HIGH-ENERGY PHYSICS
the 1964 conference at Dubna

By N. P. Samios

The twelfth International Conference on High-Energy Physics was held at Dubna in the USSR from August 5 through August 12, 1964. This chosen site is approximately seventy miles north of Moscow on the banks of the Volga River. The city of Dubna (with a population of ten to twenty thousand, depending upon whom you talk to) is the home of the 10-BeV Synchrophasitron, a 700-MeV synchrocyclotron, and a low-energy, 3-meter, heavy-ion cyclotron. During the weekend of the conference, there was a conducted tour of the laboratory in which the above machines as well as experimental apparatus were viewed. For the less technically inclined, trips to Moscow were available via bus or train (approximately three hours each way). Among the many sites to be seen were the Kremlin, the GUM Department Store, the Pushkin Art Gallery, Moscow University, and the famous Moscow subway system. However, the most enjoyable pastime was to roam the streets of Moscow, camera in hand, seeing the people and thereby gaining a feeling for the daily life in the city. Over-all, one is impressed by the enormous number of apartment buildings under construction, the efficiency and ornateness of the subways, and the drive and energy of the people. The weather during the conference was cool. Furthermore, its proximity to the Volga, which allowed for a morning or afternoon swim, indeed recommends this area for a conference during the month of August. Most of the participants (numbering in the hundreds, with the Chinese being conspicuously absent) were housed in the Hotel Dubna, which also contained the dining facilities. One must say that our hosts, under the chairmanship of Professor D. I. Blokhintsev, extended themselves in providing for our comfort, our hunger pangs (it took less than one hour per meal), and our entertainment, which involved a memorable boat trip to Kalinin as well as a variety concert of Moscow artists.

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The organization of the conference was such that three days were allotted for contributed papers grouped under two parallel sessions, one experimental, the other theoretical, and three days for plenary sessions involving rapporteur talks, each of 45-minutes duration. The parallel sessions were held in the Dubna Palace of Culture and the Conference Hall of the Laboratory of Theoretical Physics, with the plenary sessions taking place in the former. The official languages of the conference were English and Russian with simultaneous translations available during all sessions. This arrangement, although attempted with great vigor, like Intourist, left something to be desired. This was due to the difficulty of following the English translation (which varied in quality), while simultaneously hearing the Russian text from the speaker's podium in the background. The inherent time lags in the matter of slide display and explanation only added to the confusion.

It is, of course, not possible to summarize in these few pages the papers presented at the conference (it took the rapporteurs three days to do so). However, I will attempt to describe what I consider to be the more interesting of the reports presented. The highlights of the meeting were three: (1) the 2π decay of the K_2^0 observed by the Princeton group; (2) the observation of a real part to the forward scattering amplitude in high-energy p-p elastic scattering at Brookhaven National Laboratory; and (3) the nonobservance of the intermediate boson, by the CERN group.

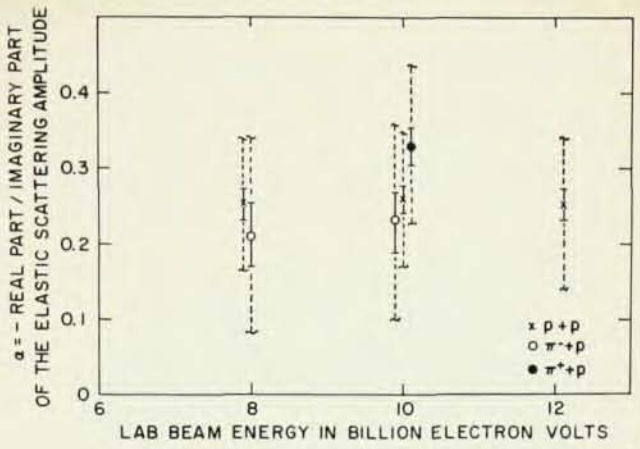
The elegant experiment described by Fitch and Cronin had been reported earlier in *Physical Review Letters*. In summary, two magnetic spectrometers looked at a neutral beam of momentum $\sim$ 1100 MeV/c situated at a distance of 300 K_1^0 decay lengths from the target. The angular and mass resolution of the apparatus was calibrated by the measurement of K_1^0 decays produced by their coherent regeneration in a tungsten target placed close to the detector. In total, 45 ± 10 events were observed which the authors attribute to the decay $K_2^0 \rightarrow \pi^+ + \pi^-$ with a branching ratio $(K_2^0 \rightarrow \pi^+ \pi^-) / (K_2^0 \rightarrow \text{All}) = (2 \pm 0.4) \times 10^{-3}$. This experiment evoked a large amount of dis-

cussion in attempting to explain this apparent violation of *CP*; in fact, the number of theoretical papers on this subject in physics journals should be gushing forth quite soon. An experiment by an Illinois group (Abashian et al.) which also looked at a neutral K_2^0 beam gave further evidence for this effect in that they observed two events in which a neutral particle of mass ≈ 500 MeV decayed into two π mesons.

In their continuing study of high-energy interactions at the Alternating Gradient Synchrotron (item 2), the Yuan-Lindenbaum group looked at elastic proton-proton and pion-proton scattering at small angles. This was done with an elaborate counter setup attached on line to a computer, and the data analysis was accomplished in a very rapid time, as evidenced by the promptness with which these new experimental results were reported. In the experiment, interference effects with the Coulomb field were observed, constructive for p-p and π^+-p and destructive for π^--p interactions. From this the authors deduced that $\alpha = 0.3$ for p-p and $\alpha = 0.1$ for π-p interactions, where $\alpha = -\mathrm{Re}\,A/\mathrm{Im}A$, A being the forward scattering amplitude. It had been expected that α would be approximately zero at high energies since most of the cross section should be absorptive.

Finally, regarding the fashionable neutrino experiments, the latest results from Europe were reported by Gaillard, Faissner, and Cundy, with Bernardini summarizing all the results in his rapporteur's talk. The main conclusion was that there was no evidence for the existence of the intermediate boson, the lower limit on its mass being 1.8 BeV, if it is only coupled to leptons. Similar conclusions were reported by M. Schwartz for the Columbia-Brookhaven work, but with poorer statistics.

In the field of strong interactions, one recent resonance was confirmed, and the quantum numbers of many of the others were determined. The Ξ^* (1820 MeV) as published by Berkeley has also been observed by the Ecole Polytechnique group as reported by B. Gregory. Since it decays into $\Lambda\overline{K}$, it must have isotopic spin $I = 1/2$, with its spin parity not known at present. The f^0 was shown to have $I = 0$ by six different groups. All of the experimental data indicated a nonisotropic decay distribution which tends to favor spin $J = 2$. However, one always worries about interference effects between the resonance and background, since they may affect this interpretation. The A_2 resonance has now been seen to decay into $\rho\pi$, $K\overline{K}$, and $\eta\pi$ final states, and its quantum numbers $I = 1$, $J^p = 2^+$ seem rather firm. This is to be



Results on elastic proton-proton and pion-proton scattering at small angles, as reported at Dubna by Yuan and Lindenbaum. Negative sign of the real amplitude means that the real potential is repulsive and its magnitude is much larger than many theorists had guessed a few years ago. Solid lines are Gaussian errors; dotted-line errors are maximum-limit values of the systematic errors.

contrasted with the A_1 which is probably $I = 1$ but with J^p either 1^+ or 2^-. The x^0 ($\pi\pi\eta$ resonance at 960 MeV) has been observed to decay into $\pi\pi\gamma$ and it seems to be another pseudoscalar singlet like the η. The κ meson (725 MeV) has again raised its head, this time observed in K^+p interactions at 3 BeV/c. However, there are some difficulties in that it is not observed when the number of particles produced in the final state is three or four, but is seen as a ($K\pi$) resonance in the five-body channel. One must look further into this question. The spin parity of the Y_1^* (1660) has been re-established by Willis et al. to be $3/2^-$. It can therefore still be grouped with other well-known 3/2– resonances to form octets, but no one has come up with eight bona fide members; the best done so far has been six to seven. Two examples of unambiguous Ω^- production (as well as six ambiguous cases) from an exposure of 5-BeV/c K^- mesons in the 80″ Hydrogen Bubble Chamber, were presented by the BNL Bubble Chamber Group. The mass of the Ω^- was measured to be 1675 ± 3 MeV with a production cross section of 2 microbarns. For a listing of the numerous possible new resonances, one will have to refer to the proceedings when they appear or gather the information from private communications with conference participants. As far as the venerable field of nucleon-nucleon interactions, the experimental data was fitted quite well by the solutions proposed by G. Breit and his group at Yale. (In Dubna, Professor Breit delighted the conference with his own translation of his remarks into Russian.)

With regard to weak interactions, a major portion of the reports was concerned with re-proving rules which were supposedly violated by experiments reported at the 1962 High-Energy Conference at CERN. In this category is the $\Delta I = \frac{1}{2}$ rule for leptonic and nonleptonic decays, in which the isotopic spin of the strongly interacting particle changes by one half unit from the initial to the final state. Here, the agreement between experiment and prediction is now excellent. Among the more pertinent numbers presented under this general category of weak interactions were: the difference in vector coupling constant g_v as determined from μ decay and the β decay of ^{14}O is: $\Delta g_v/g_v = (2.24 \pm 0.17)\%$, this discrepancy still not explained; the K_2^0 lifetime $T = (5.00 \pm 0.45) \times 10^{-8}$ sec; the famous ξ parameter (which is proportional to the ratio of coupling constants in $K_{\mu 3}$ and K_{e3} decay) which previously had dual values of either -9 or 1 has been narrowed down to be $\xi = 0 \pm 1$. The question of whether $\Delta S = -\Delta Q$ currents (i.e., currents in which the strangeness and charge of the strongly interacting particles change in opposite fashion) was reinvestigated. The results were expressed in terms of the parameter $X = [A\ (\Delta S = -\Delta Q)\,]/[A\ (\Delta S = +\Delta Q)\,]$ where A is the amplitude for the indicated currents. A value for X of 0.06 with errors of $+0.11$ and -0.14 was reported by Lagarrique (assuming CP invariance), indicating that if these currents are present their magnitude is quite small.

The theoretical contributions were of a nonastonishing nature. The remarkable successes of $SU(3)$ were reconfirmed with its successful prediction of the mass splittings. The activity now seems to be in the extension of the strong-interaction symmetries to higher groups, such as $SU(4)$, etc., as well as the hypothesizing of more fundamental groups such as triplets. The Cabibbo theory for weak interactions was shown to work very well with the limited experimental data available, but more information is desirable, especially on Ξ^- and Σ^- decays.

In conclusion, it was an interesting meeting, both from a physics and a social point of view, the physics interest being generated mainly by the experimental suggestion of a further violation of one of our cherished symmetry principles, namely CP. However, it was not as exciting as previous meetings. This was a result of the rapid publication of significant results in physics journals prior to the conference, coupled with the difficulty of maintaining the peak achieved in the previous months with the discovery of the Ω^- and the success of the eightfold way.