

The book

BETA DECAY. By C. S. Wu, S. A. Moszkowski. 394 pp. Interscience, New York, 1966. \$16.00

by Lee Grodzins

Beta Decay, by C. S. Wu and S. A. Moszkowski, is an excellent book, a refreshing book, highly recommended. Until it was written, a comprehensive knowledge of beta decay could be obtained only by studying many articles written by as many authors using a variety of notations. Now we have the coherent story written without pedantry, mixing experimental fact and theory in just proportion.

Beta decay has fascinated physicists since energetic electrons were first observed to emanate from natural radioactive materials. Such observations were among the earliest harbingers of structure, first of the atom, then of the nucleus. By 1930, the beta-decay distribution was an experimental fact, and in 1931 Wolfgang Pauli proposed (in public; see letter reproduced here for suggestion made in December 1930) that this distribution was due to the simultaneous emission of a massless neutrino. Fermi formulated the point-interaction theory of beta decay in 1934. For the next two decades, physicists uncovered the rich phenomena manifest when a neutron or proton was transformed by emitting an electron or positron. Lifetimes and spectra were measured; the classification of decay orders was completed; experiments were carried out on the interaction form and strength.

Then, in 1956, T. D. Lee and C. N. Yang conjectured that parity was not conserved in weak interactions. In a few short months, Wu, Ernest Ambler, Raymond W. Hayward, Dale D. Hoppes and Ralph P. Hudson proved this conjecture correct. The world of physics had a handedness. Beta-decay electrons had always been polarized. The feverish few years that followed produced ingenious experiments, bold conjectures. The theory of weak interactions took on a universality and an elegance it had hitherto lacked.

The excitement quieted; parity non-conservation became a tool to study nuclear spectroscopy. The quiet was

Zürich, December 4, 1930

Dear radioactive ladies and gentlemen,

I beg you to most favorably listen to the carrier of this letter. He will tell you that, in view of the "wrong" statistics of the N and Li⁸ nuclei and of the continuous beta spectrum, I have hit upon a desperate remedy to save the laws of conservation of energy and statistics. This is the possibility that electrically neutral particles exist which I will call neutrons, which exist in nuclei, which have a spin $\frac{1}{2}$ and obey the exclusion principle, and which differ from the photons also in that they do not move with the velocity of light. The mass of the neutrons should be of the same order as those of the electrons and should in no case exceed 0.01 proton masses. The continuous beta spectrum would then be understandable if one assumes that during beta decay with each electron a neutron is emitted in such a way that the sum of the energies of neutron and electron is constant. . . .

I admit that my remedy may look very unlikely, because one would have seen these neutrons long ago if they really were to exist. But only he who dares wins and the seriousness of the situation caused by the continuous beta spectrum is illuminated by a remark of my honored predecessor, Mr. Debye, who recently said to me in Brussels: 'O, it is best not to think at all, just as with the new taxes.' Hence one should seriously discuss every possible path to rescue. So, dear radioactive people, examine and judge. Unfortunately I will not be able to appear in Tübingen personally, because I am indispensable here due to a ball which will take place in Zürich during the night from December 6 to 7.

Your most obedient servant,
W. Pauli

PART OF LETTER sent by Wolfgang Pauli to Hans Geiger and Lise Meitner, who were participating in a congress at the time. The name neutrino was proposed by Enrico Fermi when a heavier "neutron" was discovered by James Chadwick. (From *Beta Decay*.)

shattered in 1962 with the demonstration that the neutrino accompanying the electron is different from that accompanying the muon, and there have been minor eruptions involving the conserved-vector-current (CVC) hypothesis suggested by Richard P. Feynman and Murray Gell-Mann in 1958. The present hiatus is surely temporary. No one doubts, least of all Wu and Moszkowski, that further surprises are in store; for at every step in the development of our understanding, beta decay has simultaneously exhibited a great simplicity and the seeds of complexity.

As we have implied, *Beta Decay* is written as an unclosed book. It begins with an historical introduction that sets the stage, the style, and outlines the major advances. The second and third chapters, which together occupy about a third of the book proper, are concerned with the preparity period. This section is my favorite. With great clarity and elegant examples, the classical theory unfolds; the experimental knowledge is codified. In chapter 3 alone there are more than 25 decay schemes illuminating all facets: the classification of beta decay, ft

values, beta-neutrino and beta-gamma correlation. The blend of theoretical exposition and appropriate examples is maintained throughout.

The modern period of weak interactions occupies more than half the volume. In chapter 4 all the principal methods for showing parity nonconservation are discussed. An example of the thoroughness, the currentness, the empirical approach, is the careful discussion of the inconsistency in the results, in Sc⁴⁶, of beta-gamma (circularly polarized) correlations, which is of interest for the study of the conservation of isobaric spin in beta decay.

Orbital capture, double and inverse beta decay are grouped in a separate chapter, and another chapter brings together the essentials of weak interactions in particle physics. The last chapter is concerned with recent developments. Most of this long section is concerned with the CVC theory, for which Wu's experiment provides the most convincing evidence. The authors close with the description of the two-neutrino experiments and the conjecture of structure in the weak interaction, that is, the search for the intermediate boson.

The extensive appendices contain the theoretical derivations. They seem meant more to refresh the physicist than to teach the student, but they are no less welcome for that.

Beta decay is one of the clearest examples that physics is an empirical science. It is therefore fitting that Wu should be the principal author of this book. For some 20 years she has concentrated her considerable attention to this field. From her earliest experiments on beta-decay spectra to her discovery of parity violation and to the test of the CVC hypothesis, she has consistently attacked the critical questions. Among practitioners in the field, her name on a paper stamps the work as definitive. Thus it is with this book. Her collaborator, Moszkowski, well known for his work on electromagnetic transitions, has a sure hand for describing theoretical aspects in a self-contained, logical, clear way.

Quantized lattice vibrations

PHONONS: IN PERFECT LATTICES AND IN LATTICES WITH POINT IMPERFECTIONS. (Scottish Universities' Summer School, 1965). R. W. H. Stevenson, ed. 448 pp. Plenum Press, New York, 1966. \$22.50

by David S. Falk

As "elementary particles" go, the phonon is one of the oldest. Like the photon, it is manifested in a classical field, and one still learns a lot about it from Lord Rayleigh's treatise. Its discovery as a quantum phenomenon may be dated with the work of Einstein and Debye at just about the same time that Rutherford was discovering the atomic nucleus. It did not get the name "phonon," however, until Frenkel suggested it in 1932, the same year in which Chadwick inferred the existence of the neutron.

This last coincidence is significant, because it is the neutron, used as a tool, which has given us some of the most direct information about phonons and which has contributed greatly to the current interest in the field. It is not surprising, therefore, that both the 1963 Aarhus Summer School (*Phonons and Phonon Interactions*, T. A. Bak, ed., W. A. Benjamin, New York, 1964) and the present volume, the

Reviewed in This Issue

- 59 GROUEFF:
Manhattan Project: The Untold Story of the Making of the Atomic Bomb
- 60 WU, MOSZKOWSKI: Beta Decay
- 61 STEVENSON, ed:
Phonons: In Perfect Lattices and in Lattices with Point Imperfections
- 63 DEWAARD, LAZARUS:
Modern Electronics: A Practical Guide for Scientists and Engineers
- 63 SAUER: Nichtstationäre Probleme der Gasdynamik
- 64 MCCORMICK: Laboratory Experiments in Physics
- 65 BATES, ESTERMANN, eds: Advances in Atomic and Molecular Physics

The result of their collaboration is a work of considerable importance to students, teachers and practitioners.

Here is a splendid example of how important it is for leading authorities to summarize their fields. When the authority writes a book about his field,

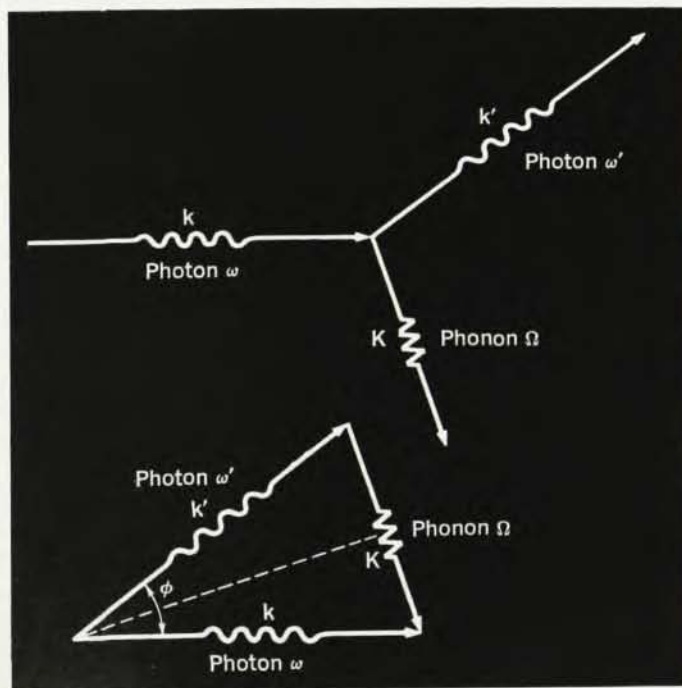
it becomes The Book. Such is the present case. Here are the pages you will read when you want to know what is known about beta decay.

* * *

Lee Grodzins is professor of physics at Massachusetts Institute of Technology.

1965 Scottish Universities' Summer School in Physics (*Phonons: In Perfect Lattices and in Lattices with Point Imperfections*), should have as one of their two common lecturers Bertram N. Brockhouse, whose group, using the technique of neutron scattering, has provided us with point-by-point mappings of phonon dispersion curves in a large variety of materials.

There is, however, a lot more one can do with phonons other than scatter neutrons off them, as even a casual glance at these two books will show. Both of them cover a wide variety of topics related to phonons and the various interactions phonons may have with each other, with electrons, with neutrons, with the electromagnetic field, and with point lattice imperfec-



INELASTIC SCATTERING of a photon of wave vector k , with the production of a phonon of wave vector K . Scattered photon has wave vector k' . In momentum balance diagram, if $k=k'$, the triangle is isosceles. The triangle base is $2k \sin(\phi/2)$.