

An insider's account of the beginning of the space age

Origins of Magnetospheric Physics

James A. Van Allen

144 pp. Smithsonian Institution P., Washington, DC, 1983. \$19.95

Reviewed by Jai S. Kim

The discovery of Earth's radiation belts led to the development of magnetospheric physics. James A. Van Allen and his students at the University of Iowa made this discovery in early 1958

certain aspects of the solar and geophysical knowledge available in 1946, the year Van Allen designates as the start of the space age. Van Allen then gives a personal account of his participation in space research, from 1946, when he worked on high-altitude observations of cosmic-ray intensity with rocket-borne equipment (a program that established the technical and scientific foundations of space exploration), to the early 1960s, when the basic

the passage of time.

The book contains an extensive and well-selected bibliography. However, an index would have been useful.

Particle Physics: The Quest for the Substance of Substance

L. B. Okun

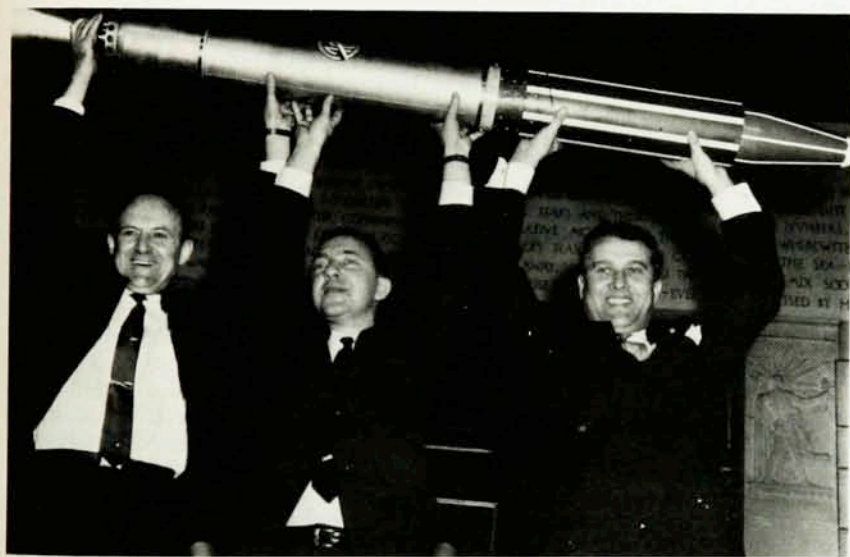
223 pp. Harwood Academic, New York, 1985.

\$44.00 hardcover; \$18.00 paper

Very few gifted theoretical physicists are also great expositors; rare indeed are those with equal mastery of the intuitive underpinnings of a theory and its formal structure; and scarcest of all are those in whom erudition lives in harmony with imagination. The Soviet theorist L. B. Okun is all of these, as this short but lucid monograph demonstrates. He has produced a handy guidebook for those newly arrived in the arcane land of fundamental particles and fields, whether they be students contemplating immigration or tourists from other subdisciplines. This work could well fill the niche that, some 25 years ago, was occupied by Richard Feynman's *Theory of Fundamental Processes*.

Okun has a remarkable knack for finding the vivid image that can illuminate a murky concept, as when he illustrates the difference between strong and electromagnetic interactions by imagining a gluon beam that, were it not for confinement, could shine in its own light.

Like most good theorists, Okun has deep respect for formal beauty. For him, Nature's most telling facts are symmetries, and her deepest laws are variational principles. The two are linked by the Lagrangian. Yet in this narrative, he usually discards formal arguments in favor of intuitive ones. The topics covered range from simple particle zoology to the airy reaches of supersymmetry. Okun introduces each topic via a historical summary, and is careful to interpret history in the light of its contribution to the modern viewpoint. Flavor SU(3) symmetry, for



James A. Van Allen (middle), Wernher von Braun (right) and William H. Pickering hold aloft a full-scale model of Explorer I at a press conference in the Great Hall at the National Academy of Sciences on 1 February 1958, shortly after the spacecraft completed its first orbit. The photograph appears in *Origins of Magnetospheric Physics*, reviewed here.

using equipment they had designed, built and flown on Explorers I and IV. Van Allen, one of the most distinguished pioneers in high-altitude and space research, has now written this brief history of an important epoch of 20th-century science: the opening up of entirely new windows to space and the universe by rockets and spacecraft.

The book begins with a brief sketch of

framework of magnetospheric physics had become firmly established.

The book is written in an informal and readable style. Its autobiographical approach, including excerpts from Van Allen's private journals, adds a sense of immediacy and excitement. His reminiscences about his experiences with many aspects of the early rocket and satellite programs are very interesting. A research proposal he wrote in 1955 (given in Appendix A) shows a marked contrast with today's proposals, and we cannot help feeling

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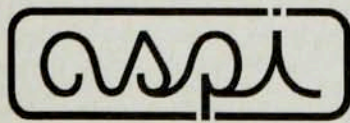
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example, is presented as an artifact of the low masses of the three lightest quarks and as a convenient bridge to the more fundamental color SU(3). His treatment is tight and leaves few loose ends; not many writers on this subject offer the reader a physical feeling for the Cabbibo angle. The book contains a useful appendix on natural units as well as an excellent glossary and an ample bibliography.

One of the strongest sections takes the reader through the transition from a perturbation description of the fleeting interactions of quarks and gluons to the quasiclassical realm of quark confinement, all by means of simple intuitive arguments that an undergraduate could easily grasp.

In particle physics, experimenters usually have to wrestle with epiphenomena far removed from the fundamental processes that, after much toil and confusion, their labors have uncovered. Okun has much to say about the interaction of experiment and theory in these difficult circumstances.

In his preface Okun reveals that this work traces its origins to a summary talk prepared for—but not delivered at—the 1980 Rochester Conference in Madison, Wisconsin. Those who suffered the disappointment of that canceled appearance may now find recompense in this much-expanded version. It is a measure of both the depth of the author's insight and of the maturity of particle physics that with the simple addition of a brief summary of recent experiments, that six-year-old perspective remains fresh and valid.

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The Nature of Irreversibility

Henry B. Hollinger and Michael J. Zenzen
340 pp. Reidel, Boston, 1985. \$39.50

Microphysics is deterministic and reversible; macrophysics is statistical and irreversible. The mathematical process of averaging cannot introduce a distinction between the two directions of time. Where, then, does irreversibility creep in?

Ludwig Boltzmann's theory of dilute gases gave the first answer to this question and furnished the starting point for all subsequent theories of irreversibility. Boltzmann's famous equation expresses the rate of change of the density of molecules in position-velocity space in terms of the rates of two-body molecular collisions. Unlike the equations that govern individual two-body collisions—Newton's equations of motion—Boltzmann's equation is irreversible. Its irreversibility arises from one of the postulates needed to derive the equation—that of molecular chaos, according to which the initial

velocities of colliding molecules are at all times statistically uncorrelated. Time-symmetric equations of motion combined with an asymmetric auxiliary condition yield an asymmetric statistical description.

But Boltzmann's postulate is too strong for an isolated gas. Even if the initial velocities of colliding molecules are uncorrelated at an initial moment when the gas is far from equilibrium, they will not remain uncorrelated. There are two ways to overcome this difficulty. If we wish to keep Boltzmann's equation we must assume that interactions between the gas and its environment destroy two-particle correlations before they have a chance to build up. Alternatively, if we wish to consider isolated systems, we must choose a weaker assumption than molecular chaos. For example, we may assume that two-particle correlations (or, in quantum systems, the off-diagonal elements of a density matrix) are absent at some initial moment. Most modern kinetic theories proceed from an assumption of this kind.

In *The Nature of Irreversibility* Henry Hollinger, a chemist, and Michael Zenzen, a philosopher, reexamine the question of "what ingredient [needs] to be added to particle mechanics, classical or quantum, to lead the mechanics through statistics to a prediction of fluid mechanics." They confine their attention to isolated systems and conclude that the necessary ingredient is "the assumption of recent equilibrium." If an isolated gas is "forcibly withdrawn" from equilibrium, it will relax to an "equilibrium plateau." Eventually (after a time comparable to the Poincaré recurrence time) it will undergo a "spontaneous withdrawal" from the new equilibrium—unless another "forced withdrawal" intervenes. In systems that exhibit irreversible behavior, Hollinger and Zenzen argue, the characteristic time interval between forced withdrawals is short compared with the characteristic interval between spontaneous withdrawals: "Irreversibility is a consequence of a simple relation between an intrinsic time t_i and an environmental time t_e ." To support this conclusion, they show in some detail how kinetic and hydrodynamic equations can be deduced from the Liouville equation (for which they give an incorrect proof) under the assumption of "recent equilibrium."

Their derivations of kinetic and hydrodynamic equations implicitly assume that the nonequilibrium state is at most a few collision times old. This assumption is far stronger than those underlying modern kinetic theories of isolated gases (which the authors criticize for being excessively formal) and it is less realistic than the assumption that external perturbations keep two-