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REVIEWS

Colloidal Dispersions. By W. B. RUSSEL, D. A. SAVILLE and W. R. SCHOWALTER. Cambridge University Press, 1989. 525 pp. £60.

Colloidal Hydrodynamics. By T. G. M. VAN DE VEN. Academic Press, 1989. 582 pp. £43.

These are two excellent texts on the physics and fluid dynamics of suspensions. A common denominator is the use of Stokes flow to model transport phenomena at the level of single particles and pairs of particles, and both texts use data from the current literature to enrich the discussions of basic principles and theories. While reviewing two books at once, even on the same subject, might lack appeal to most, I found the exercise both interesting and satisfying because of the somewhat complementary expertise offered by each set of authors. Through the process I learned quite a bit about colloid science, a field I thought I knew well before.

The book by Russel, Saville & Schowalter is intended for use as a classroom text, appropriate for a second-level course following an introduction to surface and colloid science. The text portions are extremely well written, and the chronology of the subjects, with some exceptions, follows an order appropriate for teaching. Homework problems at the end of each chapter enhance the educational value of the book. The theme running throughout is to understand suspensions from quantitative models of their microstructure, that is, particle dynamics and statistics. The emphasis is on the physics of the microstructure, with basic theories developed from principles of Stokes flow at the particle level, particle–particle distribution functions, statistical descriptions of Brownian motion, and the classical models of direct interparticle forces arising from electrostatics, dispersion forces, and polymer-mediated osmotic effects. The theoretical developments are basic and rigorous, and close enough to 'first principles' for most of us.

After an excellent introductory chapter surveying some interesting phenomena and historical perspectives of colloidal dispersions, *Colloidal Dispersions* gives an overview of two-particle interactions in Stokes flow that is easy reading yet a valuable review. The next chapter provides a nice discussion of the statistics of Brownian motion, drawing on the principles of fluid viscosity and kinetic theory. The following three chapters deal with direct forces between particles arising from screened charges (overlapping double layers), long-range dipole interactions (dispersion forces), and polymer additives (osmotic attraction or steric repulsion, depending on whether the polymer is dissolved or adsorbed). This section is a strong feature of the book, and I found the latter two chapters to be especially good. The remaining chapters, with one exception, focus on transport phenomena of suspensions, including hydrodynamics (sedimentation, diffusion, rheology), particle coagulation or capture, and electrokinetics (electrophoresis, suspension conductance and dielectric dispersion). The discussions of these phenomena build very nicely on the material presented in the first half of the book, demonstrating how the microscopic models are properly averaged to obtain suspension properties. A nice feature is the listing of references at the end of each chapter and the indexing of citations at the end of the book.

I find two important omissions from *Colloidal Dispersions*. First, there is no significant discussion of non-spherical particles, neither their transport nor effects of their orientation on suspension properties. The authors argue that the essential features of dispersions are demonstrated with spherical particles; some fluid dynamicists and rheologists will probably disagree with this assertion and be disappointed by this omission. Second, there is limited material on particle–wall interactions as they affect processes such as transport in porous media (the chapter on particle capture notwithstanding), hydrodynamic chromatography, and diffusion-limited deposition of particles onto surfaces.

The emphasis of the book by van de Ven is on the fluid dynamics of small particles rather than the behaviour of suspensions, although some suspension properties, and the averaging of microscopic models needed to obtain these properties, are discussed. Because there are no homework problems and the text is not organized in a sufficiently hierarchical manner to facilitate learning, this book is not really suited to be the primary teaching text for a course in colloid science. It is, however, an excellent reference for the behaviour of Brownian and non-Brownian particles in viscous fluids.

Colloidal Hydrodynamics begins with a broad summary of basic principles of Stokes flow and direct particle forces. The second chapter covers translational and rotational Brownian motion of single particles, spherical and ellipsoidal in shape. The author describes Brownian statistics in terms of 'jump lengths' and 'jump frequencies'. Effects of charge and adsorbed polymer at a particle's surface are included. The third chapter focuses on single particles freely suspended in arbitrary, homogeneous flows and externally imposed fields (electrical, gravitational, etc.), and although this chapter is probably too long it is an excellent compendium of hydrodynamic effects on particles. The following two chapters reconsider Brownian motion and particle dynamics in external fields when direct forces and viscous interactions between two particles are important. An important sub-topic here is how particle interactions affect the initial coagulation rate of a suspension. Particle–wall interactions, as they influence flow-induced capture and Brownian deposition of particles at solid surfaces, are treated in the next chapter. The book closes with two chapters on multiparticle interactions in concentrated suspensions.

There is no question that *Colloidal Hydrodynamics* contains a wealth of valuable material, and if one knows what he is looking for, then this book is an ideal reference. The table of contents provides a detailed outline of the book. Another attractive feature is the inclusion of experimental techniques at the end of each chapter. The sections on the transport and orientation of particles in external fields, in the strong and weak Brownian limits, are the most developed and, in my opinion, interesting parts of the book. This is to be expected from the author's background and the legacy of S. G. Mason.

The organization of topics in *Colloidal Hydrodynamics* is rather diffuse and sometimes leaves the reader wondering how the topics in one chapter tie together. For example, chapter 3 (the dynamics of single particles in externally imposed flows and fields) is so long (200 pages) that I found myself confused as to what had been covered and where I was heading. Another problem is that electrokinetic effects, resulting from coupling between flow of the suspending fluid and the electrical double layer about a particle, are introduced sporadically throughout the book without adequate presentation of basic theory, rather than being coherently discussed in one section. The treatment of electrophoresis and effects of polymers on particle dynamics, especially when two-particle interactions are important, is not as good as the fine discussions and analysis of neutral, 'bare' particles. This unevenness in coverage sometimes leads to erroneous statements by the author, for example in the section on concentration effects on electrophoresis (pp. 431–433). The lack of reference citations at the end of each chapter is also disappointing.

One omission common to both of these books is a discussion of the fluid dynamics associated with a particle moving in response to forces acting on its surface, compared to motion resulting from body forces. For example, the velocity field produced by a single particle moving by electrophoresis is irrotational at distances from the particle's surface greater than the Debye screening length; such irrotational flows are common to systems driven by interfacial forces. As a consequence, the interaction between particles undergoing electrophoretic motion goes as r^{-3}, where r is the distance between two particles, compared to r^{-1} for sedimentation or diffusion and r^{-2} for two particles in a linear shear field. Inclusion of these hydrodynamic characteristics would have enhanced both books.

Given their complementary coverages, *Colloidal Dispersions* and *Colloidal Hydrodynamics* taken together form an excellent reference for modelling suspensions at the microscopic (single particle) level. In a sense they represent a culmination of twenty years of evolution in colloid science from domination by concepts of applied chemistry to a position where statistical physics and fluid mechanics form the basis of models relating microstructure to macroscopic phenomena. A simplified but essentially accurate comparison between the two books would favour that by Russel *et al.* as a better teaching text providing a more clear discussion of how particle statistics, direct forces and fluid dynamics relate to the macroscopic behaviour of suspensions, but would rate that by van de Ven superior in its coverage of the purely hydrodynamic characteristics of colloidal particles. I value both as important references and am using them in my course on colloid science offered to doctoral students in chemical engineering.

JOHN L. ANDERSON

Oscillations and Waves in Linear and Nonlinear Systems. By M. I. RABINOVICH and D. I. TRUBETSKOV. Kluwer Academic Publishers, 1989. 577 pp. Dfl 360 (£120).

This is a curious book, but not sufficiently so to justify its price. It covers a wide domain with high technical competence but is poorly translated, poorly edited, poorly indexed, and poorly printed. It is addressed primarily to physicists, and the authors declare that their 'aim ... is to present to the reader the current state of the theory of oscillations and waves with as wide a purview as is possible without losing clarity or the formal rigor appropriate in physics'. Their scope is conveyed by the chapter titles:

1. Linear oscillators,
2. Oscillations in a system with two linked oscillators,
3. Oscillations in an ensemble of non-interacting oscillators,
4. Oscillations in ordered structures. Limit for a continuous medium. Waves. Dispersion,
5. Properties of waves with small amplitudes in continuous media,
6. Stability and instability of linear systems with discrete spectra,
7. Stability of distributed systems with continuous spectra,
8. Propagation velocity of waves,
9. Energy and momentum of waves,
10. Waves with negative energy. Linked waves,
11. Parametric systems and parametric instability,
12. Adiabatic invariants. Propagation of waves in inhomogeneous media,
13. The nonlinear oscillator,
14. Periodic self-excited oscillations,

15. General properties of nonlinear dynamic systems in phase space,
16. Self-excited oscillations in multifrequency systems,
17. Resonance interactions between oscillators,
18. Simple waves and the formation of discontinuities,
19. Stationary shock waves and solitons,
20. Modulated waves in nonlinear media,
21. Self-excited oscillations in distributed systems,
22. Stochastic dynamics in simple systems,
23. The onset of turbulence,
24. Self-organization.

Chapters 1–12 deal with linear systems, with some anticipation (as in the introduction of phase-plane diagrams) of their nonlinear counterparts, while chapters 13–24 deal with nonlinear systems. The examples assume a broad knowledge of classical physics; however, fluid mechanics enters the treatment of linear phenomena only in chapters 8–10 and 12. Fluid mechanics is more prominent in the treatment of nonlinear phenomena, but Craik's *Wave Interactions and Fluid Flows* (Cambridge, 1985) and Whitham's *Linear and Nonlinear Waves* (Wiley-Interscience, 1974) remain the references of choice for most readers of *JFM*. The discussion of turbulence as a possibly finite-dimensional dynamical system that exhibits deterministic chaos is refreshingly free of extravagant claims, although there is perhaps insufficient emphasis on the differences between open and closed flows and, in particular, the difficulties posed by open shear flows at high Reynolds numbers.

The material on chaos and self-organization is as up to date as one could reasonably expect in such a non-specialized text. It therefore is surprising to find that the electronic examples throughout the book contain vacuum tubes (valves), with diodes as the only solid-state devices. Whether this is simply a carryover from such earlier classics as Andronow & Chaikin's *Theory of Oscillations* (originally published in Russian in 1937 and as a condensed, English translation by Princeton in 1949) or actually reflects current Soviet laboratory practice is unknown to me; however, it renders these parts of the text quaint but inaccessible for the modern student (at least in the USA).

The sweep of this work provides fascinating browsing, especially in the nonlinear half; however, sloppy translation and editing make it unacceptable as a text and unreliable as a reference. The spelling of names is egregiously capricious: 'Bussinesque' for Boussinesq, 'Raus-Gurvits' for Routh-Hurwitz, 'Vyaisyalya' for Vaisala, and 'Wysem' for Whitham (whose initials occur correctly as 'G.B.' and incorrectly as 'J.B.' and 'V.G.'). The translation also yields 'arouse' for arose, 'self-simulating' for similarity and 'a not nonlinear medium.'

I am conscious, in writing this review, that nonlinear mechanics in this century has been dominated by Russian scientists, and the present authors manifestly belong to this illustrious school. It is the translator and editor(s) who must be held responsible for spoiling what could have been an attractive and valuable addition to the literature of applied mathematics.

John Miles