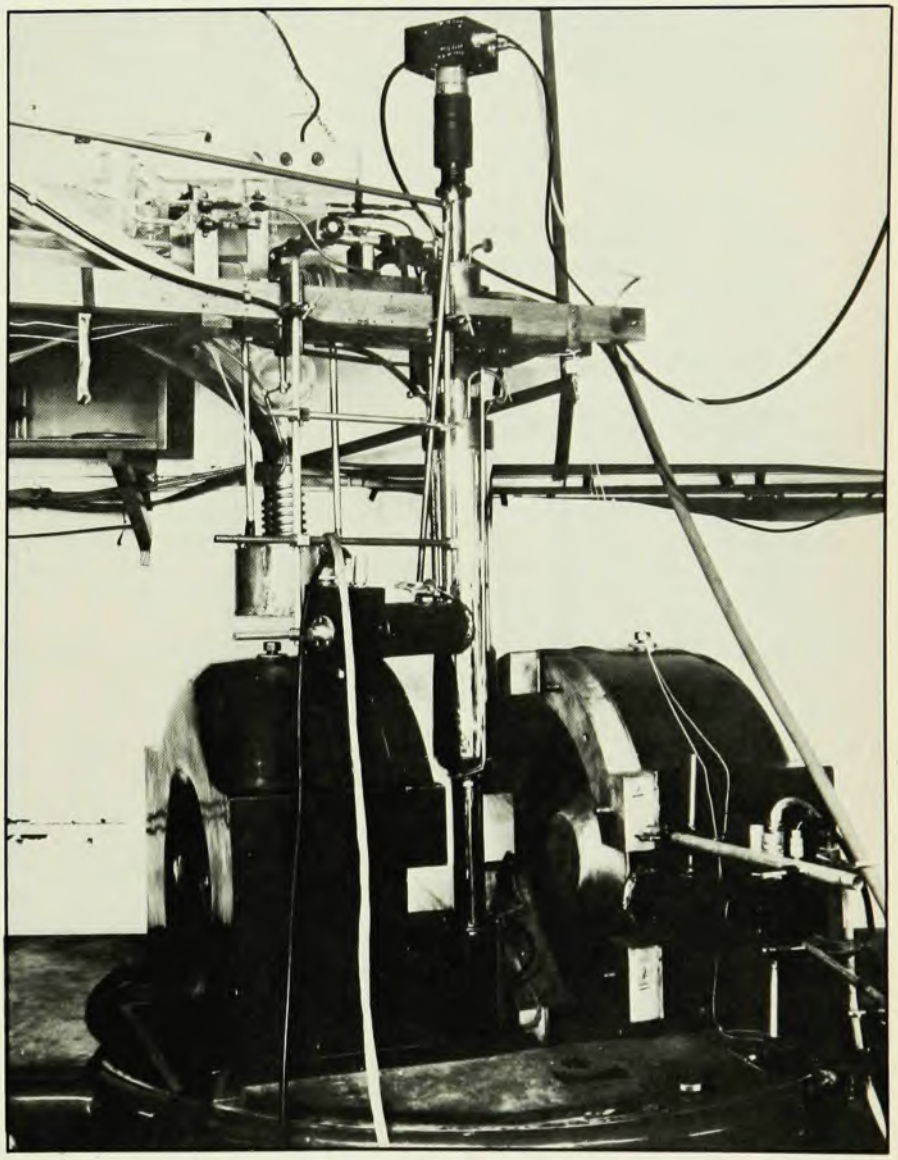
Probing the weak interaction and nuclear structure

Beta Decay and Muon Capture

M. Morita
361 pp. W. A. Benjamin, Reading, Mass., 1974. $19.50

Reviewed by Herbert Überall



The asymmetry of beta particles from oriented cobalt nuclei was demonstrated nearly two decades ago with this "parity experiment" apparatus. Illustration provided by R. P. Hudson of NBS.

Beta decay is an exciting subject to write a book about. It is the earliest-known (since Henri Becquerel, 1896) and best-understood of the weak interactions; and in the memorable period of 1956–58, after having undergone decades of a development which—with the notable exception of Wolfgang Pauli's neutrino hypothesis—had not been very spectacular, it suddenly turned into one of the most appropriate tools for confirming some of the more revolutionary physical concepts of the past quarter century: the violation of parity and of charge conjugation in weak interactions (earning the Nobel prize for T. D. Lee and C. N. Yang), the concept of the two-component neutrino, of weak magnetism and the conserved vector current. It also became the primary means for establishing the V–A nature of weak interactions, and for verifying their time-reversal invariance. At that time, the posing of these problems spawned a great number of ingenious beta-decay experiments that provided clear-cut answers, and that are now considered classic: C. S. Wu's on the beta asymmetry from oriented cobalt nuclei, H. Frauenfelder's on the longitudinal polarization of beta particles, and M. Goldhaber's on the helicity of the neutrino. I remember this period as probably the most exciting one of my professional career.

M. Morita has been in an ideal position to capture these developments into an advanced textbook on beta decay and on the related topic of muon capture from a theorist's standpoint. He spent some years around 1956 at Columbia University where Lee and Wu were active; in fact, often together with his physicist wife R. S. Morita, he contributed to the basic interpretation of these experiments, providing a complete theory of beta angular distributions from oriented nuclei as well as a multiple theory of muon capture.

Morita's book treats the subject with admirable pedagogical skill, developing it methodically, self-consistently, and in well-balanced fashion with a large, but not excessive, amount of theory, most of it quite completely but also concisely derived. This will make the book very useful as a text for graduate students as well as a reference book. The first two chapters treat "classical" beta decay, based on Fermi's theory. The following two discuss more recent developments of parity violation in beta decay and of the V–A interaction. Two more chapters concern various related topics such as K-capture; inverse beta decay and the experiments of F. Reines and C. Cowan and of R. Davis; decays of pions, muons and strange particles; distinction between electron and muon type neutrinos; W bosons as well as a complete theory of forbidden beta decays. Chapter 10 describes some more recent developments, including second-class currents and weak components in the nuclear force.

Both beta decay and muon capture may serve a two-fold purpose, namely elucidation of the nature of the weak in-

teraction, and—after the latter has been classified—their use as a tool for studying nuclear structure. Accordingly, chapter 7 and parts of chapter 10 treat the nuclear structure-dependent aspects of beta decay, including the relation of Gamow–Teller matrix elements to ground-state magnetic moments and spin densities, supermultiplet theory and the spin-flip giant resonance. While beta decay, due to the low momentum transfers involved, is not of a very universal value for nuclear structure studies, muon capture promises to be much more so, especially in view of the three or four high-flux meson facilities now operating.

Chapters 8 and 9 of Morita's book deal with muon capture from just this viewpoint. In contrast to its discussion of beta decay, however, which is as complete as can be desired, muon capture in complex nuclei is only treated through the examples of ground or low-lying excited state transitions in carbon 12 and oxygen 16. A wider scope in this subject might have been desirable here. I missed in particular the topic of analog giant-resonance excitation, which has been of importance in muon capture for a number of years now.

Morita's book competes well with three earlier works on the same subject (all from 1966), namely those by C. S. Wu and S. A. Moszkowski, by H. Schopper, and by E. J. Konopinski (in this order, progressing from more experimental-minded to theoretical-abstract). It is most similar to Schopper's, having over it the twin advantage of a greater distance from the period of most rapid development of the subject, and the inclusion of more recent subject matter. R. J. Blin-Stoyle's 1973 book *Fundamental Interactions and the Nucleus* also covers much of these subjects, but appears more like a reference work rather than a textbook as compared to Morita's book.

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Herbert Überall is a professor of physics at the Catholic University and a consultant at the Naval Research Laboratory, Washington D.C. He has done work on muon capture and has written several recent review articles on the subject.

The Jupiter Effect: The Planets as Triggers of Devastating Earthquakes

J. Gribbin, S. Plagemann
136 pp. Walker, New York, 1974. $7.95

The main argument of this book may be briefly summarized. About every 179 years an approximate alignment of the