

generation of induction lamps and LEDs — are explained, illustrated and critiqued. More than 130 illustrations (including seven colour plates) depict an enormous variety of lamps and ancillary technologies, including wick trimmers, filament pullers, bulb-evacuating pumps and primitive electrical generators. Nearly all the plates are either

reproductions of period illustrations or photographs of museum pieces in action.

Equally lavish are the text excerpts from an impressive array of sources. Bowers and his associates must have scoured thousands of potential sources to select the scores of choice quotations with which he depicts not merely the technology of lighting, but its sociology, economics and politics.

For a book about technology, nostalgia is surprisingly pervasive. Vignettes recounting the idiosyncrasies, romance, ingenuity and inconveniences of bygone lamps provide a nicely balanced counterpoint to the technical descriptions.

Despite my unfamiliarity with non-electric lighting, I found myself gently coerced into recalling the gas-mantle lanterns of childhood camping expeditions,

Bunsen burners in high school chemistry laboratories, the gas wall fixtures long since fitted for electric bulbs in a turn-of-the-century home I once owned, and floating-wick oil lamps in trendy restaurants.

Clearly infatuated with antique lighting systems, Bowers manages to engage the reader in his avocation by speeding through the chronology of lighting, and by moving fluidly among the many facets of each era's technology. A measure of his success at striking this delicate balance is that I finished the book wanting more, with an appetite whetted for deeper explanations of the physical principles of lighting and curious to learn the very latest developments and applications, particularly regarding the technical work-horses of our era: aeronautics, computers, entertainment and medicine. □

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## A thing to a void

Nothingness: The Science of Empty Space

by Henning Genz

Perseus Books: 1998. 340 pp. \$30, £20.95

Michael Redhead

If you tried to empty a box, by taking out all the material objects inside it, sucking out the air with a super-efficient pump, and cooling it towards absolute zero to eliminate thermal radiation, what would you be left with? An empty space, but is that nothing or something? If something, the box is not really empty, but if nothing, how could it be said to exist at all? These semantic puzzles about the void or vacuum intrigued the ancient Greeks. Some, like Aristotle, denied that the vacuum was a coherent concept. Others, like the ancient atomists, thought it necessary to allow the atoms to move about and change their configurations.

In this new translation of a German text published in 1994, a theoretical physicist, Henning Genz, has had the happy idea of linking these ancient discussions to the subsequent history of scientific investigation of the vacuum, such as the seventeenth-century studies of Evangelista Torricelli, Otto von Guericke and Robert Boyle, and the nineteenth-century ether theories of electrical, magnetic and optical phenomena. This leads on to modern theories of the vacuum described by quantum field theory, with exotic phenomena such as vacuum fluctuations, virtual particles, the Casimir effect, the mysterious Higgs field — supposedly responsible for spontaneous symmetry breaking of the vacuum state — and much else besides. So the vacuum of modern theoretical physics is seething with activity, and is very far removed from nothing!

While the idea of such a book was a happy one, its execution leaves much to be desired. Genz fails to cover both key issues from history and important recent developments. The history is sloppy, largely reliant on secondary sources. There is no sense of the subtlety of the arguments of the ancient Greeks. Indeed, they are made to look just stupid and

ignorant. Nearer our own times, names are misspelt and dates inaccurate — the most glaring howler is the remark that Einstein's paper on the photoelectric effect dates from 1900 (it was 1905). The translation is clumsy and in the bibliography the works of Plato and Galileo, for example, are still cited in German editions.

In explaining the physics, Genz uses no equations (other than  $E = mc^2$ ) and the level of exposition is much below the standard of *Scientific American*. Some of the cosmological discussion is well done but some of the explanations are quite baffling. I defy anyone to follow the discussion of the Michelson–Morley experiment, where the motion of the source and the motion of the observer are systematically confused. There is some discussion of Mach's principle, but I was unable to discern whether the author thought that general relativity exemplified it or not. There is passing reference to vacuum solutions of the Einstein field equations, but no adequate discussion of their significance.

In explaining vacuum fluctuations, Genz deploys familiar arguments in terms of the creation and annihilation of virtual particles. But the fact that free fields also exhibit vacuum fluctuations shows that interactions are not really the source of the problem, which lies, more accurately, in the fact that the global vacuum is irreconcilable with a local vacuum in relativistic quantum field theory, the direct opposite of the situation in nonrelativistic quantum field theory.

Moreover, Genz gives no discussion of the recent literature on the Bell inequalities and the Einstein–Podolsky–Rosen argument for the incompleteness of quantum mechanics, in the context of relativistic quantum field theory. These exciting developments throw much light on the possible interpretations of vacuum fluctuations in relativistic quantum field theory.

In summary, Genz's project is thoroughly worthwhile, but it is to be hoped that someone better qualified will make a better effort on some future occasion. □

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## Nature abhors a vacuum

But the British public likes this one. The popular Dyson Dual Cyclone vacuum cleaner is featured in the slightly ad-hoc selection of "clever things ... which have changed our lives over the last 100 years" in *Century Makers* by David Hillman and David Gibbs (Weidenfeld & Nicolson, £16.99, \$22.95).

