

ALVAREZ ON ALVAREZ: RADAR, BUBBLE CHAMBERS, LENSES, EXTINCTIONS, . . .

Alvarez: Adventures of a Physicist

Luis W. Alvarez

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Reviewed by Richard L. Garwin

Alvarez is the most recent in the science book series sponsored by the Alfred P. Sloan Foundation. I find it a gripping book. It succeeds well in making the scientific experience and the excitement of discovery accessible to the general reader. I believe it will be as instructive and entertaining to those who are not personally familiar with the author's research.

Luis Alvarez was born in 1911 and received his PhD from the University of Chicago in 1936. With the exception of his World War II activities Alvarez has spent his entire professional life in the physics department and the Lawrence Radiation Laboratory of the University of California, Berkeley. His father was an internist and research physiologist, and after retirement a popular columnist on medical matters. Family, friends and tradition mean a great deal to Alvarez, and have had an important role in his brilliant career. This book originated in 1969 when Alvarez realized that his two youngest children would know little about him if he died then, at the same age as his friend and mentor Ernest O. Lawrence.

Those who lack perfection in educational opportunity might take heart from Alvarez's experience: "By almost any standard, my training at Chicago had been atrocious. . . . From another point of view, though, my

training had been extraordinarily good. I could build anything out of metal or glass, and I had the enormous self-confidence to be expected of a Robinson Crusoe who had spent three years on a desert island. I had browsed the library so thoroughly that I knew where to find the books I needed to learn almost anything I wanted to know." And Alvarez characteristically would disappear for days into the library at Berkeley, emerging with ideas, plans for experiments and explanations for puzzling results.

Alvarez's competitive spirit was stimulated by "Bethe's Bible"—Hans Bethe's three articles on nuclear physics in *Reviews of Modern Physics* in 1936–37. Alvarez writes of Bethe, "If he said a phenomenon would never be observable, I wanted to prove him wrong, which would make both of us happy."

Alvarez's father had enjoined him "to sit every few months in my reading chair for an entire evening, close my eyes, and try to think of new problems to solve. I took his advice very seriously and have been glad ever since that I did." Time after time, Alvarez showed that dogged but imaginative persistence that forces one not to stop with the first idea, because there might be a better one. Repeatedly he would leap to a conclusion and strive to find evidence that would refute it. He writes, in recounting careful work by Frank Dunnington on the charge-to-mass ratio for the electron, that "most people are concerned that someone might cheat them; the scientist is even more concerned that he might cheat himself." Alvarez is perpetually surprised to find individuals who do not challenge their own results, and who do not immediately accept even the strongest contrary evidence.

During World War II, Alvarez played a spectacular role at the MIT Radiation Laboratory, working on radar and other systems. After early successes, radar-equipped aircraft

had become ineffective in destroying surfaced German submarines. The submarines had begun to carry radar warning receivers, which gave an increasing signal as an aircraft approached on its attack run. Alvarez thought of reducing the radar power output inversely as the cube of the range to the submarine, so that as the aircraft approached, the submarine would detect decreasing radar power and have no fear of impending attack. Meanwhile the aircraft would receive a continuously increasing radar reflection (the energy in the returned signal is proportional to the inverse fourth power of range). This technique was dubbed "Vixen" because it "foxed" the German submarines.

From the MIT Rad Lab, Alvarez and his group invented, perfected and fielded a system called Ground-Controlled Approach to allow ordinary aircraft and pilots to land at night and in poor visibility. GCA is still in use at every military and many civilian airfields in the world. During this time, Alvarez had ample opportunity to display his ingenuity, optimism and resourcefulness—and his love of flying.

After six weeks in England, Alvarez left the Rad Lab, where he had been head of Special Systems, also known as "Luie's Gadgets," to work with Enrico Fermi at the Metallurgical Laboratory at the University of Chicago. Soon afterward, he moved to Los Alamos. Among his major contributions there were the invention and development of capacitor-discharge "bridge wire" detonators for simultaneous initiation of the many high-explosive "lenses" in the implosion system of the plutonium bomb. With a detonation wave speed in high explosive of some 8 km/sec, 10 nanoseconds (one "shake," as it was called at Los Alamos) of timing uncertainty would produce an asymmetry in the shock wave of about 0.1 mm; normal blasting caps demonstrated 10 000 times' greater timing variation. Typically for Alvarez, the first trial of his

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invention involved firing a normal bridge wire with a 15-kV capacitor rather than the typical 6-volt battery. The necessary improvement in timing accuracy was accompanied by an improvement in safety due to the elimination of the more sensitive primer explosive.

After the war, Alvarez was swept up in Lawrence's passion to build a large deuteron accelerator for the production of plutonium for nuclear weapons. For once Alvarez himself did not look at the data, which would have convinced him that there was plenty of uranium to be converted, much less expensively, to plutonium in nuclear reactors. In an important and engaging passage in the book he recalls recognizing that he had drifted far from experimental physics, and recasting himself as research assistant to two of his own research assistants. This discipline and redirection have obviously borne fruit—in Alvarez's work on particle physics with hydrogen bubble chambers, for which he won the 1968 Nobel Physics Prize, and in his continuing commitment to technical work, and avoidance of management or of ceremony.

Learning from Don Glaser at the Washington APS meeting in 1953 of his 1-cm-diameter ether bubble chamber, Alvarez immediately laid plans with his colleagues to build a large liquid hydrogen bubble chamber. A 1.5-inch glass chamber worked; followed by a 2.5-inch "dirty" chamber that showed good tracks despite boiling at its walls; followed by a chamber of 4-inch diameter. It is typical of Alvarez that he drafted a "prospectus," titled "The Bubble Chamber Program at UCRL" (April 1955), for the project to build what became a 72-inch liquid hydrogen chamber. The success of the hydrogen bubble chamber and the physics done with it at Berkeley and elsewhere are now history.

From his experience, Alvarez has drawn some advice for our society: "In my considered opinion the peer review system, in which proposals rather than proposers are reviewed, is the greatest disaster to be visited upon the scientific community in this country. No group of peers would have approved my building the 72-inch bubble chamber." How would a young scientist get financial support without peer review of progress? "I think he would do it the same way I did; I apprenticed myself to Ernest Lawrence, a man with such a good track record that any proposal he made was automatically funded without peer review." (I believe, however, that a mixed strategy would be desir-

able, with the opportunity for judging both the proposal and the proposer.)

In Alvarez's long and broad history, it is striking to observe how some of his best and most practical ideas were only very much later brought to fruition by his own efforts, despite his early patents' being available to profit-minded industry at relatively low cost. The stabilized optical system for binoculars or cameras that he invented in 1963 while his wife, Jan, lay ill with malaria in Kenya has only in the last few years been sold (by a company of which Jan is president) as a stabilizing zoom lens for shoulder-mounted video cameras, although working systems existed 20 years earlier. The same lag took place with the variable-power lens he invented and demonstrated to Polaroid more than 20 years ago, which only appeared on the consumer goods market (in the Polaroid Spectrum camera) in 1986.

The life of an inventor (even one who is in the Inventor's Hall of Fame, and who won the Collier Trophy in Aviation and many other awards) may be fun, but it is not always profitable: Alvarez realized the first profit from any of his 40-some inventions just a few years ago.

The most recent work for which Alvarez is known is the result of a collaboration with his geologist son Walter and Berkeley radiochemists Frank Asaro and Helen Michel: the demonstration that the boundary between the Cretaceous and Tertiary geological strata contains very large enhancements of stable iridium in a rock stratum a few millimeters thick, and the claim that this enhancement represents evidence of the deposition of dust from the impact of a meteoroid some 10 km in diameter—an impact that largely depopulated the Earth. (See Alvarez's article in *PHYSICS TODAY*, July, page 24.) This work soon led others to perceive the potentially large climatic change that could be caused by smoke from fires started by a large-scale thermonuclear war—the "nuclear winter."

Alvarez's book is a fine supplement to his legacy of invention, organizational innovation, students and results in physics. One puts it down with regret.

Concepts of Particle Physics, Volume 2

Kurt Gottfried and Victor F. Weisskopf

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The second volume of *Concepts of*

Particle Physics develops in much greater detail the material on modern fundamental-particle theory and phenomenology outlined in the last two-thirds of its predecessor (for a review of volume 1, see *PHYSICS TODAY*, January 1985, page 99). However, its primary role is to provide intellectual justification for many of the ideas presented in the brief overview of particle physics that constitutes volume 1, while still sparing the reader the algebraic and functional "technology" now demanded of toilers in the vineyards of particle physics. This is not a manual in experimental principles and techniques for particles and fields. Both volumes are addressed not only to the broader physics community, but also to advanced undergraduates and beginning graduate students interested in careers in particle physics.

The passive reader will not find here a "royal road" to understanding the fruits of the last 20 years of revolution in high-energy physics. Kurt Gottfried and Victor Weisskopf, both distinguished contributors to nuclear and subnuclear theory, have expressly committed themselves to what they call the "oral tradition" in physics; but it is not a nonmathematical tradition, and they make no bones about that. While the book sacrifices rigor to allow greater-than-usual access by the broad community of physicists, and while it uses analogies with pre-field-theoretical physics liberally and effectively, nevertheless the arguments that form its essential content remain anchored to the mathematical substrate of "real" physics.

The aim is to liberate some of the central notions of quantum chromodynamics and electroweak theory not from mathematics, but from the necessarily long and sequential logic of quantum field theory. By drawing heavily on ideas familiar from electromagnetism and condensed matter physics, the authors make the subject accessible to those who appreciate and enjoy "physics in the round," and enrich, for the novice in elementary particles, the connections of this subfield with the whole of physics.

The prerequisites for both volumes are a solid understanding of electromagnetic theory, quantum mechanics and special relativity, and a well-developed tolerance for deferred proofs or for an occasional *deus ex machina* of the "for a complete treatment see..." variety. The books' contents thus are within the reach of virtually the entire population of contemporary postbaccalaureate physicists. (More speculative topics such as lattice QCD, technicolor, super-