

which he was reprimanded at the specific insistence of President Eisenhower. On a night train to Washington in January 1953, Wheeler took along a secret document, which mentioned the importance of lithium-6 for H-bombs. The document mysteriously disappeared, and he duly reported it. The news reached Eisenhower, who insisted on a personal reprimand. Ironically, as Wheeler remarks, lithium-6 had been used earlier in the first Soviet H-bomb. He felt he had been forgiven when President Johnson gave him the Fermi Award in 1968.

The theory of gravity, to which he and his students have made outstanding contributions, consumed Wheeler for the second half of his life; he reminds us that by now he has worked longer on gravity than Einstein did! In 1952, he started to study the singularity that may be left when a star collapses, and he popularized the term "black hole," which was suggested by an anonymous listener during one of Wheeler's lectures—an early information loss for black holes! Unlike some other phenomena he has been interested in, black holes are now accepted as real. The other two concepts of the title, and many other visions he has had, are still speculations: the geon, "a hypothetical entity, a gravitating body made entirely of electromagnetic fields," and quantum foam, "space time churned into a lather of distorted geometry."

At age 65, Wheeler accepted an offer from the University of Texas at Austin, where he stayed for ten years. There, he says, "I was not only tolerated as I pulled aside from the herd in theoretical physics to pursue my own byways. I was encouraged and supported."

Wheeler comes across as a man who dreams with open eyes; he feels he has earned the right to speculate, and his philosophical trend leads him to pronounce many dicta: for example, "The smooth flow of time is shattered when we look at short-enough intervals of time"; "There was no 'before' before the Big Bang, and there will be no 'after' after the Big Crunch" (recent observations do not favor a Big Crunch); "The laws of physics come into existence with the Big Bang as surely as space and time did." As an octogenarian, he asks himself every morning the "deep" questions: How come the quantum? How come the universe? How come the existence? He believes these questions will be answered by physics in the next century.

This is a splendid autobiography by an honest man who frankly tells us that his "naïveté" helped his scientific vision. Forever optimistic, he believes that nature has in the past made use of his visions, or may do so in the

future. One is tempted to paraphrase Shakespeare: There are more (or fewer) things in heaven and Earth, Johnny, than are dreamt of in your philosophy.

## Quantum Mechanics

▶ Eugen Merzbacher  
Wiley, New York, 1998. 3rd  
edition. 656 pp. \$90.95 hc  
ISBN 0-471-88702-1

Back in the fifties, when I was learning quantum mechanics, there were only two "modern" textbooks to choose between: those by Leonard Schiff and David Bohm. Schiff's *Quantum Mechanics* (McGraw Hill, 1968, 1955, 1949) was a bread-and-butter book, presenting the ideas as succinctly as possible and reinforcing the results with lots of very good problems. It taught calculation, but there was no discussion of tricky fundamental concepts. It bolstered the prejudice of the day (which is, unfortunately, still prevalent) that physicists learn to use quantum mechanics and don't bother to ask what it means.

Bohm's *Quantum Theory* (Prentice Hall, 1951; Dover reprint), on the other hand, was full of words. The author was worried by the theory. He examined in detail what it meant to make a measurement. He cast the famous paradox of Einstein, Podolsky, and Rosen into a form that made it possible to analyze quantitatively the problems they raised, an analysis later taken on successfully by John Bell. A wonderful book, but short on calculational techniques. A student had to study both Bohm and Schiff to learn the subject. There was no intermediate approach.

Into this breach came the first edition of Eugen Merzbacher's *Quantum Mechanics* (Wiley, 1961), pedagogically a very good book. It introduced even the simple subjects with an eye toward what was ahead so that, when students saw more complicated material, they would have the feeling that it was merely an extension of what they had already seen.

The discussion was not formal, as in advanced texts, but was always geared to physical interpretation. Here one had a book in which providing a physical feeling for what was going on was foremost, and the mathematical techniques were important but subordinate. It did not go into the deep questions of interpretation, but its emphasis on the physics made up for this to some extent.

After about ten years came a second edition of Merzbacher (Wiley, 1970). By then there was more competition, but the newer books tended to give more formal treatments of the subject. I

found myself teaching from various new books as they came out, but generally returning to Merzbacher.

Now, after almost 30 years, comes a new edition of Merzbacher. Today there are many quite good quantum mechanics books, with different strengths and weaknesses. So the question is, Which one of them should I choose as a text? I don't think there is a single answer. The best I can do is to tell you what I consider to be some of the strengths and weaknesses of this new edition and let you decide for yourself. However, I recommend that, if you do not use Merzbacher's third edition, you should at least place it on reserve so your students can consult it.

Its strengths are those of the previous editions. The discussions are physically oriented, although there is now more emphasis on the mathematics. There is a trade-off in his discussion of measurements. He still does not analyze the mechanics of measurements, but he includes insightful discussions of the use of density matrices to describe measurements, and he relates the results of measurements to information theory and the entropy of the system. The discussion of WKB theory is very strong. He cures a previous problem by introducing perturbation theory and approximate methods earlier. He has a good discussion of gauge theories at this level and even introduces a gauge transformation when talking about the Born-Oppenheimer approximation. (However, although the index looks very detailed, you won't find in it anything related to "molecule," or to a number of other topics he discusses.) Merzbacher has retained a wonderful discussion of scattering, and now there is a reasonably strong discussion of aspects of quantum optics. Another new and good feature is the inclusion of lots of useful homework problems; in the previous editions, the problems were mostly used to complete proofs in the text.

Among the weaknesses is the haphazard discussion of atomic and nuclear physics. Most of the important topics are covered (the Stark effect and the like), but they are scattered throughout the book and are used to illustrate various principles, such as symmetry. The author doesn't pull them together into a coherent subject. He doesn't introduce the Pauli principle until late in the book, in a discussion of second quantization. This is unfortunate, and it leads to no mention whatsoever of the periodic table so far as I could tell. A number of more recent topics, such as Feynman path integrals or the Berry phase, are referred to in passing, or are discussed too briefly, while the Aharonov-Bohm effect and

K-meson decay are reduced to homework problems. Other good, recent pedagogical topics are left out, such as the neutron interferometer, Bell's theorem, and the Josephson effect. But an author has to pick and choose topics, so one can't really criticize him for the omissions.

My overall conclusion? It's good to have Merzbacher back. The second edition was getting seriously out of date. The third is a good, substantial, well-written text and will compete well with the other recent good texts out there. I have had good luck with the earlier editions of *Quantum Mechanics*, so I recommend that anyone looking for a first-year graduate text consider using it.

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## Classical Dynamics: A Contemporary Approach

Jorge V. José  
and Eugene J. Saletan  
Cambridge U. P., New York, 1998.  
670 pp. \$125.00 hc (\$54.95 pb)  
ISBN 0-521-63176-9 hc  
(0-521-63636-1 pb)

Classical mechanics has for years been the Cinderella of the graduate curriculum in many physics departments. Some departments have actually stopped teaching it. Recently, mainly as a result of the renewed interest in deterministic chaos (and the discovery that the warhorse of mechanics—the Solar System—falls into this category), there has been renewed interest in the subject, and the number of modern textbooks on classical mechanics is increasing. Many of these, however, require a familiarity with differential geometry, which has led to some reluctance to adopt them in many graduate schools. *Classical Dynamics*, by Jorge V. José and Eugene J. Saletan, should certainly redress this: It strikes the right balance between physical reasoning and mathematical sophistication, at the same time as it takes the reader to the forefront of active research in the field.

From the focus of the book, one can guess that the authors' backgrounds are in particle or plasma physics rather than celestial mechanics. José is the Matthews Distinguished University Professor and director of the Center for Interdisciplinary Research on Complex Systems at Northeastern University. Saletan, a professor emeritus of physics at Northeastern, is coauthor with Alan Cromer of *Theoretical Mechanics* (Wiley, 1971) and with Giuseppe Marmo, Alberto Simoni,

and Bruno Vitale of *Dynamical Systems* (Wiley, 1985).

*Classical Dynamics*, a rather hefty book, can be used as a textbook and as a reference on newer topics in mechanics. It does not confine itself to particle mechanics, and it contains an interesting chapter on continuum mechanics and nonlinear field theory. It introduces the reader along the way to some of the differential geometric aspects of Lagrangian and Hamiltonian mechanics, without getting too involved in the mathematical nitty-gritty. It contains a wealth of worked examples and interesting problems, the solutions to which are available (to instructors) on DOS or Macintosh diskettes in PDF format.

Some of the book's refreshing features bear mentioning. Instead of the usual presentation, starting from Newton's laws or Hamilton's principle, Newton's laws are "derived" (in the spirit of Ernst Mach) by analyzing momentum conservation in two-particle interactions in an inertial frame. Mass thus appears naturally via mass ratios, and force is treated as it should be, as acceleration. The notions of stability and chaos appear as early as page 10.

The book moves on briskly to the Lagrangian treatment of constrained problems, and the notions of manifold and tangent bundle appear in chapter 2, with lots of good illustrations to facilitate understanding. Motion of charged particles in electromagnetic fields is used to illustrate gauge invariance.

The chapter on variational principles is succinct but discusses such difficult topics as nonholonomic constraints and dissipation with much greater clarity than do most textbooks I know. The chapter ends with a discussion of Noether's theorem and active and passive symmetry transformations.

There is a nice chapter on classical and inverse scattering, including chaotic scattering (with an easy introduction to fractal dimensions). A useful application is the scattering of a charge by a magnetic dipole (the Störmer problem). The chapters on Hamiltonian dynamics, canonical transformations, and completely integrable systems are clear and easy to read. The Kolmogorov–Arnold–Moser (KAM) theory is clearly explained, based on a presentation of Jean Belissard and preceded by good examples of deterministic chaos. The necessary number-theoretic concepts are explained in an appendix.

Recent interesting developments, such as the Hannay angle, are also introduced. A brief chapter on the rigid body is followed by a nice chapter on continuum theories, nonlinear field theories, and solitons. Starting with the Sine–Gordon equation as the con-

tinuum limit of a chain of coupled pendulums, the authors introduce the reader to Maxwell's equations, some special relativity, solitons, and the Euler and Navier–Stokes equations.

The book is nicely typeset and printed on an ivory-colored, heavy-textured paper that is pleasant to the sight and touch, and the illustrations are very good. There are few if any obvious mistakes and surprisingly few misprints (most of them in proper names). I highly recommend this book to instructors and students alike.

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## The Defining Years in Nuclear Physics: 1932–1960s

Milorad Mladjenović  
IOP, Philadelphia, 1998. 441 pp.  
\$150.00 hc ISBN 0-7503-0472-3

A complete history of nuclear physics is sorely needed. I say "sorely" because of all the remarkable accomplishments made since the discovery of the neutron in 1932. During this period, the existence of the mean field as represented by the shell model and the optical model was established, showing that the mean field is a good approximation in spite of the strong interactions between the constituent particles.

Nuclei were found to have deformed shapes and thus exhibited rotational and vibrational spectra and, of course, the ultimate deformation of fission. Compound nuclear resonances were discovered before World War II; the surprising giant resonances followed later. The short interaction time reactions (direct reactions) were differentiated from the long interaction time reactions (compound nuclear reactions), later, intermediate time reactions (multistep reactions) were included in the description of reactions.

It was found that highly resolved nuclear cross sections are chaotic (although that term was not used), and successful stratagems that extracted the signal from the noise were devised. Their first application led to the optical model in 1954. I shall stop this listing at this point; I could cite many more examples, not the least of which are the weak interactions.

Milorad Mladjenović's *The Defining Years in Nuclear Physics: 1932–1960s* does not, of course, cover the history of all of these various research directions in detail. The author's choices are rather idiosyncratic, governed mostly by his research interests. There are extensive discussions of nuclear instruments (pages 83 to 209) and the theory