J. Fluid Mech. (1993), vol. 247, pp. 689–691

REVIEWS

Energy Dissipators and Hydraulic Jump. By W. H. HAGER. Kluwer Academic Publishers, 1992. 288 pp. £52 or 150 Dfl.

This book aims to provide 'state-of-the-art information on hydraulic jumps and associated stilling basins'. The book is oriented towards the engineer who may need to design the structures that receive flow from dams. These could be flows of more than 1000 cubic metres per second with velocities as high as 100 kilometres per hour, so the required energy dissipation could be hundreds of megawatts. The most extreme case mentioned is a design flow of $30000\,m^3\,s^{-1}$ with a falling height of 100 m. Despite the large expense involved in the construction of large dams, this is an area where little theory is available beyond the classical hydraulic jump relations between depths and velocities. Thus much of the book is descriptive, with empirical relationships from experiments given where possible.

The book is divided into two parts. The first, of 100 pages, is on hydraulic jumps, the remainder deals with the various hydraulic structures that are used to dissipate energy and their flow characteristics. Each chapter starts with a substantial literature review, most papers being given a sentence of description, but the significant works are neatly woven into a narrative account of the chapter topic with numerous substantial quotations and illustrations. This often means that the author needs only a few paragraphs for his own direct comments, which often reveal his close involvement with the subject. This approach is useful for accessing the literature: over 600 references are included (47 pp.).

The substantial chapter on the classical hydraulic jump, as found in rectangular channels, includes little on jumps with Froude numbers, Fr, below 4.5 since they either have undular features with low dissipation or, in the range $2.5 < Fr < 4.5$, have an undesirable tendency to oscillate. For the stronger jumps there is a full account of available material on mean flows and profiles, together with the turbulent fluctuations of velocities and pressures and of air entrainment. The other chapters in the first part cover jumps on slopes, in non-rectangular channels and submerged jumps. In these cases most of the discussion is on the mean flows. For example, in trapezoidal channels there are substantial three-dimensional mean flows and waves.

The hydraulic structures, which are the subject of the second part, are needed to stabilize, and preferably also shorten the length of, jumps in order to minimize erosion of the channel and to minimize construction costs. They take the form of steps, up or down, in the bed, concrete blocks (baffle blocks) fixed to the bed, variations of channel width, stilling basis and 'buckets'. For all these examples experimental results for the flow regimes, advantages and disadvantages, and some reports of prototype experience are given. In strong hydraulic jumps the turbulent pressure fluctuations are so large that cavitation may occur even with mean pressures above atmospheric pressure, so structural integrity is an important factor. Ways of reducing cavitation are discussed.

In some cases, the flows are not unique. In a smoothly expanding channel, there is more commonly an asymmetric V-shaped jump than the radially curved jump that may naïvely be expected. Such uncertainties are not desirable for the strong flows that are described. Another example occurs at a downward or upward step, where jumps can occur in different positions relative to the step and the supercritical flow can separate into a large smooth wave rising far above the eventual tailwater level. I am surprised that this latter example is not given a little more attention, since it can lead to undesirable overtopping – and the author has been involved with experimental studies.

The book is relatively free from errors, and those I noticed should cause no trouble. However the symbols 'Tgh' in an equation caused much concern until I realized that gravity and depth were not involved and that I would have been happier with 'tanh'! There are naturally some omissions; the one I found most disturbing is the lack of a thorough discussion of scale effects. I feel this may be particularly important for air entrainment and the resulting two-phase flow, since it is a well-known difficulty in pipe flow. Further, in reporting prototype experience an example is noted where 'the hydraulic jump for $Q = 1100\ \mathrm{m^3\ s^{-1}}$ was completely submerged, although free flow prevailed on the model up to discharges of $Q = 2000\ \mathrm{m^3\ s^{-1}}$'.

In the preface the author says the book 'should not be considered as a ready-to-use guideline since the design of an effective stilling basin is much more complex than following general design steps'. However, the book clearly will be valuable to anyone involved in such designs. Further, it is of wider interest to fluid dynamicists as a guide to a substantial body of experimental work, and a reminder that for some flows we are still a long way from reducing their study to analysis and computation.

D. H. PEREGRINE

Perspectives of Nonlinear Dynamics. By E. ATLEE JACKSON. Cambridge University Press, 1991. Vol. 1, 469 pp., £19.95; vol. 2, 633 pp., £19.95.

Ruelle & Takens (1971) and Newhouse, Ruelle & Takens (1978) proved that if a differential equation has an m-frequency quasi-periodic attractor ($m \geqslant 3$), then there exist arbitrarily small perturbations of the equation such that the perturbed system has a hyperbolic strange attractor (a suitable return map has a Plykin attractor). Although hyperbolic attractors are themselves persistent under sufficiently small perturbations, this does not imply that 'most' perturbations of systems with 3-frequency quasi-periodic attractors have strange attractors. Indeed, numerical experiments suggest that typical families of perturbations are more likely to undergo frequency locking (Grebogi, Ott & Yorke 1983).

Now that we have got that straight, let us look at these two volumes. They contain a rough outline of a broad selection of topics in nonlinear dynamics, ranging from low-dimensional maps and ordinary differential equations to partial differential equations and cellular automata. The theme which runs throughout this work is nonlinearity and its effects: to complicate matters in low dimensions (chaos) and, paradoxically, to produce coherent structures in high dimensions (solitons). It is hard to classify a pair of books like this: it is certainly not a textbook – there is not enough examinable detail. Nor is it a reference book – it covers far too much ground to go through any particular topic in sufficient depth. I see it more as a pre-reference book: if you have heard of some results in nonlinear dynamics which may, possibly, be applicable in your own work then these volumes will provide a readable account of what can be done using these results and indicate where you might read more deeply. That almost every aspect of applied dynamical systems gets at least some mention in an impressive feature of Jackson's work.

Another fact: the logistic map, $x_{n+1} = \mu x_n(1-x_n)$, is one of the most studied and well-understood models that can exhibit chaotic behaviour. Quite rightly, Jackson devotes a chapter to this model and related problems. Over ten years ago Jakobson (1981) proved that there is chaotic motion for a set of μ-values with positive Lebesgue measure, and this result has since been sharpened by a number of mathematicians. It should not be called an open problem!

The scope of these books is their strength, but also their weakness. Atlee Jackson deserves a medal for bravery: he has kept the style simple and has covered a vast amount of material. The line between bravery and foolhardiness is often thin. On the subjects I know about I was often disappointed and, at times, irritated (see the facts above!). On the other hand, I found the sections on topics about which I am relatively ignorant both informative and stimulating. I suspect that this is how such books should be judged. It should be noted that these volumes seem aimed very much towards the physics community and so, as a mathematician, I should not be too hurt at how little mathematics gets in (I could find no reference to Herman, Katok or Shilnikov, to name but three).

I am the last person to comment on the fluid dynamical relevance of this material. These books are peppered with excellent examples, although rarely drawn from the physics of fluids except in the description of the early development of the theory of solitons. The Lorenz equations are 'derived' from Rayleigh–Bénard convection equations, but their relevance (or lack of relevance) is not pursued, nor is there mention of the experiments by Libchaber, Laroche & Fauve (1982). However, there does not need to be any explicit mention of fluid dynamics for the techniques and results described here to be important. If we have learned one thing from the work in dynamical systems over the past twenty years, it is that the effects of nonlinear terms (at least near the threshold of instabilities involving discrete spectra) can be described in general terms; the precise physical significance of the problem is irrelevant to the general mathematical framework. To see this it is only necessary to look back at the number of recent papers in this journal which include centre manifold calculations.

Nonlinear dynamics has given researchers a new set of tools which augment rather than replace existing techniques. Atlee Jackson has produced a fine introduction to the range of results which have been obtained in recent years, although the books should be used with caution.

REFERENCES

Grebogi, C., Ott, E. & Yorke, J. A. 1983 Are three-frequency quasi-periodic orbits to be expected in typical nonlinear dynamical systems?. *Phys. Rev. Lett.* **51**, 339.

Jakobson, M. K. 1981 Absolutely continuous invariant measure for one parameter families of one dimensional maps. *Commun. Math. Phys.* **81**, 39.

Libchaber, A., Laroche, C. & Fauve, S. 1982 Period doubling cascade in mercury, quantitative measurement. *J. Phys. Lett. Paris* **43**, L211.

Newhouse, S. E., Ruelle, D. & Takens, F 1978 Occurrence of strange axiom A attractors near quasi-periodic flows on T^m ($m \geqslant 3$). *Commun. Math. Phys.* **64**, 35.

Ruelle, D. & Takens, F. 1971 On the nature of turbulence. *Commun. Math. Phys.* **20**, 167.

P. A. Glendinning