'TO THE GLORY OF GOD, HONOUR OF IRELAND AND FAME OF AMERICA': A BIOGRAPHICAL SKETCH OF FRANCIS D. MURNAGHAN

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Abstract

The subject of this memoir is an Irish mathematician who achieved considerable recognition and was a major influence in the US mathematical world of the first half of the twentieth century. Some of his work has continued to be of importance up to the present day. He is one of the most distinguished mathematics graduates of University College Dublin. Surprisingly, there does not appear to be any biography or appreciation of him in the literature, either in Ireland or elsewhere. (All that I am aware of is a very short memoir in 1976 by Richard T. Cox ('Francis Dominic Murnaghan (1873–1976)', *Year Book of the American Philosophical Society* (1976), 109–14).) This article is an attempt to rectify the omission. Hopefully it can be read with profit by both mathematicians and non-mathematicians.

1. Introduction

Francis Dominic Murnaghan (Fig. 1) was born in Omagh, Co. Tyrone, Ireland, on 4 August 1893. He was brought up and educated in Omagh, where he matriculated from the Irish Christian Brothers' secondary school in 1910. He entered University College Dublin (UCD), where he obtained a first-class honours BA degree in Mathematical Science in 1913. This was a considerable achievement because a first-class honour in Mathematical Science was not awarded very often in those days. Murnaghan was one of only five students in UCD to achieve this grade in the period 1908–28, the first twenty years of existence of the National University of Ireland (see [19]). He then took his Masters degree in UCD in 1914 and won the National University of Ireland Travelling Studentship in Mathematical Science. This enabled him to travel abroad to further his studies. Apparently he had contemplated going to Germany to study, but the outbreak of the First World War in August 1914 made him revise his plans. On the advice of his UCD Professor of Mathematical Physics, A.W. Conway, he went to Johns Hopkins University in Baltimore to study with Harry Bateman, who, despite being fairly young, already had a considerable reputation. (Bateman later moved to California—Caltech—and his name is now probably known to most mathematicians and mathematical physicists via the Bateman Manuscript Project [5]. This project, started by Bateman and continued after his death by various other mathematicians, concerns the compilation of an encyclopaedic dossier of results on the special functions of mathematical physics. See [13] for an obituary of Bateman written by Murnaghan.) In 1916 Murnaghan obtained his PhD, after which he lectured at the Rice Institute (later to become Rice University) in Houston, Texas, for a couple of years before returning to Johns Hopkins as an Associate Professor. In 1928 he was appointed as

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FIG. 1—Francis D. Murnaghan.

Professor of Mathematics in Johns Hopkins and became head of the Mathematics Department, being only the fourth person to hold this post since the University's founding in 1876. (His three predecessors, all mathematicians of distinction, were the algebraist J.J. Sylvester, the astronomer Simon Newcomb and the geometer Frank Morley.) In the early 1920s Murnaghan also spent some time as Director of Mathematical Studies at Rutgers University, New Jersey. Murnaghan remained at Johns Hopkins until he retired in 1948 and seems to have been Head of Department for most, if not all, of that period. He visited many universities, in particular acting as Visiting Professor at the University of Chicago in 1928 and 1930 and Visiting Scholar at the Institute for Advanced Study, Princeton, in 1936, where he was associated with Albert Einstein and John von Neumann, although he seems to have no joint-published work with either of them. Murnaghan was appointed in 1949 as the first Professor of Mathematics at the Instituto Tecnologico de Aeronautica, Sao Jose dos Campos, Sao Paulo, Brazil, where he lectured in both English and Portuguese until 1959. (This institute was set up to train engineers in aeronautics after the government had decided that air travel was the future for the vast country of Brazil.

Murnaghan was ideally suited to the position in view of his experience in teaching and research in the areas of mathematics pertinent to aeronautics.) After his period in Brazil he returned to Baltimore and continued working as a mathematician, being a consultant at the Applied Mathematics Laboratory of the David Taylor Model Basin, Carderock, Maryland. (The David Taylor Model Basin was set up in 1936 as a model basin for US vessels including aircraft and for the investigation of problems of ship design. In 1967 it was merged with the Marine Engineering Laboratory in Annapolis, Maryland, to establish the Naval Ship Research and Development Center, and this is now known as the Carderock Division, Naval Surface Warfare Center.) He continued to be an active mathematician, having three books published in the early 1960s and still writing a few research articles, his final article appearing in 1972. He was a member of many organisations, including the Royal Irish Academy, the US National Academy of Sciences, the American Philosophical Society, the Brazilian Academy of Sciences and the National Academy of Sciences in Peru. He was awarded an honorary doctorate by the National University of Ireland in 1940. He wrote the mathematical definitions that appeared in the second international edition of *Webster's Dictionary*. Francis Dominic Murnaghan died in Baltimore, Maryland, USA, on 24 March 1976.

2. The Murnaghan family

The Murnaghan family seems to be a particularly interesting and talented one, and it is worthwhile giving a brief account of them. We start with George Murnaghan, father of Francis, who grew up in the 1850s near Loughbrickland, close to Banbridge, Co. Down. He was educated at a Protestant-run school in the neighbourhood, although he was, and remained, an active member of the Roman Catholic church. At the age of about 20 he emigrated to the US, seeking a better life. He achieved considerable success in business as a housebuilder and keeper of a livery stable in St Louis, Missouri, before he and his wife decided to return to Ireland in the late 1880s. (He had met a Dublin girl, Angela Mooney, before going to the US. After a while she had joined him there and they had married.) The reason for their return to Ireland was that a doctor had told George that he had an arrythmic heartbeat, which was then believed to be life-threatening. So, mainly on the instigation of Angela, they decided that, if he only had a short time left, he should spend it in Ireland. The doctor was not very accurate in his diagnosis, as George lived a further 40 years and fathered six more children, in addition to the three who had already been born in the USA. George was able to buy Lisanelly, a farm of 160 acres near Omagh, Co. Tyrone, outbidding all of the locals at the auction. The local bidders, who were Protestants, mostly Presbyterians, were not at all pleased to have been outbid by an upstart Roman Catholic who had made a lot of money in the US and who was bidding in increments of £1000 rather than £100 as was the local custom. Lisanelly was a working farm, but George Murnaghan seems to have left much of this work to his family while he devoted himself to public life. He became a member, and eventually vice-chairman, of Tyrone County Council and served in the 1890s as a Nationalist Member of Parliament for the constituency of mid-Tyrone at Westminster. His experience in the US was put to very good use, and he concentrated on getting things accomplished rather than on perpetuating and exacerbating the usual religious animosities in the region.

Francis Murnaghan, known as Frank, was the seventh of the nine children of George and Angela Murnaghan. The first three, George, Mary and James, were born in the US, and they were followed by Dan, Charles, Aloysius, Francis, Vincent and Angela, all born in Ireland. George became a solicitor in Omagh after his father unsuccessfully tried to persuade him to go to the US and look after his remaining business interests there. Mary married Felix Hackett, who became very well known in Dublin. He was Professor of Experimental Physics at UCD and was also president of the RDS (Royal Dublin Society). Mary served for a long time as vice-president of the Irish Red Cross. James became a distinguished lawyer and was made a supreme court judge in Ireland, after being a barrister and Professor of Roman Law at UCD. He was also reporter to the small group of distinguished lawyers who wrote the Irish constitution. He was an avid art collector, building up a vast collection of European paintings. Dan became a medical doctor in Omagh; Charles died of a sudden illness at the age of 18; and Aloysius lived out his life as a farmer. Then came Francis, the mathematician and subject of this article, followed by Vincent, who became county engineer for Tyrone, and finally Angela, who married W.J. Williams, later to become Professor of Education at UCD. The family thus was connected with UCD in several ways. Mary, James, Dan, Francis and Vincent are on record as having studied in UCD, and one or two of their siblings may have done also, as the records seem incomplete. (See [9] for the history of UCD.)

Moving on to the next generation of Murnaghans, we see continued links with the legal and medical professions and the academic world. George had ten children, including one son, also named George, who became an Irish high court judge. Neither Mary nor James had any children, but Dan had children, one of whom, Maurice Murnaghan, became Professor of Physiology and Histology in UCD. In 1919 Francis married Ada May Kimbell, a native of Louisiana, whom he had met during his stay in Houston. They had been married for 30 years when they went to Brazil in 1949. A year later Ada died suddenly of a heart attack. She was buried in Brazil in accordance with the law of the country, which required burial very quickly after death. They had two children, Francis Dominic, Jnr, and Patricia. Francis Dominic, Jnr, had a distinguished career in the US legal world, culminating in his appointment in 1979 by President Jimmy Carter to the US circuit court of appeals. He had initially done a degree in history and literature at Johns Hopkins, but, after war service in the US navy working as an intelligence officer on the breaking of the Japanese code, he went to Harvard Law School. Apart from a two-year stint in Germany as a legal assistant to the US State Department, he spent his working life in Baltimore, where he was very active in public life and Democratic politics. His civic activities were animated by a progressive vision, encompassing deep commitment to the public sphere, to education as an instrument of equal opportunity, and to the elimination of religious, racial and sexual discrimination. He also followed his uncle James by having a love of art and became a collector of paintings. He was closely associated with the Walters Art Gallery in Baltimore for four decades, serving as president, chairman and chairman emeritus of the Walters board, and was known as a champion of the right of the public to have access to great art. He died in August 2000. Patricia, maybe influenced by being the daughter of a mathematician, studied mathematics at Bryn Mawr. As well as raising a family, she taught mathematics at a girls' school in Baltimore, where, like her father, she was chair of the Mathematics Department until her retirement. Vincent had several children, one of whom, Sheelagh Murnaghan, was an

Irish international hockey player and also followed her grandfather's lead by going into politics. In the period 1961–9 she was a Liberal Party member of the Northern Ireland parliament at Stormont, where she represented the Queen's University of Belfast constituency. She was indeed the only Liberal member at Stormont! She tried, more than once, to introduce a bill of human rights for Northern Ireland but got very little support. Queen's University now has a visiting professorship for women academics that it has named the Sheelagh Murnaghan Visiting Professorship. Angela had only one child, Desmond Williams, who became a very well-known Professor of Modern History at UCD.

Two Murnaghans of the present generation deserve special mention. Sheila Murnaghan, daughter of F.D. Murnaghan, Jnr, is Professor of Classics at the University of Pennsylvania and a grand-daughter of the mathematician. The mathematical gene is still flourishing in the Murnaghan family as there is currently a working mathematician with the surname Murnaghan. This is Fiona Murnaghan, who is a Professor of Mathematics at the University of Toronto. She is a grand-daughter of Vincent, the younger brother of Francis.

3. Murnaghan the mathematician

We will now concentrate on Francis D. Murnaghan and his contribution to the world of mathematics and its applications. He published extensively and on a wide range of topics in both pure and applied mathematics, producing a dozen books in English, three books in Portuguese and more than 90 papers, mostly in English but a few in French and in Portuguese. Here is a list of his books in chronological order:

[1922] *Vector analysis and the theory of relativity*, Johns Hopkins Press, Baltimore.
[1929] *Theoretical mechanics* (co-author Joseph Ames), Ginn, Boston–New York; republished by Dover Publications, New York [1958].
[1932] *Hydrodynamics* (co-authors H. Dryden and H. Bateman), Bulletin of the National Research Council No. 84; republished by Dover Publications, New York [1956].
[1938] *The theory of group representations*, Johns Hopkins Press, Baltimore; republished by Dover Publications, New York [1958].
[1947] *Differential and integral calculus: functions of one variable*, Remsen Press, Brooklyn.
[1948] *Introduction to applied mathematics*, Wiley Applied Mathematics Series, New York; republished by Dover Publications, New York [1963].
[1951] *Finite deformation of an elastic solid*, Wiley Applied Mathematics Series, New York.
[1954] *Algebra elementar e trigonometria*, Companhia Editora Nacional, Sao Paulo.
[1954] *Calculo avancado*, Sao Paulo Centro Technico de Aeronautica.
[1955] *Equacoes diferenciais*, Sao Paulo Centro Technico de Aeronautica.
[1956] *Analytic geometry*, Prentice-Hall, New York.
[1958] *The orthogonal and symplectic groups*, Communications of the Dublin Institute for Advanced Studies, Series A, Dublin.
[1962] *The Laplace transform: lectures on applied mathematics, vol. 1*, Spartan Books, Washington.

[1962] *The calculus of variations: lectures on applied mathematics, vol. 2*, Spartan Books, Washington.
[1962] *The unitary and rotation groups: lectures on applied mathematics*, *vol. 3*, Spartan Books, Washington.

The merit of some of these books is indicated by the fact that four of them have been reprinted as part of the Dover Publications Classics series. They are at differing levels: some, such as the 1929 mechanics book, the 1947 calculus book, the 1948 applied mathematics book and the 1956 analytic geometry book, are at the undergraduate teaching level, while others contain more advanced material. He wrote on both pure and applied mathematics, but his philosophy was that the application of mathematics was fundamentally important. His viewpoint may be illustrated by two quotes from the preface of his 1922 book: 'it is to the physicist rather than to the mathematician that we must look for the conquest of the secrets of nature' and 'this makes it the pleasure and the duty of the mathematician to adapt his powerful methods to the needs of the physicist and especially to explain these methods in a manner intelligible to anyone well-grounded in algebra and calculus'. The 1954 calculus book in Portuguese, *Calculo avancado*, incorporates material from his 1947 calculus book and extends it along the lines of the courses he was offering at the Instituto Aeronautico. The 1955 book *Equacoes diferenciais* seems to be a companion volume to the calculus book; it is a textbook for secondary schools and covers the material needed for someone preparing to enter the Instituto Aeronautico. The book includes a dedication to his wife and some remarks about how, when asked about secondary mathematics training in Brazil, he hesitated to answer out of politeness but, when pressed, had to say that it was not very good. But he wanted to add that it was even worse in the USA. The biggest problem was that too much was crammed into too little time. The three 1962 books were based on lectures given at the Applied Mathematics Laboratory of the David Taylor Model Basin, where he was consultant. His books on group representation theory (1938, 1958 and 1962) indicate his career-long fascination with this subject. Most of the material there belongs in the realm of pure mathematics, but Murnaghan makes clear that his interest stemmed from the potential applications. He says in the preface to the 1938 book that he aims to give an 'elementary and self-contained account of the theory of group representations with special reference to those groups which have turned out to be of fundamental significance for quantum mechanics, especially nuclear physics'. The 1958 book is based on lectures given during a visit to Dublin in 1957. His first book, in 1922, which is based on a graduate course at Hopkins, shows his interest in tensor analysis, a topic to which he returned many times. It is a book written by a mathematician with the aim of providing physicists with the mathematics needed for them to understand Einstein's papers and their consequences. After doing the requisite vector analysis and tensor calculus, he gives brief applications to mechanics and electromagnetic theory, as well as to relativity. Interestingly, at the end of the preface of this book he puts his address as Omagh, Ireland, June 1922. These were turbulent times in Ireland after the partition of the country under the 1921 Treaty and the start of the Irish Civil War, but he must have come home for a visit nevertheless. The 1932 hydrodynamics book seems to have arisen from its three authors being members of the National Research Council Committee on Hydrodynamics for the US National Academy of Sciences. It is a large volume of 634 pages. He seems to have collaborated

especially well with Joseph Ames, a physicist at Hopkins who would have been somewhat older than Murnaghan. An introduction to Murnaghan's first book, in 1922, was written by Ames, and the two of them collaborated to produce the 1929 book on theoretical mechanics, a topic on which both of them had given courses of admirable clarity, according to Cox [5], who was a Hopkins student at that time. One of his motivations in teaching and research was to try to narrow the gap between pure mathematics and theoretical physics. He would surely be pleased by mathematical developments of the last two decades, where physics has had a very positive input into pure mathematics, as evidenced by the work of Donaldson, Witten and others [1].

At this stage it is appropriate to explain the title of this memoir. In the 1938 book on group representations Murnaghan writes that in the days when Ireland was known as the Land of Saints and Scholars the usual inscription on an illuminated missal or literary effort was 'To the Glory of God and Honour of Ireland'. (It is likely that the young Frank would have learned this in his education by the Christian Brothers in Omagh.) In honour of his adopted country he added the phrase 'and the Fame of America' and put the pious inscription at the end of his preface. He repeated this in the preface of his 1947 calculus book, but in the 1948 applied mathematics book and the 1951 book on elasticity he changed this last phrase to 'and the Solidarity of the Americas'. This was presumably influenced by his growing association with South America, especially Brazil. In his 1958 book, based on his Dublin lectures, he deleted the bit about America but included the pious inscription in Irish as well as in English. In the Portuguese book *Calculo avancado* he did not himself include the inscription, but the translators in their preface included the phrase 'in honor of the Master, who honors Brazil with his presence' and proceeded to supply their own version of the inscription: 'Gloria de Deus, honra de Irlanda e do Brasil, e solidariedade entre as Americas'.

Lest the above give a false impression, it should be noted that, according to his family, Francis D. Murnaghan was not an especially religious man, certainly not where outward observance was concerned. For most of his life scientific thinking seemed to influence him more than his early training, which surfaced again only when he was close to death.

4. Murnaghan the researcher

Now we come to the research of Francis Murnaghan. He published papers on a wide range of topics in both pure and applied mathematics. His especial interest in the theory of group representations is evidenced by his prolific production of papers, as well as three books, on this subject. The bulk of his research papers were on this subject. His first representation theory paper appeared in 1925 in the *Bulletin of the American Mathematical Society*, and his final one in 1972 in the *Proceedings of the National Academy of Sciences*. The 1938 book became particularly well known and was reprinted by Dover in 1963. (This writer first became aware of F.D. Murnaghan via this book while learning representation theory as a graduate student.) The 1958 book was based on his lectures in Dublin in 1957. (In parts of it he used to great profit some of the work of M.J. Newell, Professor of Mathematics at University College Galway, 1955–60, and later president of that institution. See [20] for more about Newell.) This book is also referred to in the GAP manual, for the work on tensor powers of non-linear characters. (GAP is the system for computational discrete algebra that has been developed over the last fifteen years and is used by

present-day combinatorial group theorists and other algebraists.) The name of Murnaghan lives on in the literature of group representation theory via the Murnaghan–Nakayama formula. This is an efficient inductive method of calculating character values for the symmetric group. The representation theory of the symmetric group was initiated by Frobenius at the end of the nineteenth century and developed over the following two or three decades, in particular by Schur and Young. The recursion formula discovered by Murnaghan, which appears in his 1937 paper [11], is a significant generalisation of an earlier formula of Schur. For the symmetric group on n letters, Murnaghan's formula in this paper gives a way of calculating the character of a class containing at least one m-cycle, $1 \leq m < n$, from the characters of the symmetric group on $n–m$ letters. In 1941 the Japanese mathematician T. Nakayama [15] was able to give a neater formulation of the Murnaghan formula by using the hooks in the Young diagram corresponding to an irreducible representation. Hence the formula is now known as the Murnaghan–Nakayama formula (or rule). See [6] for a full description. It is still very important in group representation theory and in combinatorics. One finds the formula and its generalisations in current research papers in algebra. Other areas of pure mathematics on which he wrote include matrix theory (a few papers in the 1920s and 1930s) and geometry of the triangle (in the 1920s). He may have been influenced in this by Frank Morley, then head of the department at Hopkins, who had made considerable contributions to triangle geometry, and also possibly by the fact that one of the acknowledged world authorities on triangle geometry, as well as Euclidean geometry in general, had been John Casey, Professor of Mathematics in UCD in the period 1872–91. (He was originally appointed as professor in the Catholic University of Ireland, which became UCD sometime around 1883. See [7] for an account of the life and work of Casey. During his UCD student days Murnaghan would surely have heard about Casey and his work.) He also contributed a paper on quaternions for the quaternion centenary held in Dublin in 1943 at the Royal Irish Academy. Because it was wartime he would not have been able to attend personally. This centenary was a celebration of the 100th anniversary of the discovery of quaternions by W.R. Hamilton in Dublin. See [8] for the full story on this discovery and for an excellent modern biography of Hamilton. Other distinguished mathematicians who contributed to this centenary were G. Birkhoff, R. Colthurst, A.W. Conway, A.J. McConnell, J.L. Synge and E.T. Whittaker. The centenary papers were published by the Royal Irish Academy in 1945 [17]. Murnaghan also wrote a few papers in the latter period of his life on topics such as polynomial approximations, asymptotic series and evaluation of the probability integral. Some of this work is referred to in N.J.A. Sloane's 'On-line encyclopaedia of integer sequences', www.research.att.com/~njas/sequences, indicating that it is still of value.

In applied mathematics he wrote on a diversity of topics. His first paper, in the 1917 *American Journal of Mathematics*, was entitled 'The lines of electric force due to a moving electron'. This came from his PhD thesis of the same title and followed on from the work of Harry Bateman, who had reduced the problem of finding the equations of these lines of force to that of solving a certain differential equation of Riccati type. Murnaghan worked out the solutions in the cases of rectilinear motion, uniform circular motion in the plane, and uniform motion in a circular helix in three dimensions. Other subjects where he made contributions include electromagnetic theory, dielectrics, gravitational fields, the planar three-body problem, hydrodynamics, aeronautics, elasticity and compressibility. His work on elasticity has been applied to great effect in geophysics. Building on the theory

of finite-strain compression in [10], the physicist A.F. Birch (see [3]), who is acknowledged as the founder of the subject of solid earth geophysics, derived in 1938–9 equations for the extrapolation of seismic velocities into the upper and lower mantle of the earth's interior. In 1952 Birch derived a new form of the finite-strain pressure–density equation of state. This equation is now known as the Birch–Murnaghan equation of state and is probably the most widely used finite-strain equation in geophysics (see [18]). It is used extensively in earth and planetary science, mineralogy and materials science, and one finds many references in the recent literature to both the Birch–Murnaghan equation and the Murnaghan equation. The Murnaghan equation seems to be the version used for small compressions, with the Birch–Murnaghan equation applicable at higher pressures. It is curious to note that two papers by F.D. Murnaghan published in the same year, 1937, and in the same journal, the *American Journal of Mathematics*, but on totally different topics, one on elasticity [10] and the other on representation theory [11], have led to the perpetuation of his name in the literature. Thanks to these papers the name of F.D. Murnaghan lives on in both pure and applied mathematics.

5. Murnaghan the teacher

Now we turn to Murnaghan as a teacher. His viewpoints on teaching can be gleaned from his 1946 and 1962 articles [12; 14] on the teaching of college mathematics and from the comments in the prefaces of some of his undergraduate-level books. He clearly had strong opinions on teaching and would have left a very definite impression on the students he taught. He believed that both what you teach and how you teach it are very important but that the latter is the more important. He believed that calculus should be taught via a judicious mix of theory and practice. He also had a slightly more controversial conviction that a calculus course should start with the students being given a clear understanding of what is a real number. In [12] he writes that it takes energy on the part of the teacher to explain what $3^{1/2}-2^{1/2}$ means and that one is simply not worth one's salary, or not earning it, if one does not have the energy or will to do this. His argument is that students cannot hope to understand limits, derivatives etc. when they do not know what a number is. His 1946 calculus book begins with a chapter on real numbers, not done in a high-powered way but so as to give the students a good grasp of what real numbers are. He believed that analytic geometry was best taught via methods of vector analysis, and this seems to have been done very successfully at Hopkins during his time there. A student's view can be obtained from Richard T. Cox, who describes Murnaghan as lecturing distinctly in an agreeable voice with a bit of a brogue, loudly enough to be heard without effort by an attentive listener but seldom louder. He wrote on the blackboard with a fine hand, his writing being large enough to be read but small enough that he could keep a great deal on the board at one time. The viewpoint of a less mathematically inclined student can be found from the Pulitzer Prize-winning journalist and writer Russell Baker [2], who started classes at Johns Hopkins in 1942. He describes calculus lectures from Francis Murnaghan as follows:

> Dr Murnaghan was a spirited rosy-cheeked gentleman with silvery locks, who spoke with a pronounced Irish brogue. His energetic classroom manner was like the theatrical performance of an Irish character actor with a fondness for pixie roles.
>
> 'The calculus, boys, is a fine and smooth machine', he was fond of saying. When Baker made one of his frequent errors Murnaghan would say 'You've fudged the machine, boy.

You must never fudge the machine.' Baker quickly decided that mathematics was not for him and ended up as a journalist and writer. An address by Murnaghan in 1944 to the American Association for the Advancement of Science shows his belief in the importance of teachers instilling the spirit of mathematics rather than just giving information on methods and results. He said 'I take it as evident that no teaching can be successful which attempts to skim off the products of mathematical fermentation and ignores the process of fermentation itself.' Cormac Smith, a UCD graduate, tells that in 1948 during his MSc year at UCD he attended two sets of lectures by Murnaghan, who was visiting the Dublin Institute for Advanced Studies at the time. Smith was interested in pursuing graduate work in the US, and Murnaghan forwarded the CV and references of Smith to Johns Hopkins, which offered him a position as instructor there. Smith's acquaintance with Murnaghan was relatively brief, since the latter was in Brazil for most of Smith's time in Baltimore. However, in December 1949 Murnaghan was in Baltimore and asked Smith to accompany him to an American Mathematical Society meeting in Washington. One speaker at the meeting went on and on, the chairman ringing the bell twice before finally cutting him off. Murnaghan advised Smith never to give a paper like that and to 'always keep your arguments short and your explanations clear'.

Murnaghan supervised a number of PhD students, one of his last students being an Irishman, Richard Ingram, who wrote his thesis in 1948 on the characters of the symmetric group. Ingram, who was a Jesuit priest, went on to lecture in mathematics in UCD until his premature death in the 1960s.

In 1920 the *Scientific American* magazine held a competition, with a $5000 first prize, for the best popular essay, in no more than 3000 words, on Einstein's theories of relativity. There were 300 entrants, one of whom was Francis D. Murnaghan. A number of the entrants were already well known in the domains of mathematics and physics, while some of the others subsequently became famous. So there was a very strong field of contenders for this prize. The winner of the $5000 was a Mr Lyndon Bolton of the British Patent Office in London. Bolton was born in Dublin and moved to London at the age of nine. While Murnaghan did not win the first prize, his essay elicited much praise from the judges. They said 'Dr Murnaghan's essay is perhaps the most illuminating of all. Even the reader who does not understand it will realize that its author brings to the subject a freshness of viewpoint and an originality of treatment which are rather lacking in some of the published essays. Dr Murnaghan has come closest to making a contribution to science as well as to the semi-popular literature of science.' The Murnaghan essay is entitled 'The quest of the absolute: modern developments in theoretical physics and the climax supplied by Einstein'. The best essays, including Murnaghan's, appeared in the *Scientific American* in 1921 and were republished, together with the judges' comments, in a book called *Relativity and gravitation*, edited by J. Malcolm Bird, published by Methuen in 1921.

6. Murnaghan the administrator

We finally turn to Murnaghan as an administrator. It would seem that, like his father, he was most successful in getting things accomplished. A constant distinguishing mark of the Hopkins Mathematics Department during his period of tenure as head was a high volume of published material, both books and articles in international journals. Also he organised a steady stream of seminars and visits by mathematicians from the US and elsewhere.

There is no doubt that he was a highly influential person on the US mathematical scene in those days. In [16] it is recounted that at Princeton in 1946 a three-day mathematics symposium was held celebrating the university's bicentenary and the return to peacetime pursuits. The meeting brought together about one hundred recognised leaders in mathematics from nine countries. It was essentially all on pure mathematics, but there was a session on 'new fields' chaired by John von Neumann, and the discussions were limited to 'classical problems related to applications, and … the need and feasibility of revitalizing work in these fields'. The discussants were G. Evans, N. Wiener and two Irishmen, J.L. Synge and F.D. Murnaghan. An indicator of Murnaghan's influence is that on his retirement from Hopkins in 1948 the president of the university said that 'the Mathematics Department as he left it was entirely of his own building'.

To complete this memoir it seems apt to repeat the last sentence of [4], which says of Francis D. Murnaghan that 'his friends would rather remember him as a dedicated scholar, a devoted and painstaking researcher, and a man of courtesy, integrity, and goodwill'.

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