changing dramatically in Europe, where brilliant students attracted to the field's challenges are now moving directly into permanent positions. European institutions have discovered that quantum chaologists are fine mathematicians as well as numerical analysts, almost of necessity, and are remarkably broad in the range of applicability of their expertise. The field is coming of age.

Hans-Jürgen Stöckmann's *Quantum Chaos* appears as the culmination of remarkable accomplishments by perhaps several dozen key researchers, but most notably Michael Berry and Martin Gutzwiller, over the past 25 years. The maturity of the study of quantum chaos was recognized by the Nobel Foundation as recently as June 2000, when one of its Nobel Symposia was devoted to the subject.

Stöckmann's book is a remarkable work, reflecting the growth and excitement of the field and containing something for almost everyone interested in chaos theory and experiment. Experts will appreciate the historical tidbits, many of which are not well known, and will enjoy Stöckmann's compelling presentation of facets of the field that are outside their own areas of specialization. Beginners will find an engaging and approachable introduction to the field, with chapters on most aspects of quantum chaos and its experimental implications. The subjects are current and reflect a broad view, including experiments, inspired by chaos, whose ultimate bearing on the field may have been marginal but whose impacts on other fields can have been considerable.

The book contains the most readable introductions to random matrix theory and supersymmetry that I have seen. The style and clarity of writing are both excellent. Stöckmann is an experimentalist, but his insights and intuition for theory are quite remarkable and worth reading. References to original work are plentiful and well chosen, and for that reason alone the book is valuable and will fast become a "must-have" for those with an interest in quantum chaos.

On the downside, Stöckmann's book is not flawless. A few painful typos exist. For example, the first time the nearest-neighbor level-spacing distribution is displayed, it is missing a factor of the spacing, "s." More subtle but more serious is Stöckmann's treatment of symmetry in quantum mechanics, which is fast and loose at best and wrong at worst. Teaching from this section would be a rocky experience. In fact, experts in a number of subfields will no doubt recognize flaws that they would want to correct.

The sum of all these flaws is not devastating by any means, but because of them Stöckmann's book just misses the mark on being a good textbook from which nonexpert instructors could teach. This is a shame: Courses on quantum chaos are a great way to introduce classical and quantum mechanics of current theoretical and experimental interest. But such courses are rare, partly because of lack of a good text. It wouldn't take much to fix this aspect of Stöckmann's book and make it such a text, and I look forward to a corrected edition. Experts could use the book as a text now, correcting a few things along the way.

Other books on quantum chaos—first generation texts from the early 1990s—include Martin Gutziller's work, *Chaos in Classical and Quantum Mechanics* (Springer-Verlag, 1990), centered on his famous trace formula, Linda E. Reichl's *The Transition to Chaos in Conservative Classical Systems* (Springer-Verlag, 1992), and Fritz Haake's *Quantum Signatures of Chaos* (Springer-Verlag, 1992). Reichl's work is a useful survey of the literature; Haake's work (due out in a new addition soon) is mainly for theorists and much more rigorous than Stöckmann's book. I am glad to own all four, but the book I show to students first is Stöckmann's.

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The Distribution of the Galaxies: Gravitational Clustering in Cosmology

William C. Saslaw
Cambridge U. Press, New York, 2000. 508 pp. $100.00 hc
ISBN 0-521-39426-0

William C. Saslaw's *The Distribution of the Galaxies* is an excellent and useful book that is especially well suited to the needs of advanced undergraduates and beginning graduate students. Researchers, as well, should welcome its comprehensive and detailed discussion of a theoretical approach that does not figure prominently in other book-length accounts of what Edwin Hubble, in a famous series of lectures, called the realm of the nebulae. Saslaw, a pioneer in the application of thermodynamics and statistical mechanics to gravitational astrophysics, modestly but accurately describes the book as "really no more than an extended essay on aspects of galaxy clustering that I've found especially interesting."

The essay's main thesis is that galaxies can be thought of as particles of a gas that evolves through a series of quasi-equilibrium states. With this assumption, and with the gas's equation of state given by the cosmic energy equation, one can use standard methods in thermodynamics, statistical mechanics, and kinetic theory to predict functions that describe the distribution of galaxies in physical space and in velocity space. A straightforward application of thermodynamic fluctuation theory then gives the distribution of galaxy numbers in a volume of given magnitude. To predict the distribution of peculiar velocities, one needs an additional assumption: the value of the parameter "b" (mentioned below).

Roughly half the book is devoted to these and closely related theoretical matters and to discussions of computer simulations and observational evidence that bear directly on the predicted distribution functions. The book also contains a relatively brief but insightful discussion of theoretical and practical aspects of correlation functions.

Most students, and many of their mentors, pay little attention to the history of the problems they are trying to solve, assuming that it is of more interest to historians than to working scientists. In reality, nothing is more helpful to the novice scientist than a deep understanding of how his or her subject has evolved. One of the best things about the book under review is its opening 50-page history of efforts to describe and understand the spatial distribution of galaxies.

A further bonus is a cluster of five short chapters dealing with nontraditional mathematical techniques for describing nonuniform spatial distributions of points: percolation; minimal spanning trees; topology; and fractals, introduced by a brief discussion of the problem of distinguishing genuine patterns from optical illusions. Here the author's talent for clear, concise, and insightful exposition is on display. Equally impressive, and especially valuable for students, are his accounts of key ideas and results in thermodynamics, including phase transitions and kinetic theory. The author does not merely apply results from other branches of physics to the problem at hand, he either derives them from the ground up or explains their provenance in ways that encourage an interested reader to seek further enlightenment.

The author's assumption that galaxies can be treated as particles in a gas that expands through a sequence of quasi-equilibrium states allows him to put to one side the question of how cosmic structure arose and evolved. My own view is that galaxy clustering is one stage in a process of hierarchical clustering that began with the formation of the smallest self-gravitating units and proceeded through stars, multiple star systems, star clusters, and so on through galaxy superclusters. In this view, the cosmic medium is a "gas" that remains on the edge of thermodynamic instability as it expands; I raise the subject here, because it leads to a prediction about a parameter that plays a central role in Saslaw's book. The prediction is that this parameter, which in Saslaw's book varies with time, has a fixed value close to 0.75; figure 4.1 on page 30 of the book shows that the Saslaw–Hamilton spatial distribution function fits Hubble's old galaxy counts almost perfectly, if the parameter "b" is assigned the value 0.72; numerical simulations also support a value close to 0.75.

The author and the editors have found many ways to make *The Distribution of the Galaxies* both attractive and reader-friendly. Cambridge University Press is to be congratulated on a splendid job of book-making. The quality of the book matches the quality of its contents.

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Journeys Beyond the Standard Model

Pierre Ramond
Perseus Books, Cambridge, Mass., 1999. 373 pp. $60.00 hc ISBN 0-7382-0116-2

Pierre Ramond, the author of *Journeys Beyond the Standard Model*, is well known for work in the dual resonance model, which is the precursor of present string theory, and for work in particle phenomenology. So he is well qualified to write a pedagogic work on theoretical high-energy physics.

More than half of *Journeys Beyond the Standard Model* is a careful description of the minimal standard model of particle physics; it could be the basis of a course for advanced graduate students with a background in special relativity, quantum mechanics, and, preferably, some quantum field theory. The "journeys" he discusses have been subjectively chosen; another author might choose differently, but Ramond's choices are well representative of, and provide a good preparation for, current research in the field.

The standard model has been established now for more than 20 years; it is the sine qua non in the armory of any researcher in high-energy theory. The main target of much present research is to find chinks in its armor. These have been surprisingly difficult to find; the theory's predictions have turned out to be robust despite experiments of extraordinary precision.

In 1998, an announcement from the neutrino-oscillation collaboration known as SuperKamiokande and buried under the Japanese alps, electrified the field by reporting compelling evidence for the first physics beyond the standard model: Data on atmospheric neutrinos showed that muon neutrinos oscillate—apparently into tau neutrinos—and hence that neutrinos have nonzero mass. These findings are at odds with the minimal standard model.

The standard model is composed of two pieces, quantum chromodynamics (QCD) and the electroweak theory. Each piece is a gauge theory with fermionic matter, so its presentation as an example of quantum field theory involves description of the Lorentz group and its representations, and the construction of a gauge-invariant classical Lagrangian. The electroweak theory presents additional subtleties, such as chiral fermions and the Higgs mechanism.

The book gives a nice description of all these bits and pieces, and it provides the students with more than 100 exercises to help them learn how it all works. The treatment includes up-to-date coverage of one-loop corrections and comparisons of precision experiments to theory.

The minimal model, with its tantalizing robustness, has 19 free parameters, strongly suggesting that it must be a part of a more unified theory with fewer parameters. One of the parameters characterizes violation of *CP* (charge conjugation–parity) symmetry in QCD, and consistency with data demands that its value be exceedingly small. This fine-tuning suggests the necessity of theoretical extension. One possibility, now more than 20 years old, leads to a curious particle, dubbed the axion, which has eluded detection but is presently being vigorously sought in ingenious experiments.

All but one of the particles of the minimal standard model have been established experimentally, the most recent (summer 2000) being the tau neutrino. The list includes 12 gauge bosons and 45 helicity states of quarks and leptons. The remaining particle is the Higgs boson, a hypothetical scalar responsible for breaking symmetry between electromagnetic and weak interactions and, more remarkably, for giving mass to everything. Suggestive evidence for the Higgs was reported on 5 September 2000 at a CERN symposium.

In the quantum theory, the Higgs gives rise to violent ultraviolet divergences, which can be canceled if an additional symmetry—supersymmetry—is present. Supersymmetry predicts partners for all of the aforementioned states of the standard model; such partners are another prime target of planned high-energy experiments.

Ramond covers all of this (except the recent Higgs work, of course). His thoroughness and perspective make this book a "must-buy" for university libraries and a valuable addition to the personal library of any student or experienced researcher in particle theory. It has a place of honor in my collection.

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Quantum Heterostructures: Microelectronics and Optoelectronics

Vladimir V. Mitin, Viatcheslav A. Kochelap, and Michael A. Stroscio
Cambridge U. Press, New York, 1999. 642 pp. $120.00 hc ($49.95 pb) ISBN 0-521-63177-7 hc (0-521-63635-3 pb)

"Welcome to the world of quantum-based devices!" This is how Vladimir V. Mitin, Viatcheslav A. Kochelap, and Michael A. Stroscio begin *Quantum Heterostructures*. The book appears at an opportune time: President Clinton's January 2000 speech at Caltech, in which he announced the "National Nanotechnology Initiative," has buoyed the field of nanostructure research and is sure to attract attention and activity to the area of nanostructures and quantum-based devices.

This book introduces the fundamental physical principles underlying quantum heterostructures and their applications to microelectronics and optoeletronics. The authors start out