BOOK REVIEWS

A View of the Particle World

Conceptual Foundations of Modern Particle Physics. ROBERT E. MARSHAK. World Scientific, River Edge, NJ, 1993. xxviii, 673 pp., illus. $86 or £61; paper, $46 or £32.

Robert E. Marshak was a distinguished theoretical physicist who grew up with the field of particle physics. The author, with Hans Bethe, of the two-meson hypothesis that disentangled Yukawa's nuclear-force carrier, the pi meson, from the unexpected muon and, with E. C. G. Sudarshan, of the V − A hypothesis that brought Fermi's theory of beta decay into accord with the evidence for parity violation, Marshak was for a half-century one of the great enthusiasts of particle physics. He was also an ardent internationalist, animator of the "Rochester Conferences" that grew into the biennial International Conference on High Energy Physics.

Marshak saw particle physics emerge from nuclear physics, pass through several periods of splendid confusion, and grow to maturity, nourished by a host of experimental results from cosmic rays and accelerators. *Conceptual Foundations of Modern Particle Physics*, which was completed just before his death at the end of 1992, is his intellectual summation, his analysis of the ideas that have brought the theoretical understanding of fundamental processes to its present highly successful, yet incomplete and tantalizing, state. It is the record of a life in particle physics, less a textbook than a statement of how the author thought, what problems captured his fancy, and what issues preoccupied him.

Conceptual Foundations opens with a rapid-fire survey of the intellectual history of particle physics, organized into three 15-year eras. During the "start-up period," 1945–1960, the idea of gauge invariance took root in the formulation of quantum electrodynamics and non-Abelian gauge theories. Spontaneous symmetry-breaking became a familiar notion, while the phenomenology of pion physics, strange particles, and the universality of weak interactions led to a growing appreciation of the power of symmetry arguments. In the "heroic period" of 1960–1975, quarks and leptons were recognized as the basic constituents of matter and gauge theories emerged as the correct descriptions of the strong, weak, and electromagnetic interactions. Marshak calls the era 1975–1990 a "period of consolidation and speculation" in which the electroweak theory and quantum chromodynamics survived increasingly rigorous experimental tests, the theoretical underpinnings of gauge theories were buttressed, and audacious speculations opened the possibility of a more comprehensive understanding. Such speculations—on the unification of the strong, weak, and electromagnetic interactions, on the origin of the three generations of quarks and leptons, and on the application of topological conservation laws—were the stuff of Marshak's late work and take up the last third of the book.

In the six chapters that make up the heart of *Conceptual Foundations*, Marshak reviews the key ideas that come together to define modern particle physics. He lays great stress on the gauge principle—the idea that symmetries determine interactions—and on the role of anomalies, quantum fluctuations that do not respect the symmetries of a classical field theory, in fixing the structure of the standard model. More idiosyncratic is the focus on issues that shaped his own thinking at crucial moments: chirality invariance, the Landau singularity in the running coupling constant of quantum electrodynamics, and no-go theorems that show the impossibility of combining Poincaré invariance with global internal symmetries.

Conceptual Foundations will be most useful to the reader who already knows the ideas treated. It is more an exegesis for knowledgeable colleagues than a systematic development for students. There are no exercises to fix new concepts in a reader's mind. Few will want to read this book from cover to cover, but it would be interesting to pull it from the library shelf, to see what Marshak has to say about a particular subject. There are some nice passages, including an unusually thorough and thoughtful treatment of the analogy between the Ginzburg-Landau picture of the superconducting phase transition and the Higgs mechanism for spontaneous breaking of electroweak symmetry.

A better subject index, as well as an author index, would have made dipping into *Conceptual Foundations* more rewarding. One of Marshak's last influential pieces of research was his exploration of neutron-antineutron oscillations in $SO(10)$ unified theories. Unfortunately, the first index entry leads, in error, to a section on *neutrino* oscillations. The reader who perseveres to the final entry will be rewarded by a clear, orderly, but swift presentation of the conditions that can give rise to neutron oscillations. In the matter of indexes and misprints, Marshak could have been better served by his publisher. A thorough copy-editing would have made the book much more appealing to read and use.

The strength of *Conceptual Foundations* is that Marshak is alive on the page, a man of many words, fully engaged, always with a definite point of view. His joy in understanding—in striving to understand—is a constant companion.

Chris Quigg
*Theoretical Physics Department,
Fermi National Accelerator Laboratory,
Batavia, IL 60510, USA*

~2.71828

e. The Story of a Number. ELI MAOR. Princeton University Press, Princeton, NJ, 1994. xiv, 214 pp. $24.95 or £19.95.

Most numbers are "transcendental." Very informally this means that they lack a simple definition. Most numbers with names are not of this variety so 2, $\sqrt{3}$, and $\frac{7}{5}$ are not such numbers. Indeed, most people only know the names of one or two transcendentals: the best known is π, the second is e. So many numbers are transcendental that if all the numbers were put in a barrel, it is as good as a certainty that the first number pulled out would be so. (In such a lottery always bet on the transcendentals.) So why do we give names to so few? In part because there are not enough names to go around, and in part because most of these numbers arise for no particularly natural reason.

Why do π and e merit special treatment? The answer lies in the ubiquitous ways in which they arise in mathematics. It is very hard to conceive of the inhabitants of a distant planet acquiring any mathematical sophistication without encountering (discovering) π and e. While π is easier to define (as the circumference of a circle of diameter 1) e is in many respects more fundamental. It is impossible to imagine the development of calculus without the invention of e and its big brother the exponential function $exp(x)$. We describe our physical world by differential equations, as we have since the time of Newton, and the most