J. Fluid Mech. (2007), *vol.* 592, *pp.* 506–507.
Printed in the United Kingdom

BOOK REVIEW

Hydrodynamics and Sound. By M. S. Howe. Cambridge University press, 2007. 463 pp. ISBN 0521 868629. £53.

J. Fluid Mech. (2007), *vol.* 592, doi:10.1017/S0022112007008713

This is a big new book by one of the cleverest workers in the subject of acoustics and unsteady fluid mechanics. It is dedicated to the memory of James Lighthill, the towering genius whose publications on Aerodynamic Noise first established the subject and who served as Howe's PhD supervisor at Imperial College. I was lucky enough to be there at the time, when research work driven by the need to contain Concorde's takeoff noise was directed from Imperial College. That work brought together a significant group of researchers who collaborated closely in attempting to understand the difficult problems of how sound was formed by flow and how the two interacted. The fact that Lighthill's aerodynamic noise theory is exact but very hard to interpret, made precise mathematical analysis of that theory one of the subject's principal tools, tools that Howe handled extremely deftly and continues to apply to important problems of hydrodynamics and noise.

Some of the issues tackled all those years ago continue to puzzle people today, so books by Howe on the subject are bound to be welcomed as possibly containing answers to current problems. This new book has many illustrative examples of incompressible potential flows, several having been described previously by Milne Thompson in his treatise on Hydrodynamics (Macmillan, 1968). Howe will know that Lighthill considered that extreme caution is needed when modelling the flow of real fluids with examples of potential flows and that he once remarked that "students of Hydrodynamics might well be unaware that water is wet".

This book avoids unreal examples by sticking to the kind of practical problem that has been most relevant to recent research in flow noise. Many difficulties of that subject have their origin in the effects of viscosity, which creates vorticity that causes a complete change in the nature of distant potential flow. Howe's insight on how best to describe vortex shedding and the subsequent convection of vorticity away from flow boundaries, has probably determined the order in which material is presented and the range of mathematical techniques covered. The reader is considered to be familiar with those techniques, which are introduced with minimal explanation, making the book heavy going for the mathematical novice but quick and to the point for experts.

One could quibble with the way the Green's function is described, as if it were some unique function regardless of the equation to be solved. Admittedly the Green's function most used in classical analyses is the function defined as G in equation 2.15.3, but the power of the technique is appreciated much better when one realises that a Green's function depends essentially on its determining differential equation.

One might have hoped that the book would tell what role different characters played in the subject and who was responsible for the probable first usage of various flow noise terms. Powell's theory of vortex sound comes to mind and also his emphasis of the Lamb vector as a source of sound in that theory. Readers would be interested to know that Powell's is one important theory that Lighthill criticised and largely ignored. Other readers will be disappointed that no reference is made to

any possible acoustical effect of the force that is induced by potential flow around a trailing edge. Does that play any part in Aeroacoustics? Howes opinion would be particularly interesting because it remains unclear whether Crighton's deduction, based on Lighthill's theory that there is no downstream influence, is incompatible with the Lamb vector being the dominant source, the view thought to be held by Howe. But it is unfair to imply a criticism of the book on such grounds. It is not that kind of book, as the author states clearly in his Preface.

The first four chapters of this six-chapter book aim to supply the basic material and theoretical methods that are used in the modern study of Hydrodynamics and acoustics. It is complementary to numerical methods; they deal more with complicated geometries but lack the power of analysis for handling crucial singularities. The early part of the book was written to help graduates follow a course on "Advanced Fluid Mechanics". The pace is rapid and functions and techniques are introduced with a minimum of explanation. The style is reminiscent of that used by Lighthill in his lectures at Imperial College. It was as if students were expected to have prior knowledge of what they were being taught. Those that could handle that pace ended up with a superb understanding of the subject – or at least what Lighthill thought of the subject. Howe's students are likely to have that benefit also. This is a superb treatise, taking the models and methods of the classical subject, supplementing and adapting them so that they apply to real fluids and analysing them with a wonderful range of analytical methods.

Chapters 5 and 6 of Howe's new book are inspired by Lighthill's big book *Waves in Fluids* (Cambridge University Press, 1978), chapter 5 dealing with Surface Gravity Waves. The analysis is clear, ship waves, diffraction by docks, harbours and breakwaters are described, gradual changes being treated in the high frequency limit where Ray Theory applies, waves travelling through an inhomogeneous medium for example. Waves on a sloping beach and surface waves generated by underwater explosions are the topics with clear current interest. Again the style used to describe the subject is fast and attractive though one sometimes gets the impression that topics are chosen for the opportunities they give for illustrating different asymptotic methods of evaluating integrals.

The final chapter is a brief "Introduction to Acoustics", a subject one would expect from the book's title to be covered as thoroughly as what has gone before. The chapter is not particularly brief but it seems so. Howe could have easily retained the students interest and taken the subject much further, by describing modern developments of Lighthill's aerodynamic noise theory, but he does not. Here he shows a proper understanding of the fact that the Green's function can be one of several and that it is equation-specific. His arguments are persuasive and his style is again fast and attractive, his rationale for dwelling on the compact Green's function for example. The generation of sound by inhomogeneities near the ends of parallel ducts, places where the cross-sectional area changes, is clearly described and leads on to the kind of problem for which Howe is the acknowledged world authority, one-dimensional compression waves induced by high-speed trains entering railway tunnels.

Researchers and advanced students of unsteady high-speed flow, particularly those concerned with the sound waves that are generated in such flows, will learn a lot by studying this book. Its errors of omission might well be a matter of taste and its typographical mistakes are trivial. Michael Howe succeeds throughout the book in maintaining the lively style pioneered by his mentor to whom the book is dedicated, and in doing so will have made some readers understand this subject much better than they ever thought possible.

John E. Ffowcs Williams