

with a simple lattice model of bosons with short-range interactions. Because fermions are intrinsically non-local (fermion operators anticommute at arbitrary large spatial separations), Wen maintains that they cannot be the input of any truly fundamental theory but, rather, must emerge from a more basic, entirely local theory of bosons. Frankly, I find his point of view appealing, but I am quite certain that such feelings are not shared by most of my particle-theory colleagues—including, presumably, Wen's doctoral-thesis supervisor Edward Witten, the modern sage of string theory.

As a whole, *Quantum Field Theory of Many-Body Systems* is an inspirational and forward-looking book exploring the mysteries and never-ending wonders of many-particle quantum mechanics. One senses an approaching sea change in our understanding of complex electronic solids. Both for ambitious graduate students and for gray-haired veterans, Wen's book offers a refreshing new look at the mysterious quantum world.

Matthew Fisher

*Kavli Institute of Theoretical Physics
University of California, Santa Barbara*

Symmetry and the Beautiful Universe

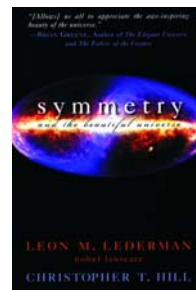
Leon M. Lederman and
Christopher T. Hill
*Prometheus Books, Amherst, NY,
2004. \$29.00 (363 pp.).
ISBN 1-59102-242-8*

Symmetry principles have played a central role in much of the physics of the past century, from the Lorentz invariance of electrodynamics, which Albert Einstein made into the cornerstone and unifying principle of an entirely new understanding of space and time, to the gauge symmetries underlying the standard model of strong and electroweak interactions. Even when symmetries turn out to be violated, such as in parity and charge conjugation, they have often been the mileage markers and guideposts by which progress in particle physics in the past century can be measured.

By venturing to explain to a general audience some of the most subtle and profound concepts of modern physics from the unifying viewpoint of symmetry, Nobel laureate Leon Lederman and his colleague Christopher Hill have undertaken an admirable and formidable task in *Symmetry and*

the Beautiful Universe. That they do succeed, at least in good measure and with minimum use of mathematical symbols, in making the subject matter of graduate theses and technical seminars seem accessible to a lay audience is a testament to their writing skills and evident enthusiasm for the subject. The scope of the book is certainly broad, ranging from a discussion of inertia in the solar system according to Newton's laws to the possibility that supersymmetry at the weak-interaction scale soon may be discovered at the Large Hadron Collider (LHC) currently under construction at CERN. The book's sweeping discussion of symmetries that run throughout physics is set against a leitmotif of the life and work of Emmy Noether, whose famous theorem relates symmetries to conservation laws in a fundamental and general way.

The grand tour through symmetries classical and quantum is often entertaining. For instance, the authors offer the account of the hypothetical Acme



SAES® NEG Pumps

Boosting UHV System Performance

CapaciTorr®, SORB-AC®, InsiTorr® and WaferGetter® non-evaporable getter pumps for surface analysis systems, analytical instrumentation, particle accelerators, multi purpose UHV systems and thin film deposition equipment

- ┐ Faster pumpdowns
- ┐ Better base pressure
- ┐ Best hydrogen pumping
- ┐ Pumping without power
- ┐ Cleaner vacuum conditions



See us at AVS 2005 - booth #1613



We support your mission

neg_technology@saes-group.com

www.saesgetters.com

**saes
getters**

Power Company, whose perpetual-motion and investment scheme depends on gravity being somewhat weaker than usual every Tuesday at exactly 10:00am. In another example, Lederman and Hill illustrate spontaneous symmetry breaking with the story of a boy unable to choose among a circle of equally attractive dance partners. He makes the decision by balancing a pencil on its sharpened tip and letting it fall to point at one of the young ladies.

Other concepts of modern physics are somewhat less amenable to entertaining analogies drawn from everyday life—and there the going is likely to get rougher for the intrepid, non-technical reader at whom the book is aimed. In the last three chapters, the book's cantering pace accelerates to a gallop through the intricacies of wave-particle duality, exchange symmetry, local gauge invariance, quark jets, loop diagrams, and Higgs fields. The following excerpt from chapter 11 illustrates the difficulties of trying to put such ideas into ordinary language:

The term gauge means that the actual determination of the physical momentum of the electron requires the presence of the calibrating gauge field. Only the electron wave function together with the gauge field, yields a physically meaningful total momentum and energy. The presence of the new field interacting with the electron is designed to compensate the change in the electron wave function, resetting the total momentum, electron plus the effect of the gauge field, back to the original momentum of our original incoming electron. This is indeed a spooky concept. . . . We emphasize that the gauge field is not observable; the electron wave function is not observable. We are performing an unobservable transformation of two unobservable objects!

By this point in the book, lay readers may be starting to feel a bout of dizziness, with discussions on non-abelian gauge transformations still ahead. It may be unfair to expect perfect clarity in describing to a nontechnical reader a concept as technical as local gauge symmetry—without using mathematics of any kind. The excerpt above may be less frightening but certainly is not more concise than

$$\psi(x) \rightarrow e^{i\theta(x)}\psi(x)$$

$$A_\mu(x) \rightarrow A_\mu(x) + \partial_\mu \theta(x).$$

The authors provide chapter notes, several appendixes, and a good bibliography for the more diligent reader

wishing to pursue the subject in greater depth. Nevertheless, it is ironic that a book dedicated to a mathematician has eliminated nearly all of the mathematics from the physics. Could it be that when she switched, at an early age, from a prospective career as a language teacher to one in mathematics, Noether was actually onto something?

A more serious question to ponder in light of the book's title and main premise is whether symmetry will play the dominant role in unraveling nature's secrets in the 21st century that it did in the 20th. Does the long march from weak decays and nuclear resonances to $SU(3) \times SU(2) \times U(1)$ lead inevitably to unification of strong and electroweak interactions in a grander gauge group? Does nature make use of supersymmetry in uniting fermions and bosons in a fundamental way at the electroweak scale? Is there a symmetry relating the generations or families of quarks and leptons?

Earlier quests for beauty in physical law offer both encouragement and caution for the future. Some might say that the standard model is not particularly beautiful. Yet it is in perfect agreement with experiment so far. Obsession with the "perfect" symmetrical shapes of circles and spheres led philosophers and scientists from Plato to Nicolaus Copernicus to the conviction that planetary orbits must be circular. This obsession led Johannes Kepler and others to look for musical harmonies in the orbital frequencies of the crystalline spheres supposed to guide the planets. If supersymmetry, even with some epicycles, is discovered at the LHC a few years from now, then 21st-century physics might very well continue on the same trajectory that Lederman and Hill have sketched from their present symmetry-centric vantage point. On the other hand, if supersymmetry is not found in nature, the prevailing confidence in more beautiful symmetries at higher energies might appear to future physicists to be as quaint and parochial as medieval Europe's unquestioned faith in the Ptolemaic system of concentric crystalline spheres seems to us today.

Finally, a preconceived aesthetics cannot decide the role of symmetry in physics. Lederman and Hill acknowledge that fact with a healthy open mind and conclude that "experiment will be the ultimate arbiter."

Emil Mottola

*Los Alamos National Laboratory
Los Alamos, New Mexico*

The Physics of Traffic: Empirical Freeway Pattern Features, Engineering Applications, and Theory

Boris S. Kerner

Springer-Verlag, New York, 2004.

\$139.00 (682 pp.).

ISBN 3-540-20716-3

I commend Boris Kerner on his pioneering research on a new traffic theory. I have been working on transportation and traffic theories and modeling for 27 years and have been with the Federal Highway Administration's office of operations R&D since 1987. *The Physics of Traffic: Empirical Freeway Pattern Features, Engineering Applications, and Theory* is the first book I have read that offers detailed discussions about traffic congestion on freeways. The author has spearheaded the development of the new traffic theory and has paved a way for advancing existing traffic theory. I enjoyed reading the monograph by Kerner, a theoretical physicist at DaimlerChrysler in Germany, and found it interesting and helpful. I believe the book's contribution to the field, in both theory and application, should be significant.

The three-phase traffic theory provides researchers with a new perspective for advancing existing traffic-flow theory for freeways. However, the three-phase traffic theory still lacks the big, or complete, picture of dynamic and complex traffic phenomena caused by the driver's instinctive response to roadways, adjacent vehicles, traffic control, and ambient conditions like visibility. Researchers have been studying separately each of the three phases of traffic theory—free flow, synchronized flow, and wide-moving jam—for years. But Kerner integrates these phases into one three-phase traffic theory.

Discussions in the book are qualitative, mainly based on limited data collected.

With more intelligent-transportation-system developments and potential vehicle-infrastructure-integration (VII) deployments in the future, richer micro-traffic data (individual vehicular data at small time intervals) will help researchers and engineers verify, understand, and develop improved traffic theories. Kerner's traffic theory uses empirical spatio-temporal traffic patterns to provide