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Book Review

Bubble Dynamics and Interface Phenomena

Edited by J. R. Blake, J. M. Boulton-Stone, and N. H. Thomas, Kluwer Academic Publishers, Dordrecht, The Netherlands, 1994, 489 pp., $216.00

This useful and informative book is the published collection of papers presented at the IUTAM Symposium in Birmingham, U.K., in September 1993. As such, it is a collection of forty-six independent papers that the editors have neatly arranged into six parts: Bubble Dynamics and Bubble Interactions; Sound and Wave Propagation; Bubbles in Flow; Sonoluminescence, Acoustic Cavitation and Ultrasound; Jet Impact and Underwater Explosions; and Bursting Bubbles, Coalescence and Internal Phenomena. These are topics that should be covered in a comprehensive treatise on bubble dynamics, and this book does a quality job touching on the state-of-the-art for each topic. The subject of interface phenomena is less well covered, and it is supposed from the content of the book that the interface phenomena apply strictly to bubble dynamics. Purview of the table of contents reveals that the editors have successfully attracted the notable authorities in the field.

The focus of the book is on bubble dynamics, and the information presented deals almost exclusively with a vorticity-free continuous phase, except perhaps locally at the bubble and in some cases for weak shear flows. Two of the three major areas covered in the book are compressible waves and bubble-boundary interactions (including bubble-bubble interactions). In this context bubble dynamics is presented as the very interesting and challenging physics problem that it is. The third area is on sonoluminescence, a subject which has attracted significant recent interest. The papers are sufficiently complex in that they exemplify the significant processes in bubble dynamics and, to some extent, interface phenomena. The reader of this book should expect an overview of contemporary research on the topic of the book. In this respect, several papers are significant contributions to the archival literature. In particular, the comprehensive papers on bubble dynamics (A. Prosperetti), dynamics of bubbly liquids (R. Nigmatulin), modeling bubbly flows (J. Hunt, et al.), bubble cavitation dynamics (L. van Wijingaarden), and sonoluminescence (L. Crum and S. Cordry) are noteworthy.

This book is balanced in considering computations, experiments, analytics, and instrumentation. Although it is not appropriate here to discuss each of the papers, some comments about a few selected papers will whet the appetite of the potential reader. A. Shima and T. Tsujino describe an experiment, with supporting computational analysis, on the dynamics of cavity clusters in polymer solutions. The theoretical analysis reveals many of the intricacies of bubble dynamics, including the added complexities of considering normal stresses and non-Newtonian rheology models. S. Gavrilyuk mathematically treats the case of linear pressure wave propagation in fluids with a continuous bubble size spectrum. This paper produces the interesting result that wave propagation degenerates to a sum of high and low frequency waves under conditions in which the wave frequency is an eigenfrequency of the bubbles. A. Esmaeeli, E. Ervin, and G. Tryggvason present the results of an advanced numerical method for directly simulating the deformation of a bubble in a weak shear flow and determining the process by which lift is generated on the bubble.

Application of this method of a bubble array buoyantly rising in quiescent fluid shows the tendency of the bubbles to form clusters, and hence to produce larger Reynolds stresses. F. Pereira, M. Farhat, and F. Avellan describe a new calibration method for high frequency response pressure transducers. A spark generator is used to create the pressure impulse, and the transducers are calibrated in situ. This procedure will lead to improvements of estimates of cavitation damage on blades. M. Hooton and J. Blake describe experiments in which a spark generator was used to create a vaporous cavity to study the effects of the bubble collapse on nearby surfaces. Computations using boundary integral methods were found to compare favorably in many respects with the digitized photographic measurements of the bubble deformation. S. Zhang and J. Duncan describe improvements to the boundary integral method using a vortex sheet to model the boundary shear layer during bubble collapse. L. Crum and S. Cordry hypothesize sonoluminescence as a process in which nonlinear diffusion effects cause a single bubble to convert mechanical energy to electromagnetic energy. The paper is enhanced by presenting the hypothesis in the historical context of investigations of sonoluminescence.

Educators and students will find this book attractive as an instructional tool because it provides the right mix of introductory information, overview, and specific examples. It is particularly useful for a subject field that is very modern and rapidly changing with revolutionary computational capabilities and innovative measurement techniques. The numerical simulations and the experiments are very good elucidations of the application of fluid dynamics theory to interpreting actual flows, even if those actual flows are idealized to the extent that the results have limited practical use.

Experienced researchers will find the book attractive as a statement of the state-of-the-art, and as a handy

compendium of example models representing more complex fluid dynamic phenomena.

As a description of the state-of-the-art, the book is an excellent reference, as illustrated, for example, by the high degree of capability to model the complex dynamics of bubbles in ideal situations in which the bubble is either large or small, inter-bubble interactions are weak, and the underlying flow is at most a weak shear. The book lightly treats real fluid effects on bubble dynamics, such as the effects of bubble clusters on the continuous phase, the interactions of bubbles with the shear layer in practical cases such as cavitation inception where the shear layer is smaller than the bubble size, and the effects of surfactants (and rheology).

The editors discuss in the preface the need to study two phase flows in applications. Does the book contribute to satisfying this need? The answer is "not very well." But that is a limitation from the research, and not from the book. A tying-together of the papers in the context of what science in needed based on the applications on the one hand, and the discoveries described in this book on the other hand, would provide important added value to the book.

This is a book that can be, and deserves to be, studied. It is a book that invites rereading, especially as the understanding of the separate papers contributes synergistically to an understanding of the comprehensive subject of bubble dynamics.

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Book Review Errata

Shock Wave Engine Design
Helmut E. Weber, J. Wiley, New York, 1994, 223 pp., $59.95

In the review of *Shock Wave Engine Design* in the May 1995 issue of *AIAA Journal,* Helmut E. Weber was incorrectly identified; he is the book's author.

AIAA regrets this error.