Classic lecture notes to challenge and enlighten

Aspects of Symmetry

Sidney Coleman

402 pp. Cambridge U. P., New York, 1985.
ISBN 0-521-26706-4. $69.50

Reviewed by Sam Treiman

The Erice Summer School is one of the great annual fixtures of subnuclear physics; one of the great features of the summer school, for many of the summers since 1966, has been the Sidney Coleman tutorial on contemporary developments in theoretical particle physics. Many a wily young theorist has gotten the jump on his colleagues and gone on to fame and tenure by being among the first to get hold of and master the latest Coleman lectures. Original edition photocopies rank among the precious treasures of whole troops of theoretical physicists. Now here comes along a collection of some of the Coleman Erice lectures, all bound together in a handsome book.

These lectures span the interval 1966–79, a period of great excitement and progress in particle physics. The material is organized in eight chapters, covering some of the major themes of theoretical particle physics that emerged during that era

- SU(3) symmetry (the lectures of 1966)
- soft pions, that is, current algebra, partially conserved axial-vector current (1967)
- the renormalization group, dilatations and so forth (1971)
- renormalization and symmetry (1971)
- spontaneous symmetry breaking, gauge theory, asymptotic freedom, and related topics (1973)
- solitons, both classical and quantum (1975)
- instantons (1977)
- the $1/N$ expansion (1979).

The longest of the chapters are 5, 6 and 7. Coleman has not attempted to update the material or to provide connecting bridges between the successive chapters. This was quite the right decision. He did, however, correct some typographical errors, though he evidently decided to leave a number of them uncorrected to engage the reader's close attention. It adds to the zest to catch the great teacher in the odd missing minus sign or excess π.

This is not a textbook of theoretical particle physics. It does not, for example, embed the theoretical material in its full setting of experiment and phenomenology, though in the early chapters especially there is some nice discussion of applications. Then too there are those missing bridges and whole missing areas of particle theory: electroweak unification, speculations about grand unification, and so on. Rather, the book is a discrete collection of topics in particle physics—the hits of their day—all expounded with brilliant clarity and organization. Coleman tends to pass himself off as a mere scribe, one who has read the year's literature and offers to pull some of the best of it together to spare others the cost of subscriptions. This picture is totally false. The pages bristle with his

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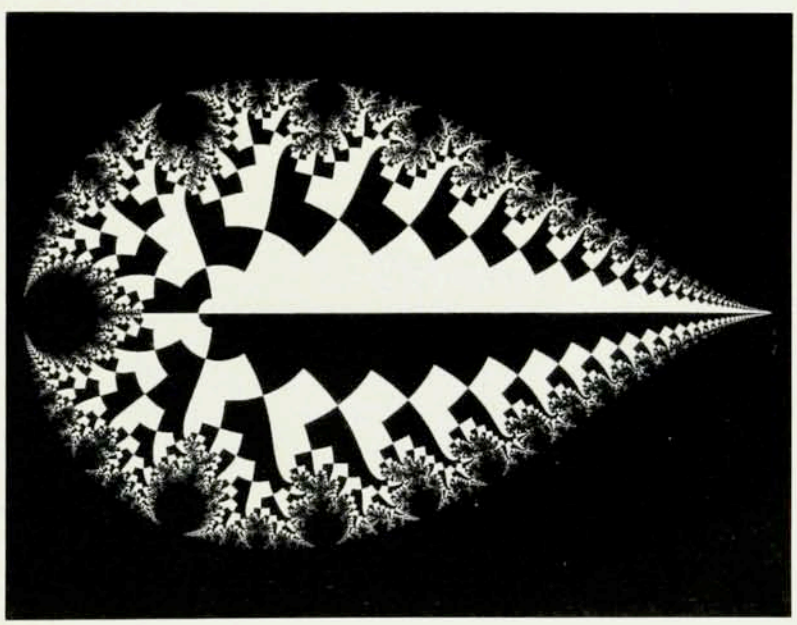

Mandelbrot set (black) and a binary decomposition in the $1/c$ plane, where c is complex, are shown in this photograph (reproduced by permission of the publisher) appearing in *The Beauty of Fractals: Images of Complex Dynamical Systems* by Heinz-Otto Peitgen and Peter H. Richter (199 pp; Springer-Verlag, New York, 1986; ISBN 0-387-15851-0; $35.00). Intended for a wide readership, this book with 88 full-color pictures and many black and white illustrations employs modern computer graphics to provide insight into nonlinear systems. Fractal objects do not alter their appearance even when observed with arbitrary magnification, thus adding a further dimension of depth to the mathematical representation of nature. But "no real structure can be magnified repeatedly an infinite number of times and still look the same. The principle of self-similarity is nonetheless realized approximately in nature: in coastlines and riverbeds, in cloud formations and trees, in the turbulent flow of liquids and in the hierarchical organization of living systems."

own original and penetrating insights. They also bristle with high technical and mathematical detail. For all the clarity of the presentation, the material is no pushover. This is professional business, requiring a good background in quantum field theory and a willingness to pay close attention.

The chapter on unitary symmetry, though splendidly done, is perhaps the least special in the book. The subject has long since been assimilated by particle physicists, there being nicely compact accounts in many other places. This is somewhat the case also with the material on soft pions, though—in my opinion—Coleman's short discussion of how PCAC is to be interpreted beats much of the longer-winded competition. In the later chapters the material becomes more deeply complex and field-theoretical. Coleman's talents are sorely needed and he comes fully into his own. Those tutorials were expository breakthroughs for their time, and still today they provide the best compact and accessible treatments. Though not a textbook, *Aspects of Symmetry* must surely be an invaluable supplement and resource for any advanced course in particle physics. It is also a keepsake for those who have known and learned from Coleman. His writing is elegant, lean, utterly authoritative—and a bit sly and tricky. He is one of the great characters of physics. Through the printed page you can see him grin maliciously—the famous Coleman grin—just as he's about to spring a logical trap on you, to teach humility. This book is a classic.

Perfect Symmetry

Heinz R. Pagels

390 pp. Simon and Schuster, New York, 1985.
ISBN 0-671-46548-1. $18.95

Few developments in science have been so thoroughly (or so hastily) celebrated in popular form as the wedding of quantum fields with astrophysics: relativistic early-universe cosmology. Steven Weinberg's pioneering effort of a decade ago, *The First Three Minutes*, has by now been embellished so many times, and by so many authors, that any new contribution to the genre had better offer something unique. Heinz Pagels's *Perfect Symmetry* meets this requirement, at least for the more astute segments of the popular audience.

The most commendable feature of this book is a solid introduction, occupying more than a third of the text, to the present state of the universe. Stellar formation, evolution and collapse, the peculiarities of compact objects, galactic structure, the cosmic distance scale, large-scale inhomogeneity, and the Hubble expansion are all clearly elucidated.

Above all, Pagels conveys a keen sense of just how recent and how hard-won all of this knowledge is. In an experimental science, once an important question is clearly formulated it is usually soon answered. Astronomy is surely the oldest science, but it remains observational. Immanuel Kant suggested in 1755 that the so-called "spiral nebulae" might be galaxies like our own. But it was still possible for an astronomer as influential as Harlow Shapley to doubt it in 1922, and the dynamic origins of galactic spiral arms remain elusive to this day.

The middle section of the book treats the early universe, which requires an introduction to quantum fields. In this branch of theory, there is complete correspondence between symmetry principles, field equations, and the properties of field quanta. Any of the three may be assigned logical primacy. Pagels, like most particle theorists, clearly prefers symmetry.

From a metaphysical standpoint, this is an eminently defensible position, in the grand tradition of Emmy Noether and Eugene Wigner. Pedagogically, however, it may not be the wisest choice.

Few readers when first exposed to physical theory are likely to find much enlightenment in the sentence: "Gluons are therefore a consequence of symmetry." In practical terms, as long as most particle masses remain free parameters, it is more natural to assign a central role to the couplings and intrinsic properties of particles. This approach has more intuitive appeal to the uninitiated.

Partly for this reason, the latter portions of this book are more suitable for undergraduates in physics or astronomy, or for serious amateurs of science, than for the casual lay reader. The interconnections within the assortment of theories that has come to be known as the "Standard Model" are more clearly explained than in other works of this type. The treatment of inflationary cosmologies is another high point, but again demands some sophistication on the part of the reader.

The author's voice is occasionally uneven, suggesting that the text might have profited from one more round of editing. Though Pagels's prose is usually lucid and entertaining, in a few places it reverts to the mustiness of the lecture hall, and in others it takes wing in fancies such as "wild baby stars."

The final chapters give a brief but comprehensive tour of the speculative frontiers, both in cosmology and unified field theories. Here Pagels is nonjudgmental to a fault: He includes some notions that one suspects are not even taken seriously by their authors.

Any such treatment is bound to be dated before it sees print, and this one is no exception. It outlines early efforts toward Kaluza–Klein compactification of supergravity, but seems to have been completed just before the boldest step on that particular path, the "superstrings" of Michael Green and John Schwarz. As with quantum field theory, Pagels again is strongest on the genealogy and family ties among theories, which can be so hard for outsiders to penetrate.

Speculation on the origins of the universe is too fascinating to be fully subject to normal standards of scientific prudence. This book is a reasonably articulate statement of what theoretical physics had to say on that subject as of 1985.

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Nobel Dreams: Power, Deceit and the Ultimate Experiment

Gary Taubes

261 pp. Random House, New York, 1986.
ISBN 0-394-54503-6. $19.95

In 1928 Albert Einstein refused a request from Heinrich Meng and Stefan Zweig to support the nomination of Sigmund Freud for a Nobel Prize. Even after collaborating with Freud in writing the booklet *Why War?*, Einstein wrote in 1949: "[He] . . . had a sharp vision; he let himself be lulled by no illusion except for an often exaggerated faith in his own ideas." Sigmund Freud never won a Nobel Prize, but Carlo Rubbia did, and from reading *Nobel Dreams*, one concludes that Gary Taubes probably would apply Einstein's judgment of Freud to Rubbia.

This book purports to tell how Carlo Rubbia of CERN and Harvard and Simon van der Meer of CERN came to share the 1984 Nobel Prize in Physics for "decisive contributions to the large project, which led to the discovery of the field particles W and Z, communicators of the weak interaction." The subtitle of this book, *Power, Deceit and the Ultimate Experiment*, reveals the author's point of view. Accordingly, only about a third of the book is concerned with the building of the CERN $\bar{p}p$ collider and the UA1 experiment through which the W and Z particles were discovered. The first part is devoted largely to a summary of some previous experiments performed by Rubbia. Taubes notes that measurement of a constant pp total cross