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G.R. Wickham: an appreciation

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Abstract

Gerry Wickham died on 24 December 1995. This article gives a short survey of his life and his work, including a list of his publications.

1. Introduction

Gerry Wickham was known around the world for his work on the diffraction and propagation of waves, especially elastic waves in the context of ultrasonic non-destructive evaluation. He died on Christmas Eve 1995, as a result of brain haemorrhages: he was 52. This special issue of *Wave Motion* is dedicated to his memory.

In this short introductory note, we shall attempt a portrait of the man and his work. To those of us who knew him, he was influential in the way he selected and tackled problems; he was also great fun to be with!

It was in this spirit that a meeting was held in Manchester, England on 15 July 1996. Lectures were given by J.D. Achenbach, M.V. Berry FRS, R.K. Chapman and J.M. Coffey, D.G. Crighton FRS, G. Kristensson, A.N. Norris, J.R. Ockendon FRS and F. Ursell FRS. The day was also used to share reminiscences and anecdotes, just as Gerry would have liked! During the meeting, Jan Achenbach agreed that a special issue of *Wave Motion* might offer a more tangible memorial.

2. Biographical sketch

Gerald Russell Wickham was born on 8 November 1943. He went to Brockenhurst Grammar School in Hampshire, England and then to the University of Surrey, England in 1962. He received a B.Sc. in Technological Mathematics in 1966, and then remained at the University as a research student. At Surrey, under the supervision of R. Shail, he was awarded a Ph.D. in Mathematics in 1970 for a thesis entitled “Some boundary effects in continuum mechanics”; this was the source of his first published paper [1].

In 1969, Gerry moved to the Department of Mathematics at the University of Manchester, England where he stayed until the summer of 1995, when he was appointed to a Chair of Mathematics at Brunel University, England.

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Gerry always played a pivotal role in the life of the Department at Manchester. For example, he was largely responsible for the computerization of the building and he was a tireless organizer of social functions over many years. Indeed, his gregariousness was legendary: he loved conferences as much (if not more) for their social interaction as for their technical proceedings. In the few short months he was at Brunel University, Gerry made many changes, and so his untimely death is a particular loss to applied mathematics there.

Gerry had wide-ranging interests apart from mathematics, including politics, music and tennis. He advised Granada Television in Manchester on mathematical recreations and puzzles. He co-authored two popular paperback books and was involved in the design and planning of various television game-shows, the best known being the long-running *The Krypton Factor*.

Gerry's sudden death came as a terrible shock. He is survived by his wife, Sue, and his two children, Jane and Andrew.

3. Scientific work

Fritz Ursell was appointed to the Beyer Chair in Applied Mathematics at Manchester in 1961. He retired in 1990, an occasion marked by the book [22]. The combined influence of Fritz Ursell and Ron Shail on Gerry's work is readily apparent: rigorous analysis of difficult problems in wave theory. An extra dimension came from his involvement with non-destructive evaluation, which provided a rich source of problems of real-world applicability.

3.1. Non-destructive evaluation

Gerry Wickham enjoyed a long and productive collaboration with the UK Central Electricity Generating Board (CEGB), Non-destructive Testing Application Centre, at Wythenshawe in Manchester, and later with the NDT scientists in the successor company Nuclear Electric. His main collaborators at the CEGB were John Coffey, and later, Bob Chapman (Chapman holds a Manchester Ph.D., obtained in 1976 for a thesis entitled "Three-dimensional problems of wave propagation in an elastic half space", written under the supervision of R.D. Gregory). Later still, Gerry worked with J. Andrew G. Temple of AEA Technology (formerly, the UK Atomic Energy Authority), at Harwell.

Gerry was especially interested in linear elastodynamics with particular emphasis on applications to the quantitative ultrasonic evaluation of material integrity. He collaborated in a number of projects relating to the quantification of radiation from ultrasonic probes and the scattering of sound from metallurgical crack-like defects. These included the development of models for ultrasonic transducers [4] and the development of theoretical techniques for the calculation of scattering from smooth fatigue cracks. This work inspired the development of the CEGB's theoretical model for the ultrasonic non-destructive testing (NDT) of smooth cracks, a model which has since been widely used to quantify NDT performance for site applications. Gerry also considered scattering from randomly undulating surfaces and cracks, and from wedges. Apart from papers published by himself and his students (and their Ph.D. theses; see Section 3.2), this work led to a number of CEGB and Nuclear Electric technical reports, including [9].

This and other work carried out during the period 1981–1988 made a significant contribution to the Safety Case for the Sizewell B pressurized water reactor which was then being introduced into the UK. Overviews of this work are available:

1. J.M. Coffey, R.K. Chapman, Application of elastic scattering theory for smooth flat cracks to the quantitative prediction of ultrasonic defect detection and sizing, Nucl. Energy 22 (1983) 319–333.
2. R.K. Chapman, An integrated model of ultrasonic NDT and its practical application, in: M. Blakemore, G.A. Georgiou (Eds.), Mathematical Modelling in Non-destructive Testing, Oxford University Press, Oxford, 1988, pp. 209–232.

3. R.K. Chapman, A system model for the ultrasonic inspection of smooth planar cracks, J. Nondestructive Eval. 9 (1990) 197–210.

More recently, Gerry was involved in the development of analytical and computational models for the propagation of ultrasound through grainy materials such as welds in austenitic steels. This work has important applications in the design and in-service testing of the components of large-scale high-integrity plant [33].

From 1988 Gerry was an invited participant in the OECD Nuclear Energy Agency PISC (Programme for the Inspection of Steel Components) Action No. 6: Validation of Theoretical Models of Non-destructive Testing.

3.2. Research students

Eight students obtained the degree of Ph.D. from the University of Manchester under Gerry Wickham's supervision; most of the theses are concerned with problems of direct relevance to the fundamentals of ultrasonic non-destructive evaluation, and several students were partially supported by the CEGB.

1. P. Cole, A new Green's function for solving the exterior Neumann problem of acoustics for an open arc, 1977.
2. P.A. Martin, The diffraction of stress waves by a penny-shaped crack in an infinite elastic solid, 1979.
3. R.J. Brind, The scattering of stress waves by an edge crack in a semi-infinite elastic solid, 1980.
4. P.S. Keogh, Some exact solutions for the scattering of stress waves by a plane finite crack in an infinite elastic solid, 1983.
5. S.A. Ramsdale, The diffraction of elastic waves by rough semi-infinite cracks, 1983.
6. P.A. Lewis, Diffraction of elastic waves by finite rough surfaces, 1990.
7. E.J. Walker, Diffraction by cracks in anisotropic solids, 1994.
8. S.J. Leppington, The scattering of sound by a fluid-loaded, semi-infinite thick elastic plate, 1995.

3.3. Early work

The transducer problem mentioned above has a classical formulation as a mixed boundary-value problem, corresponding to a vibrating rigid strip (prescribed displacement) on the otherwise free surface of a two-dimensional elastic half-space. Gerry Wickham wrote two papers on this problem [3,5], and was pleased with the short-wave analysis in [5]. Fundamental studies of problems set in elastic half-spaces recur in his work, as they often lead to difficult mathematics. See also Ref. [2].

At the same time, Gerry was becoming interested in diffraction problems. He developed the idea of what he called a 'crack Green's function', a fundamental solution so constructed that it 'knows about the presence of the crack' (it is discontinuous across the crack). Such crack Green's functions can be complicated but they lead to Fredholm integral equations of the second kind, which are easy to solve numerically. This idea is at the heart of several Ph.D. theses. Relevant papers are [6–8,25].

3.4. Collaboration with David Abrahams

I.D. Abrahams obtained his Ph.D. in 1982 from the University of London for a thesis entitled "The scattering of sound by finite thin elastic plates and cavities" (he was a student of F.G. Leppington at Imperial College). In the same year, he moved to Manchester on a 1-year contract. This was the beginning of another long collaboration, producing over a dozen papers.

First, they developed some general techniques for solving matrix Wiener–Hopf problems [10–12,15,18]. This gave the solution to a basic problem of diffraction theory, namely, scattering by two parallel, semi-infinite, staggered plates. Second, motivated by the problems of austenitic steel welds, they developed a theory for wave propagation in certain inhomogeneous anisotropic solids [13,17,21]. Third, they gave asymptotic solutions for scattering by small defects in an elastic half-space [14,16,23,24]. This made essential use of a certain expansion of the half-space Green's function [19], which dates back to Richard Brind's thesis (1980).

3.5. The Northwestern connection

Although Gerry Wickham did not have a formal connection with Northwestern University, USA, he did have a variety of informal connections. Jan Achenbach's work in elastodynamics had become very well known since the appearance of his influential book, *Wave Propagation in Elastic Solids*, in 1973. Richard Brind moved to Evanston in 1978 to take up a postdoctoral position. While he was there, he extended his thesis work on edge-cracks and co-authored several papers with Achenbach.

It was during this period that Gerry Wickham made his first visit to Northwestern University, giving a lecture there in 1980. Also, two future collaborators obtained their Ph.D.'s under Jan Achenbach's supervision: J.G. Harris for "Elastodynamic diffraction and radiation problems" in 1979; Andrew Norris for "Ray methods for inverse problems of elastic wave scattering" in 1981.

Subsequently, Gerry worked with John Harris on the scattering of ultrasound by imperfect interfaces [32,35], extending his polarization theory [26] (he also wrote a paper on imperfect interfaces with Anders Boström [20]). He worked with Andrew Norris on several structural acoustic scattering problems, beginning with an analysis of elastic Helmholtz resonators [27] as another application of the polarization theory. Later work on scattering by joined plates [31,37] involved solving Wiener–Hopf problems with high-order end conditions. Gerry's work on polarization theory and structural acoustics had another common thread in the collaboration with Douglas Rebinsky, who was a Ph.D. student under John Harris' supervision at the University of Illinois and later a postdoctoral researcher at Rutgers University with Andrew Norris.

3.6. Iowa State University

Gerry Wickham made his first visit to the Ames Laboratory, Iowa State University, USA in November 1989. He was invited by A.K. Gautesen, another Northwestern Ph.D. (obtained in 1969, supervised by W.E. Olmstead). Later, Gerry spent his only sabbatical year (1991–1992) at the Ames Laboratory. It was there that he began work on inverse problems in the time domain, in collaboration with Zhiming Sun [28,29]. This topic became one of his major interests after his move to Brunel University.

3.7. Later work

It is fair to say that, unlike most mathematicians, Gerry's publication rate increased with time, as did the number of his collaborations. The bulk of his research articles appeared throughout the last decade reflecting his increasing expertise and enthusiasm. At the time of his death, Gerry was actively discussing a variety of research topics with collaborators from around the world: these include inverse problems in one-, two- and three-dimensional acoustics and elastodynamics (with Zhiming Sun, P. Olsson amongst others); stability of fluid-loaded elastic structures [41]; new applications of the polarization method for interfaces and thin layers (with John Harris); relevance of hyperasymptotics to wave diffraction and scattering (with colleagues at Brunel University); application of a new method for matrix Wiener–Hopf factorization [30,36] to diffraction from cracks in isotropic and anisotropic materials [34,38]; diffraction of elastic waves by an imperfect fusion bond [39]; high frequency wave propagation in inhomogeneous and anisotropic solids [40]. Much of this activity has continued since Gerry's death, as indicated in the publication list to follow, and will no doubt provide further stimulus to research in coming years.

4. Conclusion

We have tried to list all of Gerry Wickham's publications: these give a physical record of his scientific and technological achievements. However, to all of us who knew him, it was his influence on our own endeavours that will remain; that, and his infectious sense of fun at myriad meetings around the planet.

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