son, Sir William Stokes (1839-1900), was Professor of Surgery at the College of Surgeons and many of his descendants are working with distinction in medicine and academia today. It is interesting to note that George Gabriel, while primarily a mathematical physicist, did, like his great-uncle Whitley, cross the boundary between mathematics and medicine by discovering the respiratory function of haemoglobin.

It is from the first Gabriel's elder son, John Stokes, that George Gabriel Stokes is descended. Much less is known about his branch of the family. Almost all of G. G. Stokes's published papers appear in the five volume Mathematical and Physical

Papers (Cambridge, 1880-1905), together with obituaries, mainly assessing the value of his contributions to science, by Lord Kelvin and Lord Rayleigh. The latter contains some personal detail of Stokes, including a much quoted anecdote, which seems to have originated with his mathematics teacher in Bristol College, "His habit, often remarked in later life, of answering with a plain yes or no, when something more elaborate was expected, is supposed to date from his transference from an Irish to an English school, when his brothers chaffed him and warned him that if he gave long Irish answers he would be laughed at by his school fellows". The additional information presented here has been obtained from manuscripts in the Cambridge University Library. These include his correspondence with, and a memoir of his life produced by, the Rev. H. P. Stokes (no relation), Vicar of St Paul's Church, Cambridge. Pembroke College, of which George Gabriel was a Fellow, lies in this Parish, and he was Churchwarden during the incumbency of H. P. Stokes. Information has also been obtained from the Notes and Recollections of his daughter, Mrs Laurence Humphry, which appear in the book edited by Larmor, [2].

In 1798, Gabriel Stokes, son of John Stokes and Rector of Skreen, married Elizabeth, the daughter of John Haughton, the Rector of Kilrea. Their first child, Sarah, died in infancy, but they produced seven further children, of whom George Gabriel was the youngest. All of his four brothers became clergymen, the oldest, John Whitley, who was already 20 when George Gabriel was born, becoming Archdeacon of Armagh. In later life Stokes talked fondly of the scenery of his boyhood and his rambles within sound of the Atlantic breakers. Even in his paper "On the theory of oscillatory waves" he writes, in the midst of mathematical equations, of "the surf which breaks upon the western coasts as the result of storms out in the Atlantic". This paper also records a visit to the Giant's Causeway to observe wave phenomena. This very private and reserved Victorian scientist had the occasional habit of breaking into poetical descriptions in the middle of mathematical proofs. In his 1902 paper on asymptotics, he describes what is now known as Stokes' phenomenon as "the inferior term enters as it were into a mist, is hidden for a little from view, and comes out with its

coefficient changed". Perhaps as a boy he had watched the mists skim the surface of flat-topped Ben Bulben across the bay, an area which was later to influence the poet W. B. Yeats. There can be no doubt that George Gabriel was greatly inspired by his upbringing in the West of Ireland, and he returned regularly for the summer vacation, a non-trivial exercise in the pre-railway era, while a student in England. Even after the death of his parents he continued to visit his brother John Whitley, then a clergyman in Tyrone, and his sister, Elizabeth Mary, to whom he was greatly attached, in Malahide almost annually until his death.

His first mathematics teacher was the Clerk of Skreen Parish, who recorded George Gabriel as "working out for himself new ways of doing sums, better than the book". He read classics with his father, who by this time was getting old; he had been 52 when George Gabriel was born. In 1832 he sent the young George Gabriel to live with his oldest brother John Whitley in Dublin so that he could attend, as a day boarder, a Dr Wall's School in Hume Street where he attracted attention by his elegant solution of geometrical problems. Gabriel Stokes died in 1834, and his widow and two daughters had to leave Skreen Rectory, but money was found to send George Gabriel to school in England. His second brother, William Haughton, had been 16th Wrangler in the Cambridge Mathematical Tripos of 1828, and obtained a Fellowship at Caius College. It was he who recommended Bristol College, whose Headmaster was Joseph Henry Jerrard, an honorary Fellow of Caius. Most of Stokes' family connections had been with Trinity College. A link with University College, Dublin, now existed in the person of his mathematics teacher in Bristol, Francis Newman, brother of Cardinal Newman. Francis Newman wrote that Stokes "did many of the propositions of Euclid as problems, without looking at the book". Stokes appears to have had a great affection for Newman, whom he records as having "a very pleasing countenance and kindly manners".

George Gabriel Stokes entered Pembroke College, the third oldest in Cambridge, as an undergraduate in 1837. H. P. Stokes points out that Queen Victoria, who had been born in the same year, 1819, as Stokes, ascended the throne in the same year as he entered university, although he outlived her by two years. Distinguished graduates from Pembroke included the martyr, Bishop Ridley, the poets Spenser and Gray, and the statesman William Pitt. Although a mathematical prodigy at school, Stokes was beaten into second place in his first year at Pembroke by one John Sykes. From second year onwards he studied, as was the custom at that time, for the highly competitive Mathematical Tripos with a private tutor, William Hopkins. So effective were these studies that Stokes was Senior Wrangler (that is, placed first in mathematics in the whole university) in 1841 and elected to a Fellowship at Pembroke. His early research was in the area of hydrodynamics, both experimental and theoretical, during which he put forward the concept of "internal friction" of an incompressible fluid. This work was independent of the work of Navier, Poisson and Saint-Venant which was appearing in the French literature at the same time, but Stokes' methods could also be applied to other continuous media such as elastic solids. He then turned his attention to oscillatory waves in water, producing the subsequently verified conjecture on the wave of greatest height, which now bears his name.

Such was Stokes' reputation as a promising young man, familiar with the latest Continental literature, that in 1849 he was appointed to the Lucasian Chair of Mathematics. At the same time, to augment his income from this poorly endowed chair, he taught at the School of Mines in London throughout the 1850's. Although appointed to the Lucasian Chair for his outstanding research, Stokes showed a concern in advance of his time for the welfare of his students, stating that he was "prepared privately to be consulted by and to assist any of the mathematical students of the university". It is recorded that Babbage, an earlier incumbent, never once addressed classes. Stokes immediately advertised that "the present professor intends to commence a lecture course in Hydrostatics", which he was still delivering 53 years later, in the last year of his life. Stokes' manuscript notes still exist in the University Library in Cambridge, although his writing was so bad that he eventually became one of the first people in Britain to make regular use of a typewriter.

The pure mathematical results of Stokes arose mainly from the needs of the physical problems which he and others studied. He was a mathematician very much driven by the needs of industrial applications in his own time. Besides his links with the School of Mines, he acted, over a period of many years, as consultant to the lensmaker Howard Grubb who ran a successful and internationally-known optical works in Rathmines. He also acted as advisor on lighthouse illuminants to Trinity House. Stokes' collected works include a paper on a differential equation relating to the breaking of railway bridges and, following the Tay Bridge disaster, he served on a Board of Trade committee to report on wind pressure on railway structures. His paper on periodic series concerned conditions for the expansion of a given function in what we now know as a Fourier series. He is also credited with having had the idea of uniform convergence of a series. His major work on the asymptotic expansion of integrals and solutions of differential equations arose from the optical research of G. B. Airy. The well-known theorem in vector calculus which bears his name is sadly not due to Stokes, but was communicated to him in a letter by Lord Kelvin. The confusion appears to have arisen because Stokes set the proof of this theorem as Question 8 in the Smith's Prize Examination Paper for 1854! There is justice in this, however, as Stokes was undoubtedly generous in sharing his unpublished ideas with others, notably with Kelvin over spectral analysis. In its leader of 3rd February 1903, following his death two days earlier, The Times wrote that "Sir G. Stokes was remarkable ... for his freedom from all personal ambitions and petty jealousies".

Stokes continued his researches in the principles of geodesy (another link with his surveyor great-grandfather) and in the theory of sound, which he treated as a branch of hydrodynamics. But perhaps his major advance was in the wave theory of light, by then well established at Cambridge, examining mathematically the properties of the ether which he treated as a sensibly incompressible elastic medium. This enabled him to obtain major results on the mathematical theory of diffraction, which he confirmed by experiment, and on fluorescence, which led him into the field of spectrum analysis. His last major paper on light was his study

of the dynamical theory of double refraction, presented in 1862. After this his time was increasingly taken up with scientific and academic administration.

A major reason for this change was that in 1851 he had been elected a Fellow of the Royal Society and shortly afterwards, in 1854, became Secretary of the Society, where he performed an important role in advising authors of research papers of possible improvements and related work. A fellow member of the Council of the Society wrote "One of the distinguishing characteristic qualities of Sir George was the generous way in which he was always ready to lay aside at once, for the moment, his own scientific work, and give his whole attention and full sympathy to any point of scientific theory or experiment about which his correspondent had sought his counsel". He acted as a sounding board for many famous scientists, including Lord Kelvin, with whom he carried on an extensive correspondence, recently edited by David B. Wilson and published by Cambridge University Press (1990), [7]. He was also extremely active in the British Association for the Advancement of Science. Many of his colleagues, including Kelvin, regretted his taking on these administrative duties and P. G. Tait even went so far as to write a letter to Nature protesting at "the spectacle of a genius like that of Stokes' wasted on drudgery [and] exhausting labour".

In 1859 Stokes vacated his Fellowship at Pembroke, as he was compelled to do by the regulations at that time, on his marriage to Mary Susannah, daughter of Dr Thomas Romney Robinson, FRS, Astronomer at Armagh. Following a change in regulations, he was subsequently able to resume his Fellowship and for the last year of his life served as Master of Pembroke. After a short stay in a house adjacent to Addenbrookes Hospital, the couple moved to Lensfield Cottage, which lay in a large garden opposite the south side of Downing College. This was by all accounts a happy and charming home, in which Stokes had a "simple study" and conducted experiments "in a narrow passage behind the pantry, with simple and homely apparatus". Do not forget that his great-grandfather had started out as an instrument maker! Unfortunately, the family life of George Gabriel and Mary was marked by tragedy: their first

two daughters died in infancy, and Stokes himself was seriously ill with scarlet fever; their second son, William George, survived to qualify as a medical doctor, but died in 1893 of an accidental overdose of morphine while a trainee general practitioner in Durham. But their elder son, Arthur Romney, a graduate of King's College, became a master at Shrewsbury School, and their youngest daughter, Isabella Lucy, married Dr Lawrence Humphry in 1889. The couple lived with Stokes at Lensfield Cottage and cared for him after the death of his wife in 1899.

Prior to their marriage Stokes, who was a tireless writer of letters, had carried on an extensive (one letter ran to 55 pages) and frank correspondence with his fiancée. In one letter, the theme of which will be familiar to all spouses of research mathematicians, he states that he has been up until 3 a.m. wrestling with a mathematical problem and fears that she will not permit this after their marriage! Based on remarks on loneliness, brooding and lack of domestic affection in other letters in this highly personal correspondence, David Wilson, [6], has suggested that "Stokes himself may have welcomed what others regretted - his abandonment of the lonely rigours of mathematical physics for domestic life and the collegiality of scientific administration".

At the General Election of 1887, Stokes offered himself as Member of Parliament for Cambridge University. As was the custom, his nomination was unopposed, but he issued a single election address, the main plank of which was opposition to the disestablishment and disendowment of the Church of England, a not surprising position for the son of an Anglican clergyman. His election caused dissension among the Fellows of the Royal Society, of which he was then President (1885-1890). Some Fellows, to judge from correspondence in Nature at the time, felt it improper that both positions should be held simultaneously and saw a possible conflict of interest. It was pointed out, however, that his distinguished predecessor, Isaac Newton, had successfully combined the holding of these academic and political offices. In Westminster, Stokes sat with the Conservatives and supported them on the Irish Question (that is, against Home Rule). He is recorded as having spoken only three times in Parliament: on 13th August 1888, in favour

of University representation on the Town Councils of Oxford and Cambridge; and on 15th August 1889 in support of two officials of the British Museum (of which he was a Trustee) who had been permitted, on behalf of The Times, to do some work for the special Irish Commission. He assured the House that the work had been done entirely out of hours! His third contribution, on 1st July 1891, was to support an amendment to the Free Education Act to enable ten shillings to be paid to every child attending school during forty weeks of the year. The amendment was defeated, and Stokes did not speak again. He found the hours of Parliament most uncongenial and he did not stand for re-election in 1892.

A deeply religious man, Stokes had always been interested in the relationship between science and religion. From 1886 to 1903 he was President of the Victoria Institute, whose aims were "To examine, from the point of view of science, such questions as may have arisen from an apparent conflict between scientific results and religious truths; to enquire whether the scientific results are or are not well founded". He delivered the Burnett lectures (on light) in the University of Aberdeen from 1883-85 and the Gifford lectures (on natural theology) in the University of Edinburgh in 1891 and 1893. Many honours were bestowed on him in later life. He was made a baronet (Sir George Gabriel Stokes) by Queen Victoria in 1889, was awarded the Copley Medal of the Royal Society in 1893, and in 1899 given a Professorial Jubilee (50 years as Lucasian Professor) by the University of Cambridge. Stokes died at Lensfield Cottage at 1 a.m. on Sunday, 1st February 1903. As a mathematician I can do no better than quote to you the leading article of The Times, which appeared two days after his death:-

"It is sometimes supposed-and instances in point may sometimes be adduced-that minds conversant with the higher mathematics are unfit to deal with the ordinary affairs of life. Sir George Stokes was a living proof that if the mathematician is only big enough, his intellect will handle practical questions so easily and as well as mathematical formulas".

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SIR GEORGE GABRIEL STOKES: THE MALAHIDE CONNECTION

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While the Irish origin and family connections of Sir George Gabriel Stokes are well documented, [1], [2], the fact that he maintained continuous contact with his family in Ireland is probably not as well known. This connection is recorded on a brass tablet which is mounted on the wall of the east (right) transept of Saint Andrew's Church, Malahide. The inscription reads

> *To the Glory of God and in memory of*
> *Sir George Gabriel Stokes Bart*
> *Master of Pembroke College*
> *and for 53 years Professor of Mathematics*
> *in the University of Cambridge*
> *which he represented in Parliament 1887–92.*
> *President of the British Association 1869,*
> *and of the Royal Society 1885–90.*
> *He was a Member of the French Academy of Science,*
> *was decorated with the Prussian Order of Merit,*
> *& received many other honours for his discoveries*
> *in previously unexplored regions of Science*
> *Endowed with rare intellectual gifts*
> *yet simple hearted as a child*
> *and seeking truth above all things*
> *He was a devout believer in Him*
> *Whom he often worshipped in this church*
> *and in the Knowledge of Whom is everlasting life*
> *Born in County Sligo, 1819. Died at Cambridge, 1903.*
> *"The Lord is my Light"*