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BOOK REVIEWS

Upwind and High-Resolution Schemes edited by **M. Y. Hussaini, V. van Leer, J. van Rosendale** (Springer-Verlag GmbH & Co. KG, Heidelberg, 1997, 588 pp.) DM 248.00 ÖS 1 810.40 sFR 216.00 hc ISBN 3 540 616551

This book is a homage to the *spiritus loci* at ICASE, the Institute for Computer Applications in Science and Engineering at NASA Langley. It consists of 21 papers on high-resolution schemes and two introductions. All but one of the papers first appeared as ICASE reports between 1981 and 1994. High-resolution schemes are specialized methods for the calculation of hyperbolic conservation laws; for example, the Euler equations of gas dynamics. Their objective is to achieve higher order (say two or more) accuracy, in smooth flow regions and a "crisp" resolution of discontinuities without spurious oscillations [or later in the development, with bounded oscillations].

The book is meant to be a historical document "to capture the spirit of this exciting period by reprinting a collection of the most significant papers on high-resolution schemes" (preface). The audience are the "aficionados" (J. Quirk) of the subject: "We hope this volume finds its way onto the bookshelves of those who share with us a fascination for computational science in general and fluid dynamics in particular" (preface).

The first introduction by Bram van Leer sketches the history of high resolution schemes. The starting point of their development was research by J. von Neumann during World War II and an important paper by S. Godunov in 1959. A their time these contributions were not much appreciated and they hibernated until the early 1970's when Godunov methods became fashionable. Their high tide reached ICASE in 1979 with the advent of van Leer's work there. In the early 1980's approximate Riemann solvers were discovered and much of the following work was closely connected to ICASE. In a manifesto-like passage, van Leer gives two reasons for that: ICASE was the meeting point *par excellence* for computational scientists providing a highly stimulating atmosphere and there they came closely in touch with NASA engineers who had formidable problems to solve. This time marks the onset of the papers found in this volume. The papers are not discussed or analyzed, but left "to speak for themselves".

The second introduction by Philip Roe is technical. He lays the basis using the method of characteristics to expose the essence of the governing equations. A high-resolution method is sketched for the scalar advection equation, and the notions of conservation laws and nonlinear reconstruction as the inner keys to their success are explained. Higher dimensional upwinding and current research trends are outlined. This introduction is very well written and a pleasure to read. However, the articles that follow are highly specialized and these 20 pages give no new information to the specialist and still leave a huge gap for the newcomer. Considering the historical aim of the volume, one would expect the following articles to be placed in historic and scientific perspective from the modern point of view. This is indeed promised in the preface but only touched upon lightly in this introduction.

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The first chapter contains three papers from 1981 and 1982 and shows the theoretical struggles in understanding the structure and implications of the newly discovered approximate Riemann solvers and flux vector splittings. The first paper by B. van Leer gives a comparison of the Godunov, Enquist-Osher and Roe solvers. It also contains interesting ideas on the incorporation of source terms. The second paper by Harten, Lax and van Leer is a review of the state of art at that time, summarises the entropy condition and gives a unifying interpretation of upwind schemes as central with a situation-dependent artificial viscosity. This paper is still essential reading for everyone who seeks a good theoretical understanding of these schemes. The last paper in the chapter introduces a flux vector splitting, now known under van Leer's name.

As with other chapters, this one is accompanied by a brief introduction and one or two sentences on each paper to follow.

The papers in the second chapter date from 1981 to 1990 and deal with Total Variation Diminishing (TVD) schemes. The first paper compares several first and second order schemes and shows that the latter are far superior, both in accuracy and computational efficiency when the goal is to achieve a given quality. Today, only 16 years later, this sounds like "a missionary talking to cannibals" (Littlewood on a book by Hardy), and indeed, the paper explicitly states that it was intended to break some traditions in the astrophysics community and is a deliberate attempt to popularize the new schemes. The van Albada limiter was introduced in this article. Two of the following papers give a profound theory of TVD schemes and the MUSCL variant and two carry the TVD ideas over to central differencing.

The third chapter on ENO schemes is best described by a quotation from one of its papers: "Realizing that TVD schemes, independent of their particular form, are necessarily only first-order accurate at local extrema, we seek a weaker notation of control over possible growth of the total variation of the numerical solution". The construction of schemes which are only "essentially non oscillatory" is described here. The latter term is defined by allowing oscillations of the magnitude of the truncation error.

The fourth and final chapter collects refinements and offspring. They deal with the construction of multidimensional Riemann solvers and flaws of the approximate Riemann solvers, occurring in intricate multidimensional situations or when used with very high resolution. Since the task of multidimensional Riemann solvers is far from being complete, the chapter appears much less coherent compared to the previous ones.

The development of high-resolution schemes coincide with an important time period in computational fluid dynamics. Their essence is to simplify a physical model as slightly as possible by bridging unresolvable fine shock structures locally by using a lower order method. When the last paper in this book was written, some researchers had already foregone this subtle approach. They use tremendous computer resources to fully resolve those fine structures, relying on the physical viscosity. This fact will not outdate the high-resolution schemes for the next future; in particular, not for real world applications: Moreover, their development brought a never-seen physical insight into numerical modelling. This is its principal contribution. The present volume documents the undeniably large contribution ICASE made to this scientific development. It does not claim to collect timeless classics, but to show a historical path. This objective should be kept in mind. If expecting an up-to-date account on upwind and high-resolution schemes, you are doing injustice to the editors and will be disappointed with the result.

The book appears to be a collection of scientific papers seasoned by the romantic reminiscences of the editors. As a scientific collection, it contains some key papers of the research field.

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