References

[1] T. Cebeci, J. Cousteix, Modeling and Computation of Boundary-Layer Flows, Springer-Verlag, Berlin, 1999.
[2] H.H. Fernholz, Review of 'Modeling and Computation of Boundary-Layer Flows', Eur. J. Mech. B 18 (1999) 1103–1104.
[3] H. Schlichting, K. Gersten, Boundary Layer Theory, 8th revised edition, Springer-Verlag, Berlin, 2000.
[4] R.C. Lock, B.R. Williams, Viscous-inviscid interaction in external aerodynamics, Prog. Aerospace Sci. 24 (1987) 51–171.
[5] T. Cebeci, An Engineering Approach to the Calculation of Aerodynamic Flows, Springer-Verlag, Berlin, 1999.

A.E.P. Veldman
Institute for Mathematics and Computing Science
University of Groningen
PO Box 800
9700 AV Groningen
The Netherlands

10.1016/S0997-7546(03)00014-1

Kinetic Theory and Fluid Dynamics
Y. Sone (Birkhäuser, Boston, 2002)

Foundation of Fluid Dynamics on Kinetic Theory has been a classical and challenging problem in a recent past. This book gives an impressive overview of the formidable amount of work done by the author on such a fundamental subject, emphasizing the need of kinetic theory for taking the molecular structure of matter into account, for explaining phenomena occurring in the continuum limit, and, in one word, for understanding fluid dynamics itself. An essential role in the deduction of fluid dynamic equations is played by asymptotic expansions with respect to the Knudsen number, a small parameter representing the ratio of the microscopic to the macroscopic scale, inasmuch as the fluid dynamic limit corresponds exactly to the limit when the Knudsen number tends to zero. The book deals mainly with time-independent boundary value problems in a general domain, where boundary conditions include both cases of a regular solid boundary and of a boundary made by the condensed phase of the gas (evaporation–condensation problems). Emphasis of the book, and one of its most interesting features, is on inadequacy of classical fluid dynamics in correctly describing the continuum limit, due to the occurrence of what are named nowadays "ghost effects", as the author himself has been calling them in the past few years. Indeed, Prof. Sone has been one of the main contributors to the discovery and analysis of such effects. Methodology is generally an asymptotic approach based on Hilbert-type expansions in power series of the Knudsen number, with proper corrections and different recipes according to the physical nature of the specific problems. Of course the limiting equations cannot satisfy kinetic boundary conditions, so that one must perform the analysis of the Knudsen layer, which provides both the boundary conditions for the fluid-dynamic-type equations and the Knudsen layer corrections.

After Chapter 1, which presents Introduction, background, and state of the art, and Chapter 2, which reviews basic results from kinetic theory, Chapter 3 applies the asymptotic algorithm to the linearized Boltzmann equation for very slight deviations from an uniform equilibrium state at rest. In Chapter 4, Mach and Knudsen numbers are both small, to mean deviation from an uniform equilibrium state at rest of the same order of the Knudsen number, and the full Boltzmann equation is required. This is a good transition to the following chapter, where removing the assumption that the variation of gas temperature is limited to a small quantity, of the order of the Knudsen number, shows appearance of a ghost effect. The asymptotic procedure of Chapter 5 exhibits in fact the new feature that the leading term of the temperature field is determined together with the next order term of the velocity, which has an important bearing on detecting the incompleteness of classical gas dynamics. In other words, the leading order Maxwellian is characterized by a temperature parameter not determined by Euler equations. Thus, when the Knudsen number goes to zero, the behavior of the gas in the continuum limit cannot be studied solely with the quantities of the continuum world. Effects of this kind do appear in real world, as shown for instance by the so called thermal-stress flow. So, the temperature field of a gas at rest in the continuum limit is not described correctly by the classical heat conduction equation for wide and important classes of problems. From a different point of view, an error of the order of the Knudsen number in the boundary velocity introduces errors of order unity in the temperature. Several concrete examples with comparison to accurate numerical solutions from the kinetic level are provided. In Chapter 6 the analysis is extended to the case of a flow around a simple material boundary when the Mach number is not small, and then the Reynolds number becomes very large, giving rise to a viscous boundary layer outside the Knudsen layer, which requires an "ad hoc" asymptotic expansion. Chapter 7 deals with the same situation as before, but for a flow of a gas around its condensed phase, with different types of boundary conditions.

Chapter 8 discusses finally in detail the application of the previous algorithms to an important problem which may originate bifurcation of the flow, namely Couette flow between rotating coaxial cylinders with evaporation and condensation.

The book is very detailed, and very carefully written, aimed at a great generality of results and physical situations. Though of advanced level, it is essentially self-consistent, with extensive but precise references to a wide bibliography for technical details not explicitly dealt with. The text is quite dense of facts and manipulations, but is made lighter to read by an appropriate use of Appendices, which contain very precious information and deserve careful attention. Each chapter presents a number of applications for which the theory expounded is well suited. Of particular interest the Knudsen compressor, for simplicity, originality, and potentiality. Appendices range from very basic stuff, like derivation of the Boltzmann equation from the Liouville equation and solution of the linearized Boltzmann equation, to more specific and recent achievements, like Golse's and Bardos' theorems. Interesting physical phenomena and engineering applications are presented throughout, described in full mathematical rigor but in non-abstract form, supported by numerical analysis and sometimes even by experimental demonstration. All of that makes the book appealing in various fields, including applied mathematics, physics, and engineering, especially at the level of graduate students and young researchers.

Giampiero Spiga
Dipartimento di Matematica
Università di Parma
Via D'Azeglio 85
43100 Parma
Italy
E-mail address: giampiero.spiga@ipruniv.cce.unipr.it

10.1016/S0997-7546(03)00015-3