OMNÈS *(continued from previous page)*

individual members of the family. (Unconventional lattice-theoretic "quantum logics", which have been much investigated, do not enter.) All physical reasoning should be carried out according to the usual rules of logical implication; this is an informal statement of the Omnès "universal rule of interpretation," which, one would hope, permits us to dispense with objectionable, handwaving arguments.

As a consequence of the above rules, Omnès succeeds in providing a derivation of the laws of classical mechanics from those of quantum theory, as well as a proof of the measurement postulates that now appear as theorems. These derivations are in principle accompanied by precisely defined error bounds that delimit their domains of applicability. Especially interesting is the status of the reduction postulate, which has been the source of virtually infinite debate. It now appears simply as an extremely convenient computational tool and is generalized to include, at least in principle, the complexities of the measuring apparatus. For ideal measurements, Omnès's result reduces to the Lüders formula.

The physical reason for the onset of classical behavior, as well as effective noninterference in superpositions of macroscopic states, is the extremely efficient and rapid decoherence effect. This phenomenon, which is carefully analyzed by Omnès, arises from the interaction of the collective coordinates of a macroscopic system with a dissipative environment.

The exceptional cases of macroscopic systems with very small dissipation—SQUIDS and quantum optical devices—were first studied by Anthony Leggett in 1980 and have been the object of numerous subsequent theoretical and experimental investigations. They provide illustrations of macroscopic systems that display quantum tunneling and quantum coherence effects. Their existence poses grave difficulties for the usual formulation of quantum theory, which virtually equates the words "macroscopic" and "classical." These examples, as well as a number of others, are analyzed in the final chapters of Omnès's text, where it is shown that they fit neatly into the consistent histories formalism. However, one wishes that a fuller exposition of the technical details had been provided; from a pedagogical point of view, it would have been desirable to provide a few more simple illustrations of the new ideas quite early in the text.

One should be alert to the presence of a fairly large number of misprints in this otherwise very valuable work. (Some of the important philosophical questions arising from the Omnès formulation are discussed in the accompanying review of *Veiled Reality: An Analysis of Present-Day Quantum Mechanical Concepts*, by Bernard d'Espagnat.)

D'ESPAGNAT *(continued from previous page)*

may be incorporated into all sensible logics without disturbing consistency and that, therein, are logically equivalent to facts, are also designated as true. These definitions of truth satisfy all of the formal requirements of mathematical logic and hence lead to no contradictions. There exist properties that may be added to some sensible logics but not to all; in those logics into which they may be incorporated, they are again equivalent to facts. Such properties clearly have a more limited significance than true properties and are designated as reliable. The failure in the first papers of Robert Griffiths and Omnès to distinguish clearly between true and reliable properties was noted by d'Espagnat and has led to considerable debate among these three authors.

Finally, I mention one further delicate point upon which d'Espagnat and Omnès differ: In addition to the collective observables, which may obey the laws of classical mechanics, there are the internal microscopic degrees of freedom designated as "sensitive properties;" these are clearly very difficult to measure and hence are veiled from view. Whether this is due to human limitations in the construction of the necessarily exceedingly complex measuring devices, as d'Espagnat believes, or is a limitation in principle, as Omnès believes, is not easily resolved. Omnès bases his view on an interesting theorem that purports to demonstrate that the size of the necessary apparatus exceeds by many orders of magnitude the size of the universe. Moreover, such enormous devices, even granting their existence, would clearly require for their understanding that due cognizance be taken of relativistic limitations on signal propagation. It is probable that this question will not be definitively resolved until efforts to incorporate general relativity into the consistent histories picture are brought to full fruition. However, sensitive observables may provide a concrete illustration of the fact that independent reality is destined to remain forever veiled.

As the author himself acknowledges, *Veiled Reality* is not a conventional textbook since, at least as far as philosophical considerations are concerned, it reflects the author's personal evaluation. However, that evaluation is buttressed by such a careful and erudite analysis that this work will provide a virtually indispensable supplement to courses on the foundations of quantum theory.

High Energy Astrophysics: Vol. 2

Malcolm S. Longair
Cambridge U.P., New York, 1994. 393 pp. $69.95 hc
ISBN 0-521-43439-4

Contemporary astronomers study the universe using a wide variety of probes, measuring electromagnetic energy at wavelengths from radio waves to very-high-energy gamma rays, neutrinos from the Sun and stars, and high-energy cosmic rays. There are searches for the presence of ubiquitous dark matter and gravitational radiation. Vast amounts of data are steadily being collected with new ground- and space-based instruments and techniques. A textbook that can present all of this information in a coherent, comprehensive and readable manner as well as fit it into a theoretical framework is much needed.

Specialized texts exist on stellar structure, accretion phenomena, high-energy radiation processes, cosmic rays, cosmology and other topics, but no one brings the whole subject together with the brevity and clarity of a broad-band perspective. Malcolm Longair's *High Energy Astrophysics* texts are most welcome steps towards filling this void. Volume 1 was published in 1992; Volume 2 has now appeared and I understand that Volume 3 is on the way. Longair is a leading authority in astronomy and high energy astrophysics, and in *High Energy Astrophysics: Volume 2*, he provides an expert's view on this wide-ranging subject. The book will be welcomed by those of us who teach this subject to undergraduate seniors and first-year graduate students and by physicists who are interested in doing nonaccelerator astroparticle physics.

One of the main strengths of the presentations in Longair's second volume is strong emphasis on physical principles and the discussion of general results, rather than detailed discussion of particular models. The descriptive sections of the book are written in a clear and easily readable style. The majority of the quantitative derivations are described in sufficient detail (very little is left to: "it can be easily shown . . .", and the

reader is referred to specialized texts where needed. Material is up to date, and references to the original articles are included. The main shortcoming of the presentation is the absence of problems with which students can test their understanding of the material; one hopes that an accompanying problem booklet is forthcoming.

Longair's first volume concluded with an introduction to the terrestrial and heliospheric environment, including a discussion of shock waves in solar wind plasma. The second volume explores the relevance of the observations described in the first (and that of other experimental studies), to the life history of stars, the structure of our galaxy, the role of the interstellar medium in star formation and the importance of the cosmic-ray gas. The thread from which the fabric of this book is woven is the evolution of stars, from birth to death, with particular reference to our Galaxy.

The book treats such current topics as the solar neutrino problem and helioseismology. The author discusses various scenarios of mass transfer, stellar winds and accretion discs with respect to such diverse systems as x-ray binaries, cataclysmic variables, novae and supernovae of type I, to mention a few. A rather complete, though elementary, discussion covers the structures of white dwarfs and neutron stars and the formation and properties of radio pulsars and black holes. To encourage understanding of the birth of stars, Longair gives a detailed description of the interstellar medium, including current views on star-formation regions in giant molecular clouds.

He presents characteristics of radio emission of the Galaxy, after a comprehensive discussion of synchrotron radiation theory. He develops the distribution of low-energy gamma rays in the Galaxy, and their relation to the distribution of high-energy electrons is developed and includes a presentation of recent radio emission contours from various galaxies related to synchrotron radio emission. Finally, he gives an excellent summary on the origin, acceleration and propagation of electron and nuclear components of cosmic rays in the Galaxy. This includes a reasonably detailed outline of current models for shock acceleration of cosmic rays in various scenarios.

This is an exciting and timely book in a rapidly expanding field, and it should provide an excellent teaching text for high-energy astrophysics.

GAURANG B. YODH
University of California, Irvine

The Cosmological Milkshake: A Semi-Serious Look at the Size of Things

Robert E. Ehrlich
Rutgers U. P., New Brunswick, N.J., 1994. 259 pp. $24.95 hc
ISBN 0-8135-2045-2

The Cosmological Milkshake takes its title from the essay "How big are the bubbles in the cosmological milkshake?", which discusses the observation that the galaxies that make up the universe seem to be distributed along surfaces resembling numerous connected bubbles. This is but one of the book's 135 relatively short (500- to 600-word) essays on physics aimed at a general audience. The whimsical essays on, as the subtitle says, "The Size of Things," are divided into five sections on how big or far, how heavy or massive, how hot or cold, how fast and how old. What could be better than a lively book about mass, length, time, velocity and temperature?

In appealing to nonscience majors in college (and to young children), excellent questions can be and often are asked by simply extending the range. For example, it is quite natural to go from the size of our planet to the Solar System to the Galaxy to the edge of the universe. Conversely, one can ask what is inside the atom, then the nucleus, then the proton and then the quarks.

A great, Zen-like triumph of 20th-century physics is that the basic understanding of the fundamentals of particle physics is necessary for understanding the origins and evolution of the universe. Starting with almost any essay in *The Cosmological Milkshake*, the reader is naturally led to the next level up or down. Thus, as the author suggests and I agree, the 135 essays can be read in almost any order. It would be an interesting experiment to hand out a copy of the table of contents in a classroom of nonscience majors and, based on their interests, use chapter topics as the spine for a course. (The preface notes that teachers who assign the book to their classes can obtain kits of problem sets and answers, illustrations and review questions.)

In any book that attempts to explain basic ideas of physics in short, topical essays, there remains a constant tension—in a sense a complementarity—between clarity and correctness. The clearer one tries to be to a nonscientific audience, often the less accurate and detailed the explanation. In Ehrlich's collection, the approach works best for such simple ideas as equating the national debt to the height of a pile of dollar bills. It works less well with the complex, sense-defying, nondemonstrable laws of special relativity or quantum mechanics.

There are a few minor typos (liquid nitrogen at 72 K), and perhaps some "clairvoyance" when Ehrlich reports that the record high temperature reached for superconductors at the time of publication (1994) is 164 K (the number for a sample under high pressure). Very occasionally the physics is not quite accurate, as in the statement, "at room temperature, the electrons in a wire have an average speed of 118 km/s," in the essay on "how fast does electricity travel in wires?" (The author neglects to take into account the fermion nature of electrons.)

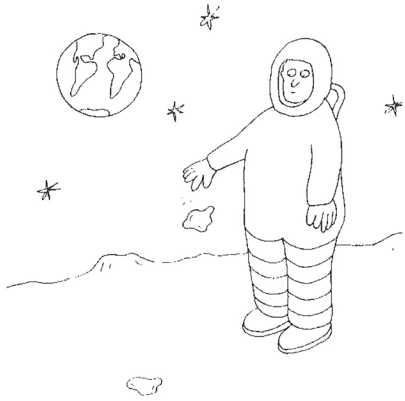

FIGURE 19. In observing that things fall slower on the Moon, Jim concludes that the Moon has stronger levity rather than weaker gravity. (From *The Cosmological Milkshake*, with permission.)

No review of this book would be complete without commenting on the "deliberately weird" cartoons by Gary Ehrlich, the author's son. Each essay has at least one line drawing cartoon that, in a zany manner, plays off an idea in the essay. (In a few of the more complex essays, two figures are associated with the essay, one a zany cartoon, the other a textbook-style illustration of the physics, and in one essay, three figures are presented.) The author states in the preface that some of the cartoons may strike you as "for adults only . . .though tastefully done." True on the "adults only" comment, while the "taste" is in the eye of the reader. Most of the cartoons are quirky enough to entice many nonscience readers. The book contains a very modest bibliography.