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BOOK REVIEWS

Avian Flight. By John J. Videler. Oxford University Press, 2005. 258 pp. ISBN 0 19 856603 4. £55

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In this volume, published as part of the Oxford Ornithology Series, the author's intention is summarised in the preface: "I would like to display the interrelationships among the variety of aspects around avian flight in an attempt to make the subject comprehensible for interested readers from all disciplines." When the target audience comprises professional ornithologists, amateur bird watchers, physicists, mathematicians and aeronautical engineers, the enormity of the challenge is clear. While I feel that the number of readers able to fully absorb all aspects of the book is fairly small, the author certainly succeeds in providing stimulating summaries of all aspects of avian flight, together with detailed literature reviews helpful to those focussed on the more specialist aspects of the field. With such a wide target readership, any review is likely to be angled to a certain perspective. My own perspective is that of a mathematician with interests in aerodynamic theory and an amateur interest in bird behaviour, despite no background in biology. A review from a professional ornithologist with little mathematical background would undoubtedly be very different.

Chapter 1 looks at the historical development of man's fascination with flight, starting from an 11 000 year old example of Mexican cave art and ending with the study of leading-edge vortices and their role in both insect and bird flight. Chapters 2 and 3 consider the anatomical structure of birds related to flight, including detailed discussion of feather structure. While this is necessarily rather technical and challenging for those with no background in physiology, some unanswered questions related to aerodynamics are included. For example, needletail swifts have spine-like shafts protruding from their tails. Since they are not used for support during perching, do they have an aerodynamic advantage for the high-speed flight typical of swifts?

Chapter 4 is concerned with the aerodynamics of flight. The author's chosen method of presentation is to remove mathematics to boxes separate from the general flow of the narrative, which works well. The description of the vortex structures in the wake, as a function of flight characteristics, is of particular interest, using photographs and measurements to compare chaffinch flight, with closed vortex rings from each wingbeat, with the flapping flight of a kestrel, showing a continuous pair of trailing vortices. Detailed results from the author's own work on flow over the wing of a swift provides an illuminating illustration of the structure of leading-edge vortices. As with any work of this form there are some omissions: I would have liked to see some analysis of the use of ground effect by gliding birds such as the albatross, but at least references to other work are extensive.

After a somewhat quirky diversion into the evolution of bird flight by comparing the prehistoric *Archaeopteryx* with the locomotion of Basilisk lizards (otherwise known as Jesus-Christ lizards) over the surface of water, the author returns in Chapter 6 to analyse the different modes of flight. Alongside the chapter on aerodynamics, this probably provides the most of interest to the fluid mechanicist. The wing motion associated with flapping, gliding, soaring and hovering is compared, including examples of wing-tip displacements in various modes of flight. The discussion of the V-shaped formation flying associated with larger birds reveals that measurements on spacing do not immediately support conventional theory regarding trailing vortex structure. The book concludes with chapters analysing the muscle structure of birds and the energy cost of flight.

This volume will not be head of the queue of books published recently to be added to the bookshelf of the well-read fluid dynamicist. However, the publication of such a book is a considerable achievement. It will provide much food for thought for those of us who combine an interest in fluid mechanics with an interest in birds: in particular, the idea that simple explanations from conventional aerodynamics may not provide the whole story where bird flight is concerned.

PAUL W. HAMMERTON

Topics in Hyposonic Flow Theory. By R. KH. ZEYTOUNIAN. Springer, 2006. 284 pp. ISBN 3 540 25549 4. £61.50

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It is the author of this book's view that '.....after subsonic, transonic, supersonic and hypersonic flows, now fluid dynamicists must cope with a new challenge: the theory of 'hyposonic fluid flows'.' Hyposonic flows? Reference to a good dictionary indicates that *hypo* is derived from the Greek *hupo* meaning 'under, below, slightly'. This is indeed what the author has in mind, namely low-Mach-number (M) or, if you like, slightly compressible flows.

The declared purpose of the book is to present various facets of unsteady small-Mach-number flows. The first three chapters serve as an 'enlarged introduction'. Therein the areas to be considered are outlined. These include small-Mach-number unsteady external aerodynamics, for example acoustics and weakly compressible low-Reynolds-number flows, internal aerodynamics, including piston-type problems, combustion, nonlinear acoustics, slow atmospheric motions and thermal convection. The Euler and Navier–Stokes equations for a compressible fluid are introduced, including a one-step irreversible chemical reaction appropriate for combustion. Approximations of these equations are considered for the various low-Mach-number flows under consideration; the point being made that solutions of them are not necessarily uniformly valid. For example far-field difficulties may arise at large distances, $O(M^{-1})$, for unbounded flows, and for impulsively started flows initial times, $O(M)$, must be carefully treated. Rigorous mathematical results and numerical simulations, not germane to the main thrust, are treated only cursorily.

Chapter 4 deals in more detail with external flows. The low-Mach-number equations are re-visited and the first part of the chapter discusses acoustic problems, in particular aerodynamic sound generation in relation to the far-field difficulty. Burgers equation for weak nonlinear planar acoustic waves is derived from the basic equations. Other problems include the weakly compressible flow past a semi-infinite flat plate in the distinguished limit $M^4 Re = O(1)$ as $Re \to \infty$, where Re is a Reynolds number. For low-Reynolds-number flows the distinguished limit has $M^{a-1} Re = O(1)$ as $Re \to 0$ where $0 < a < 1$. For flow past a finite body there are inner Stokes and outer Oseen regions as in the incompressible case; but for this weakly compressible flow the leading-order Oseen flow is not uniformly valid.

Chapter 5 considers several aspects of low-Mach-number internal flows in a bounded domain. Acoustic waves will be generated when the boundaries deform slowly in comparison with the speed of sound. For impulsive motion, as for example a piston in a tube, solution on a timescale $O(M)$ has to be investigated. The case of an inviscid perfect gas is considered first, followed by that of a viscous, heat-conducting perfect gas for $Re = O(1)$. For $Re \gg 1$ the damping of acoustic oscillations by viscosity is analysed.

The author returns to another of his low-Mach-number themes in Chapter 6, namely slow atmospheric motion. This opens with a discussion of the Boussinesq approximation which leads to an inviscid lee-wave model based on the distinguished limit $Bo/M = O(1)$ as $M \to 0$ where Bo is a Boussinesq number. (The author has, himself, contributed to the study of lee waves; on that count alone the neglect of Crapper's seminal work on the problem, see for example Crapper, G. D. 'Waves in the lee of a mountain with elliptical contours', *Phil. Trans. R. Soc. Lond.* A, vol. 254 (1962), p. 601, is puzzling.) The Boussinesq approximation is also employed in the discussion of free atmospheric circulation, or breezes.

The final chapter contains a *potpourri* of topics. Amongst these is a discussion of the Rayleigh–Bénard problem in which the Froude number is interpreted as a pseudo-Mach number, and the compressible Rayleigh problem in which an infinite plane is set into uniform motion instantaneously parallel to itself.

Misprints are sprinkled liberally throughout the book, but none are misleading. References, listed chapter-by-chapter, are not uniformly treated; some research papers have their title included, others have not, which adds to the air of a book that has not been assembled too carefully.

Does the author make a case for a new coherent discipline in fluid mechanics? The answer is no; in literary terms he presents not a novel but a collection of short stories. Researchers who are involved with, or interested in, a particular topic in the low-Mach-number regime are more likely (and advisedly so) to turn directly to relevant source material than to the volume under review.

N. Riley