Alice-like K mesons

THE CP PUZZLE: STRANGE DECAYS OF THE NEUTRAL KAON. By P. K. Kabir. 137 pp. Academic Press, London, 1968. £2:0:0.

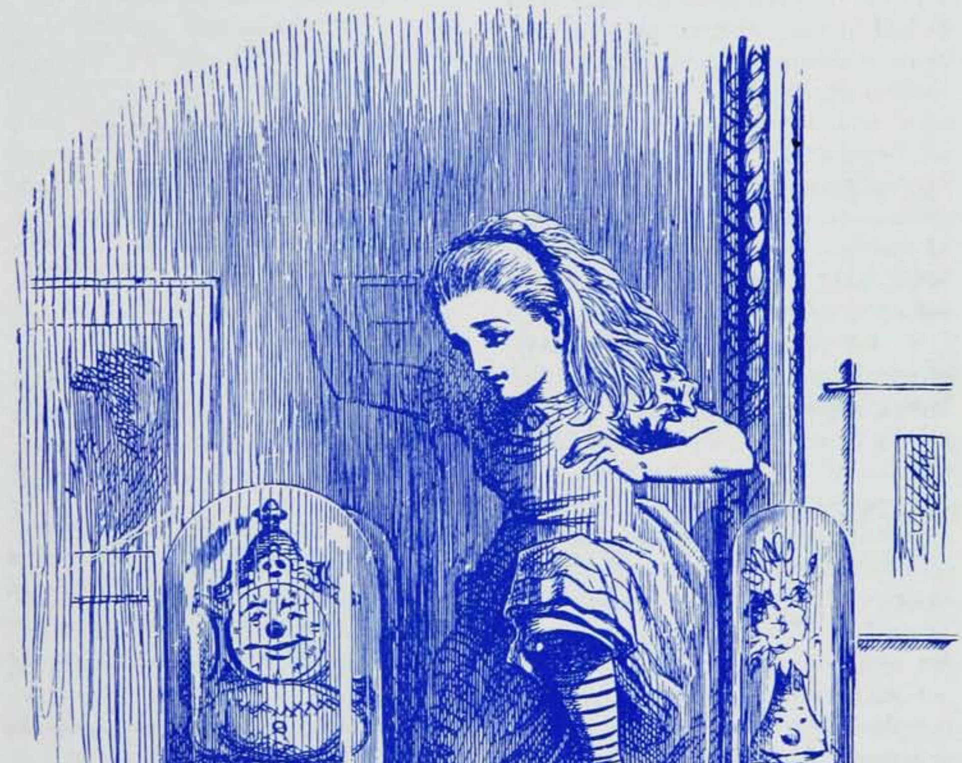
by ROBERT G. SACHS

If Lewis Carroll had heard about the neutral K mesons he might have been tempted to stake out a priority claim on the basis of his *Through the Looking Glass* for its fantasies if not for its facts. The two kinds of neutral K-mesons, called K^0 and $\bar{K}^0$, bear a mirror relation to one another both in space and particle–antiparticle character; that is, they are related by the operation CP where C interchanges particles with antiparticles and P inverts (mirrors) the space reference frame. But, Alice-like, they pass back and forth through this "looking glass" and reveal a fascinating and tantalizing world of surprising phenomena. These phenomena have important, probably even "deep," implications with regard to the nature of weak interactions that in turn may require a deeper penetration into the meaning of physical concepts.

In 1955 Murray Gell-Mann and Abraham Pais pointed out that the combination of properties of the K^0 and $\bar{K}^0$ (that they are electrically neutral bosons of opposite strangeness and both capable of decaying into two pions in a given state) leads to a transitive relationship between them. After its creation in a collision of strongly interacting particles, a K^0 meson passes through the particle–antiparticle mirror to become a $\bar{K}^0$, which in turn reverses the process. As result, a beam of the decaying particles behaves like a mixture of two kinds of particles. One has a short lifetime (K_S), the other has a long lifetime (K_L), and neither has a definitely assigned strangeness. Although this phenomenon is caused by second-order effects of the weak interactions, which are usually observable only in first order, it is readily observable and is well confirmed by experiment.

Because of these properties, the K^0 mesons are an extremely rich subject for experimentation and theoretical analysis. Their transitive character leads to some remarkable interference phenomena that make it possible to carry out very sensitive interferometric studies on the weak interactions. Because these phenomena are so closely tied in with the concepts of the CP transformation, they are particularly useful as a sensitive test of the concept that the physical laws should be unchanged under the CP operation. It is now well known that the surprising experiment of James H. Christenson, James W. Cronin, Val L. Fitch and Rene Turlay in 1964 established that the long-lived K_L can decay into two pions. This result was contrary to expectations based on CP-invariant theories.

The CP Puzzle by P.K. Kabir is concerned with this discovery and its implications. It includes some historical background and discussion of the general principles relating to the K^0-meson phenomena. It describes relevant experiments in detail and contains an analysis of these experiments including a discussion of the unsuccessful attempts to account for the



NEUTRAL K MESONS ". . . pass back and forth through the looking glass to reveal a fascinating and tantalizing world of surprising phenomena." BETTMANN ARCHIVE two-pion mode of the long-lived K meson without invoking a violation of CP invariance. There are several appendixes giving some of the details of the phenomenological analysis and theoretical background of K^0-meson physics. In total the book is more in the nature of a review than a text.

It is difficult to discern for what audience this book is intended. It may be useful for those who are working in the field as an overall view of the subject and summaries of certain relevant articles. However, the unwary should be warned that there are some rather important errors of principle in the discussions of theoretical foundations. Students should be especially cautious of accepting such statements as, ". . . if all interactions are C-invariant, the $K_+{}^0$ state could decay only to states with $C = +1$ . . ." (page 4). Semileptonic states that are not eigenstates of C have apparently been overlooked by the author in this statement, as in "A neutral 2π state with specified angular momentum l is an eigenstate of C with eigenvalue of $C = (-1)^l$ . . ." (page 5). An l-odd state of two neutral pions does not satisfy this condition. In section 3.2, the discussion of choice of phases for defining decay amplitudes is very misleading. For example, on page 45 it is stated that ". . . the phase of r has no absolute physical significance . . .," but the following appears on page 47: "In Appendix D we show that r is essentially real . . . ." Another significant error that caught my eye was: "We shall also see that the *only* CP-noninvariant *effect* which can be predicted with any assurance . . . is an interference effect" (page 77). The charge asymmetry in the semileptonic decay of the $K_L{}^0$ is not an interference effect. Although the observation of this effect occurred so recently that it is mentioned in this book only in a note added in proof, the prediction dates from the beginnings of the subject.

The unfortunate thing about these fundamental errors is that they tend to shake the reader's confidence in the author's treatment of the foundations of his subject, and the foundations comprise one of the very few aspects that are likely to have any lasting value because the field is undergoing continuous and rapid change. The rapidity of change is illustrated by the need to incorporate in proof, as noted above, mention of the important experiments on charge asymmetry in semileptonic decay of the $K_L{}^0$. Even more significant is the unfortunate timing of the book in regard to measurements of the rate $K_L \rightarrow 2\pi^0$. The experimental conclusions concerning this rate that are quoted in the book have since been called into serious question as the result of additional, presumably more accurate, experiments. At present the discrepancies are not resolved and a reliable rate is not known, yet very strong conclusions are drawn throughout this book on the basis of the early experimental results. Therefore some firmly stated conclusions may be wrong, or they may be based on the wrong reasons. An example would be the author's use of the $K_L{}^0 \rightarrow 2\pi^0$ rate to rule out certain cosmological explanations of the $K_L \rightarrow 2\pi$ phenomenon (page 27). Another example is the statement (page 58) ". . . the $\pi^+\pi^-/\pi^0\pi^0$ ratio in $K_2{}^0$ decay proves that CP noninvariance cannot be restricted to the leptonic channels only," and there are many others.

The book includes a good selection of topics relating to the subject and a reasonably broad coverage of the theoretical ideas. The detailed discussion of the experiments appears to be a paraphrasing of the original experimental papers without any critical evaluation, as one might expect since the author is a theorist. Sometimes this paraphrasing goes further into the details of the experiment than would appear to be relevant.

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Beginner's nuclear physics

NUCLEAR MATTER AND NUCLEAR REACTIONS. By Ken Kikuchi and Mitsuji Kawai. 334 pp. North-Holland, Amsterdam (Interscience, New York), 1968. $16.00

by JOHN L. GAMMEL

The blurb on the dust jacket says that this book will be useful as a textbook for senior or first-year graduate courses. Therefore, an obvious book with which it may be compared is M. A. Preston's *Physics of the Nucleus* (Addison-Wesley, Reading, Mass., 1962). Investigation reveals that these books overlap to a considerable extent. A unique feature of Kikuchi and Kawai's book is their 100-page account of high-energy reactions, treating cascade processes in nuclei (rather like direct reactions except that many occur one

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