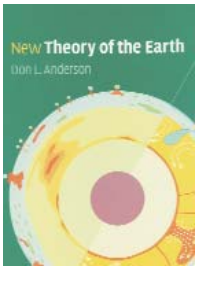
Treaty on the Non-Proliferation of Nuclear Weapons (NPT), and to stop nuclear terrorism. One issue concerns the Comprehensive Nuclear Test Ban Treaty (CTBT) for which the US Senate declined to give its advice and consent in 1999. Since then, the UN General Assembly has elected five times to support the CTBT, with a cumulative vote of 870 to 7 (5 negative votes for the US, 1 for Palau, and 1 for North Korea). The September 2007 conference intended to encourage the CTBT into force had 106 nations in attendance, including Iraq, Iran, Pakistan, China, and Russia—but the US, India, and North Korea were absent. I believe the viability of the CTBT affects the viability of the NPT.

Bernstein's complex book is well crafted, and his descriptions are insightful; I caught only a couple of minor errors. For example, does the photo on page 22 depict Enrico Fermi joking about the fine structure constant? I was glued to *Nuclear Weapons*, even after having read Rhodes and other authors. It is sobering to realize that without the existence of a rare isotope (uranium-235) of a moderately rare element or the use of many particle accelerators, we would not be confronted by a global nuclear threat. Nuclear physics is less studied today than it was between 1930 and 1980. Today's new PhD-holders do not know about spontaneous fission of plutonium-240 and obtaining tritium from lithium deuteride. *Nuclear Weapons* should be required reading for any physics undergraduate, as it can educate the next generation on such matters. Those who want to extend their study can then move on to Rhodes's magnum opus.

New Theory of the Earth

Don L. Anderson
Cambridge U. Press, New York, 2007. $70.00 (384 pp.). ISBN 978-0-521-84959-3

Don L. Anderson's *New Theory of the Earth* is the much-anticipated, second edition of his monograph on the internal structure, composition, and dynamics of our home planet. The release of the first version, *Theory of the Earth* (Blackwell, 1989) roughly coincided with the 200th anniversary of the classic, similarly titled treatise by James Hutton, the founder of modern geology. In the new version, Anderson updates the important factual material that earned his first edition its stellar reputation, and he adds his own perspectives on the enduring controversies that make debates about Earth's interior so lively.



What sets *New Theory of the Earth* apart from other books on this subject is its broad scope, drawn from the vast storehouse of information the author assembled from every branch of solid-Earth science. Anderson, a professor emeritus of geophysics in the division of geological and planetary sciences at Caltech, asserts, quite rightly, that the traditional disciplines have fostered overly narrow views of Earth's interior. Geochemists, seismologists, petrologists, and geodynamicists often see Earth so differently that it is easy to forget we are all looking at the same planet. Anderson succeeds in countering this tendency by offering a genuinely interdisciplinary perspective of Earth, delivered in his engaging yet authoritative style.

The focus of the book is Earth's mantle, the mostly solid silicate and oxide shell between the crust and the core, that makes up about two-thirds of our planet's mass. The mantle largely controls Earth's internal dynamics and its long-term evolution. Anderson approaches the twin problems of interpreting mantle structure and inferring its dynamics by synthesis rather than by analysis. His skill for combining widely diverse observations into a coherent picture is on full display in the book. It must be said that not all of his interpretations reflect the community's consensus. For example, he infers that compositionally derived buoyancy forces are on a par with thermally derived buoyancy forces in the geodynamic engine; by contrast, the conventional interpretation is that thermal effects dominate the process, at least in the present-day mantle. Conventional or not, he is nevertheless careful to provide the data that underlie his interpretations; he thus empowers the readers to come to their own conclusions.

The sequencing of topics is one of the book's best qualities. Instead of describing structures in Earth in chronological order of their discovery, which is too often the approach in older monographs, Anderson begins with a brief comparison of the terrestrial planets and then offers a critique of the current ideas on mantle dynamics; that critique quickly establishes the theme for the rest of the book. The introduction is followed by the "meat and potatoes" of the book: a review of Earth's structure and composition, from the crust to the core; an interpretation of mantle-derived isotopes and magmatic products; and a survey of the physical properties of mantle minerals and their assemblages. I found those parts to be the best in the book; they are insightfully written and replete with informative tables, diagrams, and figures. The final two parts include the author's interpretation of the mantle heterogeneity as imaged by seismic tomography, followed by a nice account of the flow of thermal energy through the mantle system in space and in time, all without recourse to a single formula.

One aspect of the new edition that readers might find problematic is the reliance on "Googlets," key words inserted into the text for directing web searches. Those entries are used in place of ordinary text citations in referring to the recent literature on a given topic. However, Anderson has retained many of the older text citations from the first edition, and that practice has given his referencing scheme a discernible bimodal quality. Interactive referencing may eventually supersede traditional citation methods as search-engine capabilities increase, although my own experiments with several of his Googlets met with mixed success.

Like its predecessor, *New Theory of the Earth* offers an insightful, insider's view of what our planet is made of and how it works. Because it is so well written and well conceived, it is suitable either as a graduate-level textbook or as supplemental reading in an advanced undergraduate course. And because it is so comprehensive, it deserves to be within arm's length of every serious student of Earth.

Peter Olson
Johns Hopkins University
Baltimore, Maryland

Von Braun

Dreamer of Space, Engineer of War

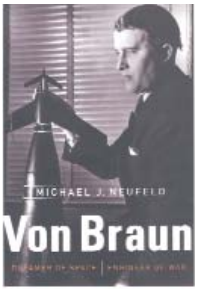
Michael J. Neufeld
Alfred A. Knopf, New York, 2007. $35.00 (564 pp.). ISBN 978-0-307-26292-9

The development of spaceflight and the success of harnessing of the atom are the great stories of 20th-century technological and scientific achievement. However, both challenge historians to explain how scientists and engineers could willingly, even fervently, apply their talents to projects of great moral ambiguity. Wernher von Braun

(1912–77), whose *Saturn 5* moon rocket was an extension of his Nazi V2 design, offers an excellent subject for such study. Michael J. Neufeld, chair of the space history division at the Smithsonian Institution's National Air and Space Museum, took up that challenge two decades ago. In scholarly articles, editorial collaborations, and *The Rocket and the Reich: Peenemünde and the Coming of the Ballistic Missile Era* (Free Press, 1995), Neufeld examined the undertakings of the German rocketeers, setting them in the context of World War II and the cold war.

However, in *Von Braun: Dreamer of Space, Engineer of War*, Neufeld focuses on the central enigma—the moral compass of his protagonist. He asks what and when von Braun knew about atrocities and slave labor at the underground factory that assembled his machines and how he justified working toward Third Reich goals, then carefully covering incriminating tracks or letting others do it for him. A scholar also of Weimar history, Neufeld argues persuasively that to be Junkers—Prussian aristocrats, as the von Brauns had been since 1573—meant upholding conservative values: tradition, nationalism, and military and public service. In young von Braun's case, a Junker upbringing combined with genius resulted in a polyglot engineer who played piano and cello beautifully; flew sailplanes, propeller planes, and jets; and revealed his vision of space travel via US congressional testimony, popular US and European magazines, and Walt Disney cartoons.

From a very tender age, von Braun also demonstrated incredible talent for managing large-scale technical projects. At 21 he had completed half of his PhD in physics and been hired by the German army for the "conception, management of buildup . . . and conduct of experiments" (page 58) that would lead to the A2 rocket two years later. By age 25 he was supervising 350 employees at Peenemünde in northeastern Germany. Because of his inherited wealth and station, Neufeld says, the young von Braun was naive about the realities of politics and economics. Consequently, the university student who welcomed army funding in 1932 was, within a few years, an apolitical yet card-carrying Nazi wunderkind coveted by Reichsführer-SS Heinrich Himmler. Von Braun joined Himmler's Schutzstaffel (SS), but because of the machinations of the army and Albert Speer, minister of armaments and war production, Himmler could control only the V2 slave labor camps, not the design of the rocket or engineering personnel.



By 1942, however, Himmler's SS was supervising von Braun's forced-labor assembly workers. For von Braun, Neufeld writes, "the implicit bargain he had made with the Nazi regime had come due. If he wished to have money for rocketry, if he wished to have a career, if he wished even to keep himself out of danger from the apparatus of repression, he had to participate in stoking the fires of hell" (page 162). Von Braun's V2s killed more of the slave laborers who built them than targeted enemy civilians, notes Neufeld, and, for moral and practical reasons, von Braun would later regret the use of prison workers. Moral growth took time, though, and meanwhile von Braun and his American friends would know enough to keep the bargain a secret.

At the war's end, von Braun persuaded his Peenemünde group to surrender to the US Army. Only in America, he told his colleagues, could they pursue their dream of space travel. Such adaptability allowed von Braun to also change his rocket and space-station designs for almost anyone who asked—*Collier's* magazine, Disney, or the US government—take up new hobbies and change domiciles and his church affiliation as he pleased. That adaptability also kept him, his team, and their dreams alive. By 1960 he was in charge of NASA's Marshall Space Flight Center, the administration's largest facility, with nearly 7000 civil-service and contract employees. The center produced the Saturn rocket series, which in its 12 years had no catastrophic failures in flight and boosted every Apollo capsule and the *Skylab* space station.

Neufeld adeptly incorporates engineering detail, describes at greater length than other biographers his protagonist's complex relationship with the media, and adds to the understanding of cutthroat, interservice rivalries of the armed forces in the US and in Germany. I would request, though, that the book have charts showing the evolution of German and US hardware, the branches of the military or divisions of NASA and the programs they worked on and when, and the rockets that flew and flopped.

The number and quality of sources well support Neufeld's assertions about von Braun's actions, motivations, and character, and set the standard for historians of the Nazi period. Thorough evaluation of von Braun as a complex, Faustian figure has been heretofore stymied by sanitized memoirs and biographies written by von Braun himself, friendly journalists, and coworkers. Some authors seem to believe that finding a few documents through the Freedom of Information Act constitutes responsible research that provides a solid basis for making moral accusations. It does not. What does is scholarship through the long haul: patiently seeking out obscure primary sources, sifting through gossip and legend, consulting original-language documents, deciphering technology and tedious detail, and challenging loyal family and friends for full disclosure. The result of such research is present in *Von Braun*. Neufeld's biography is a must-read for scholars, students, and anyone interested in aerospace history, Nazi Germany, and the mind, morals, and motivations of the scientist and engineer.

Maura Mackowski
Gilbert, Arizona

Fundamental Forces of Nature

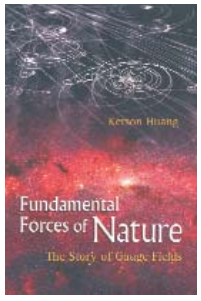
The Story of Gauge Fields

Kerson Huang
World Scientific, Hackensack, NJ, 2007. $54.00, $30.00 paper (270 pp.). ISBN 978-981-270-644-7, ISBN 978-981-270-645-4 paper

Sometimes physicists, in the twilight of their careers, undertake a coherent account of what they have learned about nature at its most fundamental level. The occasional one will even publish the result of the exercise. An example of such a summation is the late Sam Treiman's *The Odd Quantum* (Princeton University Press, 1999); Kerson Huang's *Fundamental Forces of Nature: The Story of Gauge Fields* is another. Treiman found his most profound insight in the concept of quantum field theory; Huang zeroes in more narrowly on gauge fields. Both books should be read in the way one listens to the reminiscences of one's grandparents: patiently, indulgently, and respectfully. The value of Treiman's and Huang's books lies not in their details but in their perspective and wisdom.

Huang is a professor emeritus of physics at MIT and has taught theoretical physics there for half a century. His contributions have been chiefly in the areas of many-body theory and high-energy physics. He has written several graduate-level textbooks, and I have personally enjoyed teaching from his classic *Statistical Mechanics* (Wiley, 1965). *Fundamental Forces of Nature* is his first venture into what he calls "semipopular exposition." But more about that later.

In the preface, Huang describes his aim: "The story of gauge fields is the story of our quest for the fundamental law of the physical world." His work is not a textbook, a history book, or a technical monograph; it is a narrative, with lots of equations and figures, about the evolution of a central component of modern physics. Huang's use of the word "law" in the singular suggests that he hopes to understand the world once and for all, to find a world-formula, as it were. A couple of paragraphs later, also in the preface, he writes, "Theoretical physics has given us a *true* understanding of the physical world" (his italics). In support of this bold assertion he cites the one-part-in-a-trillion accuracy of quantum electrodynamics. I hear an echo of Albert Michelson's premature claim in 1894 that the most important fundamental principles of physics have all been discovered.



Huang's story starts with $F = ma$ and ends with the standard model of particle physics. The major intermediate steps are sketched in lapidary style—with the exception of general relativity, which motivated the original, unsuccessful gauge theory of Hermann Weyl. Maxwell's, Schrödinger's, and Dirac's equations; Pauli matrices; commutation relations; electromagnetic field tensors; $SU(3)$ generators; and Feynman's path integral are displayed in full splendor. But to try to get at the real meaning of gauge theory, Huang reaches for a visual analogy. In the past, others have invoked, with varying levels of success, imaginary stopwatches, rolling ping-pong balls, and color exchanges among quarks to explain the concept. Huang, inspired by the name of the mathematical theory of fiber bundles, pictures gauge fields as beads sliding along fibers anchored at spacetime points. Eventually each fiber picks up a ring around its foot, and finally a miniature gyroscope. The resulting picture is clumsy, but better analogies are very hard to come by.

The difficult story is further fleshed out by anecdotes and lots of images, including thumbnail photographs of most of the physicists mentioned. The pictures, together with Huang's relaxed style, lend a very appealing texture to the book, a little like a family album or a personal diary. God, Napoleon Bonaparte, and the ancient Chinese poet Qu Yuan make discreet cameo appearances. There is also a physics poem, *The Waste Lecture*, attributed to T. S. Eliot and first published in John Lowell's "Mr. Eliot's Guide to Quantum Theory," on page 46 of the April 1989 issue of PHYSICS TODAY. The unsuspecting reader might be misled into believing in its authenticity by Huang's failure to flag it for what it is: an April Fools' joke.

Who should read Huang's book? Huang contends that mathematics cannot be avoided in any discussion of physics, but that this does not mean one "has to understand the equations. One could get the flavor of what is being discussed without the equations, just as one could enjoy a foreign movie without the subtitles." I disagree. A reader with no knowledge of physics would no more understand this book than I would enjoy a movie in Chinese. However, people with some physics background, including readers of