

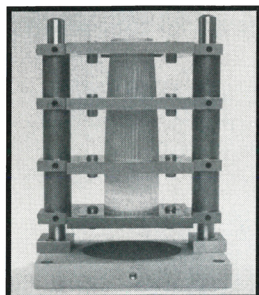
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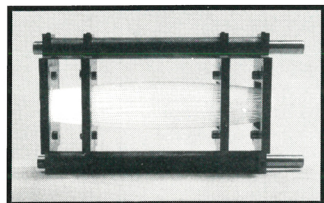
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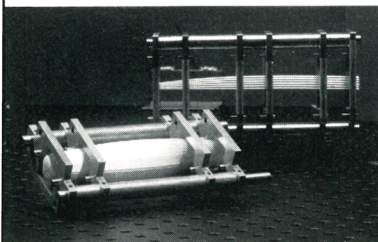
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characteristically clear and insightful, but all too brief, concluding discussion of the philosophy and psychology of time perception. The reader is left hoping that Davies will find or make the time to develop his ideas on these topics at greater length.

DAVID LAYZER

Harvard University
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Principles of Condensed Matter Physics

Paul M. Chaikin and Thomas C. Lubensky
Cambridge U. P., New York, 1995.
665 pp. \$49.95 hc ISBN
0-521-43224-3

What is the material world around us made of? The answer depends on whom and when you ask. A century ago the strongest answer would have come from the chemists. For them the world was made of atoms, those 98 elementary entities newly organized into the periodic table. Through the first half of this century the physicists were developing a competing view based on quantum mechanics. For them matter was made of Schrödinger waves coursing through space and confined by one another. The ascendancy of the quantum view was marked by the 1953 publication of Charles Kittel's famous *Introduction to Solid State Physics* (Wiley).

Kittel's textbook expanded the notion of what it meant to understand matter. But its scope was limited; it aspired to describe matter only insofar as matter could be viewed as a periodic lattice. Thus it necessarily left out phenomena as basic as the freezing, boiling and flowing of a drop of water. Curing this deficiency has been a major preoccupation for condensed matter physics ever since. This effort, like the quantum paradigm before it, has now reached a level of comprehensive understanding.

Paul Chaikin and Tom Lubensky's *Principles of Condensed Matter Physics* marks this development. Chaikin is a distinguished condensed matter experimenter; Lubensky is a distinguished theorist. Their 700-hundred-page work, in progress since 1986, is an important achievement. It brings into focus a new approach to the question, What is matter made of? For Chaikin and Lubensky, matter is *phases*—organizations of indefinitely large amounts of matter with a well-defined broken symmetry.

Phases are solids, liquids, liquid crystals or quasicrystals. Phases also define electronic organizations of matter such as the ferrimagnetic or the

superconducting states. By extension, fractal aggregates, surfactant membranes and flexible polymers are also viewed as phases. To understand matter in this approach is to explain the structure, thermodynamics and types of motion distinctive to a particular phase or to a transition between phases.

Among the book's pedagogical features are a wealth of daunting problems, a pithy glossary of intimidating terms and concrete descriptions of experiments and technological applications. At some points the charm of a gifted teacher shines through, as in this playful aside: "[Polymerized membranes] have a negative Poisson ratio . . . , i.e., when stretched in one direction, they expand rather than contract in the other. This effect can be seen with a crumpled piece of paper—try it." Still, for all but the most dedicated and sophisticated doctoral students, learning from this book will be tough going. There are long stretches of unmotivated manipulation and occasional confusing misstatements.

Like any unified discussion of a broad field, this one has its limitations. As announced in the preface, the book is not about the behavior of individual electrons or ions in matter. It leaves out important cooperative phenomena like the origin of metallic and insulating behavior and the consequences of quenched disorder. Thus the book complements traditional solid-state textbooks; it doesn't supersede them. It also leaves out conformal invariance, the powerful symmetry that fixes the values of many critical exponents in two dimensions. Likewise, collective phenomena far from equilibrium, such as turbulent flow or material fracture, go unmentioned. Given the real scope of the book, it might be better titled "Principles of Phase Behavior in Condensed Matter." In this important domain the book represents a great advance in unification. It will strengthen the understanding by students and researchers for a long time to come.

THOMAS A. WITTEN

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Chicago, Illinois

Diagrammatica: The Path to Feynman Diagrams

M. Veltman
Cambridge U. P., New York, 1994.
284 pp. \$29.95 pb
ISBN 0-521-45692-4

On the whole, *Diagrammatica* is a masterful introduction to quantum

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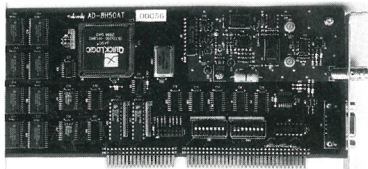
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field theory and its application to elementary particle physics through Feynman diagrams. (The title is evocative of the famous 1973 CERN yellow report *Diagrammar* by Gerard 't Hooft and Martinus Veltman, which has been the standard guide for understanding dimensional regularization and the Feynman rules of gauge field theories for high-energy physicists ever since.) The approach is constructive rather than deductive, and the book offers many fine insights into the physics content of results that may be thought of as purely mathematical. It is a good supplementary text for a beginning graduate student, but it cannot replace a standard text that takes a more conventional approach.

The explanations of such fundamental concepts as Lorentz invariance, commutators, Hilbert space, propagators and the like are very well done. At virtually every new step, there are clear statements regarding the assumptions and potential pitfalls. Explicit discussions of the constraints imposed by Poincaré invariance, gauge invariance, unitarity and causality pervade the book, helping the reader to appreciate the physical foundation of the formalisms involved. On the other hand, new equations often appear out of the blue (such as the gamma matrices in section 4.1) or with only plausible arguments for their correctness (such as the equations of motion in section 3.5). This will undoubtedly be confusing and mysterious to the uninitiated reader.

The strength of this book is in its detailed examples. Whereas the origins of many expressions and equations are not entirely clear, the subsequent calculations that result in such physical observables as cross sections and decay rates are very instructive and very clear. There are also many exercises throughout the text. The only shortcoming here is the author's insistence on using a space-time metric where $x_4 = ict$. The appearance of this imaginary fourth dimension requires special handling in a quantum framework, because complex conjugation appears often; the practitioner of this metric must remember that four-vectors must not be complex-conjugated, whereas the four-dimensional antisymmetric tensor $\epsilon_{\alpha\beta\mu\nu}$ must be considered imaginary. Some people will find this an unreasonable burden and a possible source of calculational error.

After the first four preliminary chapters the author plunges into a number of selected topics and examples of particular interest in elementary particle physics. Again the uninitiated student is likely to be over-

whelmed by the sheer volume of seemingly unrelated and arbitrary facts. On the other hand, a student already familiar with the basic structure and systematics of the standard model of elementary particle interactions will find the many detailed discussions valuable and illuminating; these include pion decay and the triangle anomaly, the Lamb shift and the correction to the ρ parameter due to the top quark (a topic of current research interest). There is a very nice discussion of the problem of requiring both Lorentz invariance and unitarity for the interacting massless photon, which is resolved by gauge invariance with its associated Ward identity. There is also a nice example showing how the form of the propagator is actually related to unitarity and how the latter also requires the interaction Hamiltonian to be Hermitian.

There are five appendices, the last one being a catalog of the various terms of the Lagrangian of the standard model. Since no discussion of non-Abelian gauge symmetry or the Higgs mechanism has been given, this will again appear baffling to the beginning student. If the reader of *Diagrammatica* already has a working knowledge of the standard model, or at least of quantum electrodynamics, then it does offer complementary insights into the interconnectedness of fundamental physical principles and will be an excellent choice for learning how to do some detailed calculations.

ERNEST MA
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Quantum Mechanics: Historical Contingency and the Copenhagen Hegemony

James T. Cushing

U. Chicago P., Chicago, 1994. 317 pp. \$27.00 pb ISBN 0-226-13204-8

The standard formalism for quantum mechanics—a state vector Ψ evolving via the Schrödinger equation in a Hilbert space $\mathcal{H}$, with observables as operators on that space—was consolidated in the late 1920s by Werner Heisenberg, Niels Bohr, Wolfgang Pauli and their associates, the Copenhagen School. It is, in terms of prediction, the most outstandingly successful theory in the history of science. The well-earned prestige of quantum mechanics (and its inventors) guaranteed widespread assent, at least as lip service, to the interpre-