

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. Strosio
*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. Strosio 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 optoelectronics. The authors start out