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Review: Colliding Paths
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## Heat's Bouncer

**Maxwell's Demon: Why Warmth Disperses and Time Passes.** Hans Christian von Baeyer. 256 pp. Random House, 1998. $25.

The successful popularizer of science should guide the reader through a jungle of ideas, some of them accessible to the uninitiated, others too complex for brief treatment. The secret of good science writing is in the choosing. By carefully selecting targets for the narrowly focused flashlight beam of clear exposition, a good popular science book presents a well-lighted path of conceptual milestones, while steering the reader past tangles and thickets of unnecessary complication. *Maxwell's Demon: Why Warmth Disperses and Time Passes* is such a book.

Named for the theoretical homunculus capable of sorting hot atoms from merely warm ones, the book explores the three laws of thermodynamics, in particular the Second Law. Energy inexorably flows downhill, from hot to cold; from a state of orderly concentration toward one of dilution, dissipation and disorderliness: entropy. As a thought experiment, James Clerk Maxwell devised the idea of a microscopic demon who can reverse the flow toward entropy using intelligence about atoms. Operating a sliding door in a wall that separates two containers of lukewarm air, Maxwell's demon opens the door to admit hot, fast atoms but closes it to slow, cool atoms. Thus, the hypothetical demon concentrates useful heat in one container and increases order in the universe, violating the Second Law.

Writing in a style as light and fast-paced as a novel, the author deftly introduces and explains Maxwell's demon in a historical context that breathes life into both the science and the scientists. The reader empathizes with scientists as real people struggling to unravel the mysteries of thermodynamics. Reminiscent of Isaac Asimov, von Baeyer incorporates personal experiences to make a point. For example, he recruits his teenage daughters to flip coins and graph the results to explain the bell-curve distribution of molecule speeds. These vivid, human touches stand the reader in good stead when the time comes to venture deeper into the jungle. By then, almost effortlessly, the reader has gained a clear understanding of Boltzmann's epitaph: "Entropy is the logarithm of probability."

The book suffers from some unevenness of style, occasionally deteriorating from brilliant into merely very good. Also, the discussion of recent theories about the demon, entropy and information theory is tantalizingly brief. Still, the book stands as a masterful distillation of information. Like Maxwell's demon, von Baeyer manages to bring order from chaos by making good choices.—*Randall Black, Irvine, California*

## Optical Allusions

**Waves and Grains: Reflections on Light and Learning.** Mark P. Silverman. xii + 410 pp. Princeton University Press, 1998. $22.50.

This is a special physics book in that it is personal: It is Sir Peter Medawar's *Advice to a Young Scientist* and much more. It is "What Physics Means to Me" from someone to whom physics clearly implies connections across not only subdisciplines but also centuries. It is about physics as a discipline and a human pursuit. What's more, it is written in the language of physics. Although not *Physics for Poets*, it *is* poetry for physicists who might be wondering what drew them to their discipline and for others with an inkling that they might be so drawn.

This book doesn't teach optics; it teaches the *joy* of optics. Mark Silverman is matter-of-fact about his calculations—neither condescending nor tutorial. He allows the reader to glimpse his world, and one may either admire his algebraic facility or gloss over it and come back to it in graduate school.

The material collected here appears to be the overflow of an autobiography, the apocrypha, as it were, of a career. Each chapter is an etude executed with its own virtuosity, drawing yet another connection. Some chapters start out as technical studies, as a pianist might practice fingering but with analytical agility. Insights spill out. Some of them deal with fundamental concepts such as the wave-particle duality of light; others deal with the seemingly esoteric, with experiments that seldom receive attention because they are analytically messy—but here again, connections emerge. Silverman has made a career, he informs the reader, of studying the unfashionable.

This approach leads Silverman to a philosophy of scientific pedagogy and to a thoughtful analysis of the role of the science professor. I was inspired to imagine a holographic physics curriculum in which concepts such as interaction or scaling or invariance might be taught from the inside out and applied, by way of examples, to various subdisciplines.

Silverman concludes that the qualities that have advanced and enriched the history of optics (and, by extension, science) have been creative genius, experimental skill, articulate expression, incisive wit, personal courage and, in a few cases at least, compassion and simple humanity.— *Samuel J. Petuchowski, Bromberg & Sunstein LLP, Boston*

## Colliding Paths

**Image and Logic: A Material Culture of Microphysics.** Peter Galison. 982 pp. University of Chicago Press, 1997. $34.95.

Peter Galison's history of high-energy physics traces the development of particle detectors, instruments that are fascinating in themselves. Galison gives us rich detail, skillfully woven into a smooth and entertaining narrative. The detectors are inherently beautiful—involving subtle craftsmanship and brute-force engineering. But Galison's purpose is not so much the detectors per se as seeing what these devices (which originally cost a few hundred dollars and now cost hundreds of millions) can tell us about physics, physical science and the nature of scientific revolutions. Because these detectors represent in hardware and software what physicists believe about the way nature is constructed, the story of the detectors is inevitably the story of physics itself.

Galison starts with the earliest uses of cloud chambers and Geiger-Müller tubes and follows the field through the development of huge, expensive, com-



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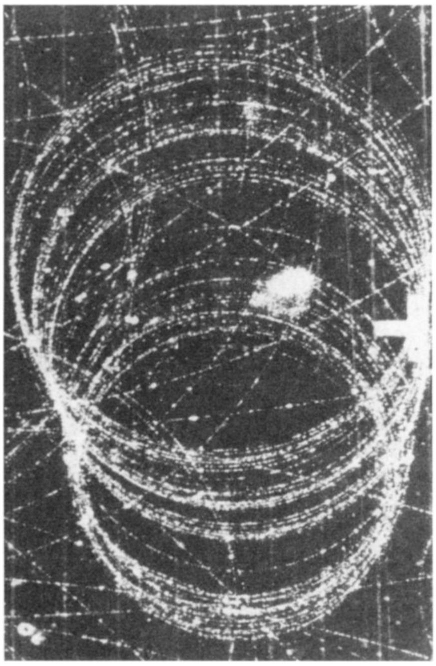

**Particle route: from *Image and Logic.***

plicated devices found at accelerators in the United States and Europe. Galison argues that the detector development proceeded along two distinct paths: the *image* machines (cloud chambers, nuclear emulsions and bubble chambers) and the *logic* machines (Geiger counters, hodoscopes and spark chambers). The adherents, traditions and methods for each mark a rich intellectual tradition that persisted over time. More significantly, each path's participants had different views of what constituted compelling evidence for the existence of a particle or phenomenon. The image groups sought golden events, perfect mimetic figures—literal pictures of the entities themselves. One perfect photograph could be conclusive evidence of a new particle or interaction. The logic groups saw nothing in a single event but rather used accumulations of individually meaningless events to form a collection that was itself conclusive. Developments along the logic path involved ever more complicated reasoning about coincidence between ever more complicated arrays of solitary detectors. In the logic world the accumulations were all.

These paths collide in the current generation of detectors where both traditions are combined. These detectors are titanic machines, the largest scientific creations dedicated to the smallest entities. They generate images through logic, using the computer to gather, collate and finally draw pictures based on thousands of discrete, individually meaningless measurements—the mimesis is discarded at first in exchange for a bewildering wave of data but then regained by deliberately assembling and constructing. The scientist synthesizes nature.

This wonderful synthesis is purchased at great cost. The division of labor and deliberate long-term commitments to specific methods and designs that are essential to creating and operating these detectors inexorably led to the deconstruction of physics itself. In a variety of ways, the physicist disappeared into a group that included mechanical, electrical and chemical engineers; administrators and programmers; project planners; and a panoply of technicians. This has called into question what it means to do physics.

Galison's historical view challenges mainstream philosophers of science by noting that the machines and methods produce a continuity that most accounts do not credit. Many experimental techniques, devices, traditions and methods are sustained during transition from the old to the new. Galison argues that the persistence of material, experimental cultures makes it possible for a durable community of physics to exist. This view of experiment, which Galison began in his earlier book *How Experiments End*, denies both the classical empiricist view that data drives theory and the modern sociological view that theory constrains data. These polar extremes fail to capture the dialectic between theory and experiment. This leads Galison to devise a place for the dialectic which he describes as "trading zones." He reaches into anthropology for this term, which describes areas where new language is developed to permit commerce between cultures that lack a common language. Galison shows how this allows people with disparate roles to create modern physics by delimiting meanings in ways that allow productive work to go forward. This is a powerful idea when applied to high-energy physics, but it will have great impact elsewhere. Such zones exist in the intensive care units of research hospitals and elsewhere.—*Richard Cook, Cognitive Technologies Laboratory, Anesthesia and Critical Care, University of Chicago*

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