

BOOK REVIEW

Rarefied Gas Dynamics. By C. CERCIGNANI. Cambridge University Press, 2000.
320 pp. ISBN 0521 65992. £18.95.

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Rarefied Gas Dynamics is a relatively neglected topic and a new book by Carlo Cercignani – who is certainly an acclaimed expert in the area – will be greeted with enthusiasm. The subject covers flows that fall between the continuum and free molecular regimes and which are characterised by their scale ranging from being roughly equal to, to being 10^3 or even 10^4 times, the fluids local mean free path. Historically the predominant interest in this topic has been generated by the requirement to analyse spacecraft flows when they are flying in the very low density upper atmosphere. However fresh interest is being generated in the subject by the increasing significance of flows for which the rarefaction is due the very small size of the domain. Examples include the new areas of nano-technology and micro-machines and a whole variety of gas/surface phenomena (such as in chemical vapour deposition, condensation and evaporation) where the controlling fluid dynamic effects occur within regions extending only a few mean free paths from the surface. Navier–Stokes formulations are inadequate for such problems and meaningful solutions require the use of techniques based on kinetic theories in which the molecular character of the gas is recognized. This book approaches fluid mechanics from this viewpoint and is a clear and well-constructed description of the basic concepts available for solving problems, covering the use of both analytical and numerical approaches. This book specifically addresses some gas/surface interaction phenomena.

The book's subtitle is "From Basic Concepts to Actual Computations". In common with many other areas of fluid mechanics, rarefied gas dynamics has changed dramatically due the impact of computers. Today, powerful particle simulation methods are available which have almost entirely replaced previous complicated attempts at solving problems using analytical Boltzmann equation level formulations. With this emphasis on numerical methods has come a tendency to gloss over the fundamentals of the underlying kinetic theory and it is apparent that one of Professor Cercignani's objectives in writing this book has been to redress this. Writing from his broad experience of both analytical and numerical solutions and armed with a very comprehensive understanding of the subject, he has written an excellent appreciation of how the two inter-relate. The volume is only 300 pages long and it is thus unreasonable to expect it to be a definitive textbook with full derivations of the theory or detailed descriptions of the computer codes. However, his objective is developed with clarity, expounding the various kinetic theory approaches to the subject and, at least in some instances, how corresponding numerical simulations can be devised. The author has structured the book interestingly by basing it on specific examples of increasing complexity, starting with Couette flows under rarefied conditions solved in one dimension, moving on to flows in half-space, then transitions such as shock waves and finally two-dimensional rarefied flows. He concludes the book with an interesting chapter on the near-surface phenomena associated with evaporation and condensation.

This is a very informative and excellently written book with comprehensive cross-referencing. The foundations of the subject are laid out clearly and for those working in the area (or contemplating doing so) this is a recommended read. One minor criticism would be that it has been written from a theoretician's view point and in some instances strays away from practicality. Solving most of today's rarefied gas dynamics problems depends almost exclusively on numerical techniques, in particular the direct simulation Monte Carlo method. The author certainly gives details of the method but he does not delve into it to the depth that the subtitle perhaps might suggest. The extent of the discussion and details provided may prove a little disappointing for those hoping to write or implement software of this type.

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