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Book Review: *Kinetic Theory and Irreversible Thermodynamics*

Kinetic Theory and Irreversible Thermodynamics. B. C. Eu, Wiley, New York, 1992.

The fields of the kinetic theory of gases and of the nonequilibrium statistical mechanics of fluids could certainly use a new book. Some of the most useful and most recent, such as those by Résibois and De Leener, by Boon and Yip, by McLennan, by Reichl, and by Lifshitz and Pitaevsky, do not cover a broad enough range of topics and are, of course, somewhat out of date. I am looking forward to a book that starts with the Boltzmann equation and its generalization to higher densities made possible by the work of N. N. Bogoliubov, M. S. Green, and E. G. D. Cohen in the mid-60s. Such a book should discuss the divergence difficulties in the density expansions, their renormalization, and the long-time tail effects that follow from the renormalized theory. It would also discuss "long-time tail effects" in light scattering, and comparisons with computer-simulated molecular dynamics, including recent work on cellular automata lattice gases. If there were enough space, it would also discuss quantum systems, particularly localization phenomena that are closely related to classical long-time tail effects, as well as superfluids. If the author were truly ambitious, he or she would also make the connections between the molecular chaos of Boltzmann and the dynamical chaos of Sinai and other workers in this field. I would really love to see such a book!

Unfortunately, the book under review is not what I am waiting for. Not because it does not include all the topics mentioned above—one could hardly expect that from any single author—but rather because it presents an approach to the kinetic theory of gases that has been developed by Eu and his collaborators that is very much outside of the mainstream of kinetic theory that I outlined above. Eu rejects the divergence problem whose resolution has led to so much of the current work. Having rejected the divergence problem, Eu is then forced to reject its consequences, so there is no serious discussion of long-time tails, hydrodynamic modes, or

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any of the related phenomena that form the core of modern kinetic theory. By rejecting the foundation of the modern theory, Eu places himself in the position of having to come up with a better theory as well as having to explain where other workers, myself included, went wrong. Unfortunately, he does not manage to do either. Eu criticizes the more traditional arguments of many authors which lead to the divergence problem both for classical and quantum systems, for a lack of care given to the many-particle collision operators, but no specific errors are demonstrated and it is difficult to follow his argument in the wealth of formulas that he presents.

The first 11 chapters of the book cover the topics of irreversible thermodynamics, scattering theory, and the kinetic theory of dilute gases. These are mostly uneventful chapters. They will not supplant the treatments by DeGroot and Mazur and by Keizer, or by Chapman and Cowling, or Cercignani. They do, however, contain references to recent work. I do have some problems with Chapter 9 on scattering theory, where we clearly disagree on the properties of the binary collision expansion (the interested reader may consult Ronis and Oppenheim[1]).

My more serious problems occur in Chapter 12 and beyond where Eu treats the kinetic theory of simple dense fluids. Eu does not present a dramatically new and alternate theory that supports one's intuition as to how things ought to go in kinetic theory. Instead, Eu seems to graft the Kirkwood theory of equilibrium correlation functions and the superposition approximation onto the BBGKY hierarchy of equations, and does not consider the effects of correlated sequences of binary collisions. I have no basic objection to this, other than that it is an extension of the Enskog theory of dense gases, that the recent work of Ernst and van Beijeren on the modified Enskog theory is not mentioned, and that I find Eu's presentation of his approach confusing—I do not know where the approximations and assumptions are. Everything is buried in a wealth of formulas (not that this does not plague traditional kinetic theory), and there are no illustrations (i.e., figures) in these chapters whatsoever.

Eu does mention the Choh–Uhlenbeck three-body collision integral, but drops it quickly, and does not mention the heroic calculations of Sengers' and collaborators on its evaluation for hard-sphere molecules. The "ring collision sequences" of three or more particles that lead to long-time tails in the time correlation functions for transport coefficients are not mentioned at all. All that Eu has to say about the long-time tails is that they are due to the use of "the Liouville operator as a [time] evolution operator without subtracting out the secular part of the motion of a many-body system, or [to] numerical or approximate methods used to calculate the time correlation functions" (p. 478). The fact that long-time tails have been observed in real systems[2] as well as in computer simulations, and that long-time tail effects in nonequilibrium fluids have been observed by Law *et al.*[3] ought to give one pause about Eu's comments on the subject.

In summary, Eu presents an idiosyncratic approach to kinetic theory that is neither terribly clear nor well motivated. People willing to study his approach will still need to be convinced to do so.

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