Computational Methods in Environmental Fluid Mechanics

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Compton, and Enrico Fermi) on how the bombs were to be used—whether in noncombat demonstration or against a Japanese target—is particularly thorough. Noting that it took place in July 1945, Herken corrects the date usually attributed to one of the meetings. That was before the Trinity test, when it was not clear whether the implosion mechanism would work. The new date casts a different light on Oppenheimer's recommendation that the atomic bomb be used against Japan.

Of the three men whose lives he recounts, Herken seems to understand Lawrence best and to admire him the most. With his strong advocacy and support of the nuclear test ban treaty, Lawrence broke with Teller and Strauss. Herken movingly narrates Lawrence's change of heart to test-ban advocacy before his death in August 1958. Herken finds it much more difficult, if not impossible, to make sense of Oppenheimer. And wisely, he lets Teller speak for himself. If only partially successful in making these men understandable, Herken has eminently succeeded in illuminating some defining events of the 20th century.

Nature's Flyers: Birds, Insects, and the Biomechanics of Flight

David E. Alexander
Johns Hopkins U. Press, Baltimore, Md., 2002. $49.95 (358 pp.). ISBN 0-8018-6756-8

Bound as we are to Earth, we find bird and insect flight endlessly fascinating. Most of us perhaps have wondered, at one time or another, just how birds and insects flap their wings, and how they manage to stay aloft. Scientific work inspired by biological flight dates back to the 1500s, when Leonardo da Vinci designed a number of birdlike flying machines (ornithopters). The quest to achieve aviation based on bird flight continued and reached a climax with Otto Lilienthal, who designed ingenious gliders and daringly flew them. Sadly, before he could test one of his powered-glider designs, Lilienthal was killed in a gliding accident in 1896. A few years later, the success of the Wright brothers changed our view of flight. Abandoning the often unstable ornithopter design, the Wright brothers adopted a fixed-wing design. As we know, the fixed wing works remarkably well at large scales and high speeds.

Although the fixed-wing design has engineering advantages, it cannot be simply scaled down to the size of insects, nor do devices built with fixed wings have the maneuverability that birds and insects have. Recently, scientists have used robotic, computational, and theoretical models to make important advances in the study of flapping flight. So now is an exciting time to seriously explore flapping flight at small scales and to take a closer look at birds and insects.

How do birds and insects maneuver, how do they stay on course, how do they navigate and migrate, and how did they evolve? These are the topics of *Nature's Flyers: Birds, Insects, and the Biomechanics of Flight*, by David E. Alexander. An assistant professor in the department of entomology at the University of Kansas, Alexander has been interested in biomechanics for more than 20 years.

The book is aimed at a popular audience that does not necessarily have a background in fluid mechanics or biology. Alexander achieves the difficult feat of explaining intrinsically complex phenomena without using mathematical or entomological jargon. As a result, the book is clear, beautifully written, and suitable for people at all levels.

Primarily, the book focuses on the physical aspects of flight. Its first half, devoted to the physics of how a wing works, reviews the canonical example of a classical airfoil moving in fluid. Alexander then discusses different flight styles seen in nature, such as gliding, soaring, and flapping. He explains the maneuvering and power requirements during flight. Although the book includes a brief summary of recent findings in insects' use of unsteady mechanisms, such as dynamic stall and wing and wake interactions, most of the discussions are based on the classical lift and drag of a fixed wing. Such a treatment is appropriate for the level of the book. But of course, it is risky to deduce results about flapping flight using analogies with airplanes. There is no telling when such analogies will go wrong. The old myth of bumblebee flight was an easy case in which anyone could see that the theorists had made an error. Other cases could be much more deceiving. For example, in low-Reynolds-number flapping flight, lift and drag no longer take their traditional role that lift is good and drag, bad. Flapping flight can make use of both.

The second half of the book moves beyond the detailed physics of flight to insect evolution, migration, and navigation, and to the global impact of animal flight. The discussions are brief and general, but introduce readers to some long-standing puzzles. For example, how do some insects manage to fly nonstop over hundreds of miles? How do migrating birds find their way?

It should be clear from reading *Nature's Flyers* that many of the questions it broaches are still open-ended. Perhaps the open-endedness will encourage some readers to take on the challenge of solving puzzles in this rich area of research. The book contains an extensive list of references up to 1999, thus providing a good starting point for further investigations. I recommend the book to anyone who is curious about flight.

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Computational Methods in Environmental Fluid Mechanics

Olaf Kolditz
Springer-Verlag, New York, 2002. $54.95 (378 pp.). ISBN 3-540-42895-X

Environmental fluid mechanics (EFM) is the study of natural fluid systems with emphasis on the transport and dispersion of environmental contamination. The diverse field includes fluid flows in the atmosphere; in surface waters such as wetlands, rivers, estuaries, and oceans; and in subsurface regions. A wide range of time and spatial scales and a multiplicity of interacting processes often make numerical simulation of such flows challenging and computationally intense. Continued increases in computer power allow modeling of larger, more detailed, and more complex problems; increase the accuracy and scope of flow and transport simulations; and create excitement among researchers.

Because of the diversity and complexity of EFM, it is not surprising that most texts limit their focus to specific areas. For example, Jacob Bear's excellent text *Dynamics of Fluids in Porous Media* (Dover, 1988) focuses on subsurface flows and transport. Benoit Cushman-Roisin's *Introduction to Geophysical Fluid Dynamics* (Prentice Hall, 1994) discusses oceanographic and atmospheric flows. However, a good text is long overdue on computational methods in EFM, tailored to the masters or beginning PhD level and addressing the many challenges of numerical-model design. I was therefore interested to read Olaf Kolditz's *Computational Methods in Environmental Fluid Mechanics*.

The book comprises four parts. In part I (chapters 1–4) Kolditz gives a general introduction to the partial differential equations (PDEs) that describe fluid flows, including turbulence and flows in porous media. The discussion, limited to flows in inertial frames of reference, does not include large-eddy simulation and therefore excludes many geophysical flows. Part II (chapters 5–8) introduces numerical methods—finite differences, finite volumes, and finite elements—for solving PDEs. Part III (chapters 9–11) is devoted to object-oriented programming and emphasizes a software package Kolditz and his colleagues developed for the simulation of flows in fractured porous media. Each chapter in part IV (chapters 12–15) discusses a particular application in the complex and challenging field in which Kolditz is active—flow and transport in fractured porous media.

According to the preface, the first three parts are taken from a masters course in computational fluid mechanics at the University of Tübingen. The level is suitable for beginning graduate students. In contrast, part IV is based on research papers written by Kolditz and colleagues and is therefore pitched at a much higher level. The book has a narrower scope than the title suggests, but that is to be expected considering the diversity of EFM.

Unfortunately, the contents of the book are disappointing. Part I offers mostly mathematical discussion but little physical insight. Chapter 3's introduction to flows in porous media does not provide sufficient background for parts III and IV. Part II would have benefited from an additional chapter on the challenges to numerical simulation of porous media flows, such as upscaling, geological uncertainty, and effects of numerical diffusion and dispersion. Although part III gives a good overview of RockFlow, Kolditz's object-oriented software package, it does not provide general insight into object-oriented programming. For example, Part III does not explain the essential concepts of encapsulation and polymorphism. Also, the RockFlow software is not distributed with the book. Part IV requires extensive additional reading for people not trained in flows through fractured porous media, although it does offer domain experts a nice overview of Kolditz's research.

The text of parts I–III is sketchy, at times sloppy, and resembles class notes more than a textbook. The sloppiness is annoying; for example, chapter 5 states the Lax equivalence theorem as if it were valid for all fluid-mechanical systems. Roughly half of the chapters in parts I–III come with exercises, but almost all merely ask the student to regurgitate material covered in the text and are therefore not very interesting. The equations are hard to follow because the book has no list of symbols. Also, many figures lack appropriate commentary. Finally, except in part IV, reference lists are surprisingly short. For example, part I has only 17 references, 8 of which are to sources in German.

Unfortunately, I cannot recommend *Computational Methods in Environmental Fluid Mechanics* as a textbook. Until a better alternative is published, I will stick with the excellent texts by Bear and Cushman-Roisin, supplemented by C. A. J. Fletcher's *Computational Techniques for Fluid Dynamics* (Springer-Verlag, 1991) or Joel Ferziger and Milovan Perić's *Computational Methods for Fluid Dynamics* (Springer-Verlag, 2001).

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Defects and Geometry in Condensed Matter Physics

David R. Nelson
Cambridge U. Press, New York, 2002. $110.00, $40 paper (377 pp.). ISBN 0-521-80159-1, ISBN 0-521-00400-4 (paper).

For 25 years, David Nelson has made major contributions to the study of how defects influence the properties of such condensed matter systems as solids, liquid crystals, superfluids, and polymer solutions and melts. His dominance in the field has been reinforced by his excellent surveys in the proceedings of summer schools, workshops, and conferences from 1983 to 1996. *Defects and Geometry in Condensed Matter Physics* is primarily a compilation of eight of those reviews. Each article has a new short preface, which usually refers the reader to more recent reviews and provides updates of the bibliography. An opening chapter, which ties the collection together, makes clear that Nelson selected the reviews not to be comprehensive but to emphasize work in which he was directly involved. The book is aimed at graduate students in physics, physical chemistry, and chemical engineering, and to more advanced researchers in those fields.

Chapter 2, a reprint of Nelson's review of defect-mediated phase transitions, was originally published in volume 7 (Academic Press, 1983) of the series, *Phase Transitions and Critical Phenomena*, edited by Cyril Domb and Joel Lebowitz. It is by far the most commonly cited of the eight reviews, and I find it the most accessible treatment of its subject. It is a masterly survey of the theory of vortex-driven transitions from superfluid to normal fluid in helium films and of melting two-dimensional solids. Early in his career,