IF THE HIGGS IS THE ANSWER, WILL THERE BE NO MORE QUESTIONS?

The God Particle

Leon Lederman
with Dick Teresi
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Reviewed by Donald H. Perkins

Progress in the study of the fundamental particles of matter and the interactions between them depends largely on the provision of ever bigger and better accelerators. Undoubtedly the biggest and best (and the dearest, at around $8 billion) so far is the Superconducting Super Collider under construction at Waxahachie, Texas, near Dallas. Leon Lederman's book *The God Particle* is primarily about the 2000-year-old search to understand the development of the universe, its basic constituents and the forces that shape it (in fact the book's subtitle is *If the Universe Is the Answer, What Is the Question?*). The book is also an explanation to the layman of the need for the SSC as the next logical step in the search, hopefully to discover the "God particle"—known to physicists as the Higgs boson. Steven Weinberg's recent book *Dreams of a Final Theory* has a similar theme, although it is written by a theorist and in a quite different style. Perhaps we should sit up and take notice when two Nobel laureates, both strong proponents of the SSC, almost simultaneously produce popular scientific texts on virtually the same topic.

Lederman has impressive credentials for his task. He shared the Nobel Prize for the discovery in 1962 that the electron-type neutrino (accompanying electrons in nuclear beta decay) is distinct from the muon-type neutrino (accompanying the muon or "heavy electron" in pion decay). He also discovered the upsilon meson (signaling a fifth type of quark, the b quark), the long-lived neutral kaon and parity violation in muon decay. He was director of Fermilab for 10 years, and he has made notable contributions in education and in the public's appreciation of science.

Lederman, working here with Dick Teresi, also clearly has considerable gifts as a writer: He tells his story with panache, wit and humor (even if the gags and one-liners tend to grate at times). The book starts off with an imaginary conversation with Democritus, the first person to postulate the existence of the atom. The historical thread is traced through the work of Galileo, Newton, Faraday, Planck, Einstein and others up to modern times. Most people will be familiar with the ideas and the contributions of these early practitioners: The fascination and value of Lederman's text is in bringing out, in terms understandable to the layman, the crucial issues and the "Eureka moments" when the big breakthroughs occurred. He is especially good in detailing the incredible ingenuity and foresight of the early experimenters. The story is also made more vivid by the inclusion of personal details on the great figures of the past. We learn, for example, that the young Faraday once had to survive for a week on a loaf of bread and that Schrödinger produced his celebrated wave equation during an illicit weekend in the Alps!

All this is in preparation for the Higgs boson, the postulated scalar particle whose interactions are supposedly responsible for the creation of mass and for spontaneous symmetry breaking in the electroweak sector—the fact that the weak interactions at low energy are much more feeble than the electromagnetic. The Higgs particle is also postulated to resolve many difficulties in cosmology, by, for example, providing a mechanism to account for the observed matter–antimatter asymmetry, as well as by seeding the inflationary stage of the Big Bang and solving the flatness problem, the absence of magnetic monopoles and so on. We can see why Lederman calls it the God particle.

Would the detection of the God particle at the SSC solve all our problems? Unfortunately, no. It would be a tremendous step forward, but Lederman makes no pretense that discovering this particular Higgs—that associated with electroweak interactions—is the final key to the secrets of the universe. It will be but one more step along the way. There are presumably other Higgs particles on even larger energy scales. He ends his account with an impassioned plea for the support of basic, curiosity-oriented research, which has led to practically all our major advances in technology. This investment, he points out, at far less than 1% of the gross national product, has consistently outperformed the Dow Jones average.

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Science with a Vengeance: How the Military Created the US Space Sciences After World War II

David H. DeVorkin
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In an earlier book, *Race to the Stratosphere: Manned Scientific Ballooning in America* (Springer-Verlag, New York, 1989), David H. DeVorkin linked scientific ballooning to a broad set of cultural and political forces that helped shape its use as a research method. In *Science with a Vengeance*, DeVorkin tells the story of another scientific vehicle: the research rocket. Focusing primarily on the use of captured German V-2 rockets to carry instruments into the upper atmosphere during the decade following World War II, this book analyzes the development of a new scientific pursuit within the context of military sponsorship.

DeVorkin first takes up the means by which rocket research was organized in America after World War II. Having secured boxcarloads of V-2 parts, the US military sought to determine their use and purpose, in part by a series of test firings of the captured wonder weapons. The army's goal was to learn the basics of missile operations, but the V-2 also presented an opportunity for scientists to send instruments farther aloft than ever before: a chance for important atmospheric and astronomical observations to be accomplished. For its part, the army recognized that some experimental data on ionospheric conditions would be of prime importance for rocket development, but chose not to arbitrate disputes over the details of instruments to be carried aloft. Out of this situation, DeVorkin shows, came two central institutions: the White Sands rocket base in New Mexico, the main site for research launches during the V-2 period, and the V-2 Rocket Panel (later the Upper Atmosphere Rocket Research Panel), created for presenting to the army a coordinated program of experiments using the rockets. As DeVorkin demonstrates, the V-2 Panel served as organizing forum and advocacy body for rocket-based research, and it became the framework underlying the new science.

In the book's second section, DeVorkin turns to the astronomical and atmospheric research carried out by the most important groups in the field. By their ability to lift instruments above most of the atmosphere and into its unexplored upper regions, research rockets presented a new research tool for studies of astronomy and meteorology—but not, DeVorkin argues, for astronomers and meteorologists. Physicists from other areas migrated into the field, bringing their instruments and skills with them. In studies of the Sun's x-ray and extreme ultraviolet spectra, in the mapping of the Earth's upper atmosphere and in cosmic-ray studies, these rocket experimenters remained a distinct group with marginal relationships to established research fields, although they exchanged data and methods with outsiders. They competed among themselves and were defined by their military affiliations, their connections to the V-2 Panel and their willingness to build instruments that would function within the constraints of sounding (research) rocket flights. These constraints discouraged established researchers in other fields. A rocket-borne experiment promised astronomers, for example, only a few minutes at most of spinning (if not tumbling) flight as a seldom-used guidance system attempted to focus an instrument on the Sun, followed by the rocket's midair explosion and crash back to Earth: perhaps the furthest thing imaginable from an observatory's methodical, long-term viewing program.

DeVorkin's point here, which he proves in this exhaustively researched and lavishly illustrated volume, is that this research program required not only new practices but new practitioners as well. The military brought both into being by providing the researchers with the essential financial and institutional framework for their work; in effect, then, it "created" space science. This book is an important contribution to the historical study of postwar American science.

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Taming the Atom: The Emergence of the Visible Microworld

Hans Christian von Baeyer
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In this profound and delightful book, von Baeyer wrestles with two fundamental questions: What does it mean for us to "see" an atom, and what happens to our notions of reality when we do?

He begins his approach to these questions—as any exposition of the atom must—with the Greek philosophers, and with Democritus in particular. In this early section of the book, von Baeyer's unique approach to science writing becomes evident. Along with the usual description of the basic philosophies, he talks about the modern Greek ten-drachma coin. This coin has a classic head of Democritus on one side, a sketch of an atom on the other. In musing over this unusual form of recognition, von Baeyer notes the serious aspect and wrinkled brow of the man portrayed on the coin and contrasts it with Democritus's nickname, "the laughing philosopher." Not to worry, though: The atom on the reverse side has three electrons in it. It is lithium, the primary element used in the treatment of depression. It is this kind of attention to small but fascinating details that makes this book such an interesting read.

The history of late 19th and early 20th century atomism is the next subject, particularly the argument about whether the atoms are real or whether nature merely behaves "as if" (what a marvelous pair of weasel words!) matter is made that way. This discussion terminates with a series of chapters dedicated to the modern ways of seeing the atom—David Wineland's photographs of individual atoms at the National Institute of Standards and Technology and the efforts of many people to develop the scanning probe microscope that has become standard equipment in so many laboratories. The sight of a single atom in Wineland's apparatus, particularly watching it blink on and off as its electrons moved in and out of metastable states, clearly affected von Baeyer deeply. It was the excitement of seeing the sight, the culmination of an age-old quest, that inspired this book. He manages to convey a great deal of this excitement to the reader.

But where does this insight lead us? Will the ability to isolate and visualize individual atoms really change the way we look at the world, or is it merely a technical trick? Von Baeyer argues for the former option. Some of his arguments will be familiar to physicists—he talks at length, for example, about the new atomic standards for length and time as well as modern attempts to replace the kilogram with a standard based on the mass of individual atoms.

But he doesn't stop with the technology of the atom. He argues cogently that our ability to look at individual atoms may provide a way to overcome the severe problems physicists have always had interpreting quantum mechanics—the problem of so-called quantum weirdness. He gives as good an explanation of the planned "quantum eraser" experiment as I have seen and argues that it will have as profound an effect on our perception of the atom as did John Bell's theorem and the experiments it spawned. He closes with the fervent wish that we will soon bring the atom back into the world of human intuition.

On this last subject, I must disagree with my friend and colleague. When and if these new experiments are done, I believe they will simply confirm what most of us fear: that in quantum mechanics we have found a region of the universe where the human brain is simply unable to be comfortable.

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