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BOOK REVIEW

Multicomponent Flow Modeling. By V. Giovangigli. Birkhauser, 1999. 331 pp. ISBN 3 7643 404 87. DM 138.00.

Although this book appears in a series entitled 'Modeling and Simulation in Science, Engineering and Technology', its main concern is to investigate the mathematical structure of the system of equations in multi-component flow modeling. It is aimed at post-graduate students studying applied mathematics, mechanical engineering and physics, especially in French Universities, where the emphasis is often on mathematical rigour rather than physical mechanisms and applications. The author ambitiously aims at 'an interdisciplinary approach that encompasses a physical, mathematical and numerical point of view' and manages one of these visions.

Following a brief survey of the book's contents, in the second chapter the author introduces the basic equations of fluids, thermodynamics and chemical reactions, possibly on the assumption that the underlying physical processes are superfluous or perhaps sufficiently well understood. For example he introduces the word 'equilibrium' on p. 10 without definition, which allows him to assert 'that the thermodynamics obtained in the framework of the kinetic theory of gases is valid out of equilibrium and has, therefore, a wider range for validity than classical thermodynamics introduced for stationary equilibrium states' – that classical thermodynamics underpins Fourier's law of heat flux must then be a puzzle. A description of local thermodynamic equilibrium (LTE) is missing, but it is essential in transport theory. Also he states on p. 23 that 'it is important to note that the diffusion matric D is symmetric … which is compatible with Onsager reciprocal relations' but this conclusion is presented as a mathematical result rather than as a consequence of the underlying physics (e.g. the principle of detailed balance plus microscopic reversibility) and later (Chapter 8) it is stated that symmetrization of the transport fluxes can be obtained mathematically, without any need to involve 'Onsager's phenomenological constants'. Entropy is introduced as a mathematical function without a mention of either the Second Law of Thermodynamics or the fundamental concept of macroscopic irreversibility.

Chapter 3 deals with several approximations, such as small-Mach-number flows, while in Chapter 4 there is a review of the derivation of the equations from the kinetic theory of gases. The reader is referred to other books for the derivation of Boltzmann's kinetic equation and physical concepts like collisional time scales and mean free paths are not employed. That the entropy production rate is positive is deduced from Boltzmann's kinetic equation, which is assumed to be valid without constraint on the (unmentioned) Knudsen number. The close and essential connection between positive entropy production and stability is missing. Various transport coefficients are derived in the next chapter, but without reference to their experimental determined values, leaving the reader with complicated algebraic expressions, but no guidance as to their relevance.

Chapters 6 and 7 are concerned with the mathematics of thermochemistry and transport coefficients, with theorems, lemmas, and corollaries adding mathematical authority to the account. Again however, physical insight is missing; for example in Chapter 6 the author observes that there are a large number of state variables in chemical systems, but does not explain how their relaxation times could be used to reduce this number, e.g. by treating some as being 'frozen' and some as being 'relaxed'. Chapter 8 deals with symmetrization, Chapter 9 with asymptotic stability, with estimates of the rate of decay towards equilibrium (in the form of theorems rather than practical expressions). The entropy function is given a central role in the theory, but the fact that it is a function of state and that 'state' is an observer-dependent concept does not intrude into the mathematical certainties. (The late Harold Grad's famous article 'The many faces of entropy' (*Commun. Pure Appl. Maths*, vol. 14, 1961, pp. 323–354) might have given pause here.)

Chemical equilibrium flows are considered in Chapter 10, and in Chapter 11 plane flame equations are derived from the kinetic theory of dilute polyatomic reactive gas mixtures, and existence theorems round off the analysis. The last chapter, entitled 'numerical simulations', describes a laminar flame model, which is then applied to a hydrogen–air Bunsen flame. At last the exciting possibility of a comparison between theory and observation seemed imminent, but flickered out on page 12 of this brief excursion into the real world.

The book might have some interest for those for whom 'rational mechanics' has an appeal; the work is well referenced, with the author's 60 or so works leading the field, but I cannot recommend it to the general reader with a real interest in 'Modeling and Simulation in Science, Engineering and Technology'.

L. C. Woods