

HIGH-ENERGY NUCLEAR PHYSICS CONFERENCE

Kiev, July 15–25, 1959

A Report by J. C. Polkinghorne

RUSSIA is no longer a *terra incognita* from which an occasional traveler returns with strange tales of prodigious toasts in vodka and the palatial magnificence of the Moscow Metro. It is several years too late for the author of this article to be able to indulge in discoursing widely on East and West and he must confine himself to the business in hand. It suffices, therefore, to say that Kiev is a finely laid out city that has made a remarkable recovery from the devastation of war, and to express gratitude to our hosts, the Academy of Sciences of the USSR, for all that they did to make our stay pleasurable and profitable. One thing however they could not provide: a host of new discoveries in the preceding year. In consequence it was rather a bread-and-butter conference, with caviar only in the most literal sense.

The discovery of recent years that has born the greatest fruit is, perhaps, the existence of the complex plane. Many functions of physical interest seem to be the boundary values of analytic functions of complex variables. The early work in this field was connected with dispersion relations which are concerned with analyticity in a single energy variable. Somewhat over a year ago Mandelstam conjectured a double spectral representation for scattering amplitudes which would imply that they were analytic functions (with certain cuts) of both energy and momentum transfer. A hot debate has ensued about the validity of this conjecture. The problem is so difficult that it has had the effect of resurrecting perturbation theory from the waste paper basket. People have studied the analytic behavior of Feynman graphs with the hope that if a property can be shown to be possessed by all graphs of any order then it may be taken to be a true property of the theory. Karplus, Sommerfield, and Wickman have been able to show that if certain inequalities hold among the masses of the participating particles then the singularities of perturbation theory are more complicated than would be expected on simple physical grounds. In this case the Mandelstam representation certainly fails. Whether it holds when these inequalities do not remains an open question. An intensive study of fourth-order diagrams shows that certain unwanted singularities which might have been expected to appear do not in fact do so. This is variously interpreted as a coincidence too remarkable to be repeated in higher order or as the sign of a fundamental property of the formalism.

These matters were dealt with mainly at informal meetings outside the plenary sessions of the conference at which the personality and ideas of Professor Landau made an especial mark.

Whether Mandelstam's conjecture is true or false it has already born much fruit in a new branch of mathe-

matical physics which goes, in some quarters, under the somewhat distasteful title of "polology". The singularities of scattering amplitudes nearest the origin are usually poles at which the magnitude of the residue is closely connected with the coupling constants and its sign is often related to some relative parity. If, therefore, these residues can be determined, information can be extracted which was beyond the wildest dreams of theorists a few years ago. Unfortunately the price to be paid is some method of extrapolation from measured physical values of the scattering amplitude to the unphysical regions where poles occur. Analytical continuation by computer is, to say the least, a hazardous process, particularly when data contain large errors. However this is a technique which promises much in the future. Its justification does not require the complete validity of Mandelstam's representation but only the much weaker requirement of knowledge of singularities near the origin. Its advantage over conventional dispersion relations is that the use of a momentum transfer rather than an energy variable permits the method to be based on just the measurement of angular distributions at a single fixed energy.

The more austere program for the study of analyticity properties which does not condescend to the particularities of perturbation theory but uses only general properties and mathematical rigor has not made much progress in the past year. The nonlinear character of the unitarity condition is a notable stumbling block.

AFTER Yang and Lee's successful prediction that parity might not be conserved in weak interactions there was a tendency for physicists to hold nothing sacred. However the experiments of the past year have shown that nature is still fairly conservative. Extensive experiments in the region up to 800 Mev have revealed no case of failure of charge independence in pion physics. One of the simplest of these investigations was the experiment at Dubna which found that the cross section at 400 Mev for the forbidden reaction, $d + d \rightarrow \text{He}^4 + \pi^0$, was less than 10^{-31} cm^2 . The strange particle interactions also seem to agree with the predictions of charge independence and a rumor that they did not conserve parity proved to be due to a statistical fluctuation which has now disappeared with increased data. Only those theorists who were forearmed with ingenious explanations of these phenomena will regret their nonoccurrence.

A lot of work in pion physics has been concerned with confirming the existence of two $I = \frac{1}{2}$ resonances

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in pion-nucleon scattering at 600 Mev and 1000 Mev and investigating the detailed nature of the corresponding resonances in photopion production. Measurement of the polarization of the recoil proton in π^0 production seems to show that the first is associated with an electric dipole excitation. A great deal more data on pion production by pions and by nucleons has been obtained and awaits a more refined successor to the various crude and contradictory phenomenological models which have been used up till now. In this connection use has been made of the pion-pion interaction to knock pions out of the cloud. This interaction is a popular subject in several contexts: the theorists would like to use it to produce a resonance useful in explaining nucleon structure, and Chew and Mandelstam have used it as the simplest, because most symmetrical, model for attempting to exploit double spectral representations.

A most useful tool has been placed in the hands of physicists by Day, Snow, and Sucher who have been able to show that K^- absorption at rest essentially always takes place from S -states. This is because the Stark effect of the unscreened proton field mixes angular momentum states and then absorption takes place from the state with the greatest overlap, that is the S -state. However it is most probably an S -state with $n > 3$! This information can then be used to argue, for example, that the isotropy of the decay products of the Σ^+ produced shows that their spin is $\frac{1}{2}$. (A curious side issue is that π^- absorption in deuterium still shows the π^- to be pseudoscalar but for a revised reason!) Stop press news from Berkeley on strange particles was that the interference between the K^-p interaction and the Coulomb interaction appears constructive so that the former is attractive. In a theoretical report that was lamentably curtailed by shortage of time Salam presented an analysis of K^- absorption data which seemed to indicate that global symmetry does not hold.

Weak interactions are a continual source of interest. During the past year the discussion of why the π^-e decay did not occur was curtailed by the discovery that it did at the rate predicted by a universal Fermi interaction. However the hyperon leptonic decays remain a factor of 10 weaker than a universal theory would lead one to expect. Remeasurement of the difficult branching ratio for $\theta_1^0 \rightarrow \pi^0 + \pi^0$ has brought it into accord with the $\Delta I = \frac{1}{2}$ rule, which therefore seems to hold good. This is a challenge to theorists who have been unable to provide an explanation of this rule.

Various aspects of μ decay have been carefully investigated. The Michel parameter has continued its upward rise and its latest determination by Plano (0.80 ± 0.02) has actually overshoot the mark of $\frac{3}{4}$ set by the theorists. No doubt a satisfactory equilibrium position will be achieved. A remeasurement of the μ lifetime has increased the accord between the μ -decay coupling constant and the Fermi constant in β decay but no definite results were reported on the existence of "weak magnetism" which the conserved current explanation of this phenomenon would require. Several rare decay modes of the μ have been seen but two are missing. One is

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$\mu \rightarrow e + \gamma$ which has a frequency of less than 2×10^{-6} . If the Fermi interaction were mediated by an intermediate boson and if the neutrino associated with the μ meson were the same as that associated with the electron this mode might be expected to have a frequency of $\sim 10^{-3}$. Another unseen mode is $\mu \rightarrow e + e + \bar{e} + \nu + \bar{\nu}$ although five examples of $\mu \rightarrow e + e + \bar{e} + \nu + \bar{\nu}$ have been seen.

More information on μ capture would be welcome. An elegant experiment reported by Telegdi has provided the first indication that the interaction may be $V-A$.

During the year the existence of the Ξ^0 was confirmed at Berkeley and a new particle may have made its appearance at Dubna. This is in an event which can be interpreted as the cascade decay of a doubly strange meson of some 1500 electron masses.

ATENDING a session on new theoretical ideas is rather like watching a conjurer—one never knows what is going to come out of the hat next. One very interesting new theoretical idea did emerge. Van Hove has a Lee-type model which produces from bare interactions of unit strength an effective interaction which in the limit of large but finite cut-off produces a strong interaction with symmetry properties together with a weak interaction which is asymmetrical. The moral in terms of elementary particle physics is obvious. If this is the pattern of the true theory our task is even harder than we had supposed.

The conference was conducted in two languages, English and Russian. Thus it posed for its organizers new problems which will necessarily be a feature of all future representative conferences until we all become linguists as well as physicists. The talks of the rapporteurs were simultaneously translated and the discussions were consecutively translated. Simultaneous translation is a difficult art at the best of times and when it is concerned with talks using a highly specialized vocabulary it is not surprising that it does not always achieve perfection. Consequently all the delegates were especially grateful for the labors of the rapporteurs and conference secretariat who produced duplicated texts of most of the talks before they were delivered.

The discussions suffered more from the language difficulty as the need to pause for translation precluded the possibility of cut-and-thrust exchanges. Also many speakers from the floor read prepared statements about their work, an abuse which the reluctance of some chairmen to exert their authority did little to curtail.

These difficulties were more than made up for by the convenience of having all delegates housed in the same hotel. It is a commonplace that the most important part of conferences is the opportunity for informal discussion and many stimulating encounters took place over a leisurely meal in the restaurant. It was a pleasant and profitable occasion and all delegates will look forward to 1962 when the High-Energy Conference should again be held in the USSR.