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This conference took place in Paris from 26 to 31 July 1982 and brought together more than 1000 participants from various countries of the world. Over 2000 papers were presented at the conference, of which approximately 150 were given in parallel sessions, the material of the others being included in 17 rapporteur's talks. The conference summarized the development of elementary-particle physics during the past two years. What were these results?

The main efforts were directed at tests of the standard picture of the quark–lepton interaction and at attempts to find some deviations from this picture. (We recall that this picture is based on the $U(1)\times SU(2)_L$ gauge theory of the electroweak interaction of quarks and leptons, which is realized by emission and absorption of the three heavy intermediate bosons Z^0, $W^{\pm}$ and the photon, and on the $SU(3)_c$ gauge theory of the color (strong) interaction, so-called quantum chromodynamics (QCD), realized by exchange of an octet of colored gluons.)

The problems of testing the standard theory of the electroweak interaction were the subject of rapporteur talks by G. Kalmus, L. Maiani, and M. Davier and, in part, a talk by F. Halzen. We can say at once that no deviations from the standard theory have been discovered.

Careful studies have been made of the properties of the recently discovered τ lepton—its lifetime, its interaction with other leptons, and so forth. In particular, the currently measured lifetime (the weighted average of four groups using the accelerator PETRA) is $\tau_\tau=(3.4\pm0.7)\times10^{-13}$ sec, in agreement with the theoretical value $(2.8\pm0.25)\times10^{-13}$ sec. The partial widths of the various decay channels ($\tau\to\nu_\tau e\bar{\nu}_e$, $\nu_\tau\mu\bar{\nu}_\mu$, $\nu_\tau\pi$, $\nu_\tau K$, $\nu_\tau K^*$, $\nu_\tau\rho$, $\nu_\tau A_1$) are also in good agreement with the theory, and this indicates universality of the properties of the e, μ, and τ leptons. At the same time, searches for neutrinoless decays ($\tau\to e\gamma$, eee, $e\mu\mu$, $\mu\mu\mu$, $e\rho$, $\mu\rho$, ek, μk, $e\pi$, $\mu\pi$) have given negative results and indicate that the τ lepton and the ν_τ neutrino are characterized by a new lepton quantum number.

In addition, no significant deviations from the standard theory have been observed in measurements of the angular asymmetry A due to the parity-violating neutral currents in annihilation of e^+e^- into leptons (Fig. 1) and into quarks ($A_c=35\pm14\%$ and $A_b=17\pm10\%$ instead of the theoretical values 14 and 8.4%, respectively). The latter favors universality of the electroweak interaction of leptons and quarks. In connection with the measurement of the asymmetry, it should be emphasized that this is apparently the first evidence for a finite Z^0-boson mass, $M_Z=70^{+20}_{-10}$ GeV/c^2, an effect which theoreticians have long awaited with impatience, hope, and perhaps a certain amount of apprehension.[1)]

New confirmation has been obtained for the effect of neutral currents in atomic transitions, first discovered by Barkov and Zolotarev. The circular polarization of light from transitions between levels of opposite parity, measured by the group of M. A. Bouchiat using cesium atoms, in is good agreement with theoretical calculations (which are much simpler than for the more complex atoms of bismuth; $(1/\beta)\,\mathrm{Im}\,E_{PV}=1.34\pm0.22\pm0.11$ mV/cm instead of the theoretical value 1.73 ± 0.9 mV/cm).

A very delicate measurement of the asymmetry of polarized muons in deep inelastic scattering was made by the collaboration NA-4 with the participation of physicists from Dubna. The value of the Weinberg angle obtained in this experiment is regarded as one of the most reliable. The best value for this parameter is $\sin^2\theta_W=0.23\pm0.01$.

The situation concerning the lifetimes of the heavy baryons $D^{\pm}$, D^0, Λ_c, and $F^{\pm}$ seems much better at the present time. For example, the ratio $\tau(D^{\pm})/\tau(D^0)$ has been reduced to 2.2 ± 1.0 instead of the previous value

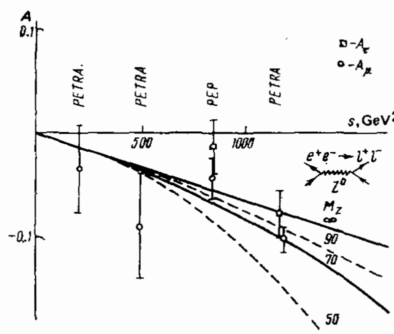

FIG. 1.

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1) A recently published paper by the UA1 collaboration presented six events of production of the W boson with mass 81 ± 5 GeV/c^2 on the basis of its decay into $e\nu$ (see CERN Preprint EP 83-13 (1983)).

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5 (an international collaboration at CERN with the participation of experimentalists from the Institute of High Energy Physics at Serpukhov) and is in much better agreement with the theory, although in general the situation requires richer statistics.

One of the most interesting problems relates to the t quark, whose existence is required by quark-lepton symmetry. It does not manifest itself up to masses of order 17 GeV/c^2. Theoretical estimates based mainly on the mass difference between the K_L and K_S mesons give for it a mass in the range 25–125 GeV/c^2, depending on the details of the models. In any case, however, theoreticians have devised possible variants of "topless" models (without the t quark), although there is as yet no adequate scheme. In this respect, great interest attaches to the measurement of the lifetime of the B meson containing the b quark, which makes it possible to distinguish between variants with the t quark ($\tau_B > 3\times10^{-14}$ sec) and without it ($\tau_B \sim 10^{-15}$ sec). So far, the existing experimental data give only the upper limit $\tau_B < 1.4\times10^{-12}$ sec.

The fields which are so necessary for spontaneous symmetry breaking in the Weinberg-Salam scheme of Higgs bosons have also not been detected. They are seen in neither e^+e^- annihilation (for $M_H < 14$ GeV/c^2) nor decays of the Υ meson (the groups JADE, CLEO, TASSO, MARK-II, and MARK-J). The only evidence for Higgs bosons can be considered to be the fact that there are fewer ν_e than ν_μ in the energy range up to 40 GeV in the beam-dump experiment, since decay of a virtual H^+ boson can lead to production of a larger number of μ and ν_μ pairs (paper by F. Halzen).

A special plenary session was devoted to discussion of results obtained using the $p\bar{p}$ collider at CERN, which has provided the present record energy of 540 GeV in the center-of-mass system (equivalent to the cosmic energy of 154 000 GeV in the laboratory system!). Interesting results on soft processes in this energy region have been obtained. They show that our ideas about the picture of multiple production of hadrons, based on the Regge-eikonal picture and on duality, are on the whole correct.

The total cross section continues to rise as $\log^2 E$ and is equal to 66 ± 7 mb at this energy. (Preliminary data from the installation "Fly eye" give for cosmic-ray protons with $E = 10^{18}$–10^{21} eV the cross section ≈ 120 mb, which lies on the continuation of the quadratically logarithmic growth.) The slope of the diffraction peak, $b = 13.3\pm1.5$ GeV^{-2}, is consistent with a logarithmic growth of this parameter. The behavior of the ratios σ^{el}/σ^{tot} and b/σ^{tot} agrees with so-called geometrical scaling.

The average number of charged particles also continues to rise as $\log^2 E$ and has the value $\langle n_{ch}\rangle = 29\pm0.5$. This growth occurs because of the growth of the interval of rapidities of the secondary particles and because of the logarithmic growth of the height of the inclusive distribution $d\sigma/dy$. The distribution of secondary particles exhibits the well-known short-range correlations, $|\Delta y| \approx 2$, but the importance of long-range correlations increases appreciably. The behavior of the topological cross sections is in good agreement with KNO scaling. The mean transverse momentum of the pions is $\langle p_T\rangle_\pi = 0.38$ GeV/c, but this same characteristic for the kaons is practically twice as large: $\langle p_T\rangle_K = 0.65$ GeV/c. This difference had already been indicated many years ago by cosmic-ray data, but as yet it has no theoretical explanation. Cosmic-ray data have also indicated events involving production of only charged particles and photons in this energy region (Centauro events), but searches for such events using the collider have not given a positive result.

A considerable number of parallel and plenary sessions were devoted to *hard processes*—the natural region of application and verification of QCD. These included experimental papers by G. Wolf, F. Eisele, and D. L. Burke and theoretical papers by D. Politzer, C. Rebbi, and E. Brézin.

One of the important elements of QCD was the prediction that there is an appreciable fraction (about 10%) of three-jet events in the annihilation process $l^+l^- \to$ hadrons. Such events are now being definitely observed using the accelerator PETRA (the groups TASSO, MARK-J, PLUTO, and JADE). However, the estimate of the value of the chromodynamical coupling constant α_s on the basis of the cross section for these events depends on the model for fragmentation of the produced quarks and gluon into hadrons. Thus, for independent fragmentation of each of them this constant has the value $\alpha_s \approx 0.165\pm0.015$ ($\Lambda_{MS} \approx 130$ MeV), while in the model of string fragmentation $\alpha_s \approx 0.2$. The angular distribution of the jets makes it possible to determine the spin of the gluon and definitely favors spin 1.

Study of the hadronic content of jets shows that as the momentum fraction increases the proportion of light particles ($\pi^\pm$) falls off from 90 to 40%, whereas the proportion of heavy particles (K, p, $\bar{p}$) increases to 60%. The fragmentation of jets originating from heavy quarks (c and b) is found to be much harder. Gluon jets have been identified with sufficient reliability. They have proved to be somewhat broader than quark jets, $\langle p_T\rangle_g = \langle p_T\rangle_q + 30$ MeV/c, and contain many more baryons (for example, 2–3 times as many Λ and $\bar{\Lambda}$ particles), in qualitative agreement with the theoretical expectations. Interesting data have been obtained on the fragmentation of diquarks (uu) and (ud) in deep inelastic scattering of neutrinos and antineutrinos on hydrogen (the group ABCM). With regard to the average number of charged particles, this fragmentation does not resemble the fragmentation of a quark nor a pair of quarks.

In deep inelastic scattering of neutrinos and antineutrinos on deuterium (the chamber BEBS) it is possible that the first observation has been made of scaling violation in the fragmentation functions $D_q^{\pi^\pm}(z, Q^2)$ in the region of Q^2 up to 32 GeV/c^2, in agreement with QCD for $\Lambda_{MS} = 200$ MeV.

Numerous new data were presented on the structure functions of hadrons in deep inelastic scattering of muons and neutrinos. Here all the experiments with high statistics give structure functions which are mutually compatible in form. The discrepancies in absolute value are about 10%. All the groups see violations of scaling. Particular emphasis should be given to the observation of a growth of the structure functions in the region of small $x<0.2$ (the groups CDHS and CCFRR), in agreement with QCD for $\Lambda \approx 300$ MeV.

New data were obtained for the ratio $R=\sigma_L/\sigma_T$ at $Q^2 \approx 38$ GeV/c (the group CDHS). Whereas in the SLAC energy region ($Q^2<20$ GeV/c) this ratio was large (≈ 0.2) and in sharp conflict with QCD, new data in the region $x>0.4$ show that it is comparable with zero ($R=0.006 \pm 0.012 \pm 0.025$) and consistent with QCD. For a more careful test, it is necessary to measure R in the region of small x, where it should rise sharply.

The currently available rich material makes it possible to determine the form of the distributions of the quarks of all flavors in the proton, as well as that of the gluons. In particular, these measurements show that the ratio d/u falls off as $x \to 1$, and the distributions of sea quarks is far from symmetric. For example, there are half as many strange quarks as $\bar{u}$ and $\bar{d}$ quarks, and the fraction of the momentum carried by the c quarks is half as small again. The value of the parameter $\Lambda_{\overline{MS}}$ in experiments on deep inelastic scattering varies within the range 100–300 MeV. The most reliable value $\Lambda = 250^{+150}_{-100}$ is given by the structure function $F^{NS}(x, Q^2)$. In all probability, the discrepancy between the value of Λ and the SLAC data obtained at lower values of Q^2 can be explained by the influence of the preasymptotic corrections $O(1/Q^2)$ (the contributions of higher-twist operators).

Two remarks concerning deep inelastic scattering by nuclei. First, one can frequently encounter the lack of understanding that a nucleus is entitled to its own structure function, whose evolution with increasing Q^2 is determined by the same equations as for a hadron. In this respect, the nucleus is no worse (and in certain respects, even better) than any hadron. However, it must be remembered that the structure function is determined in a much broader interval of the Bjorken variable $x>1$, as is indicated by the results of the experiment NA-4, which revealed a rather large value of the structure function up to $x \approx 1.3$. Secondly, the structure function of a nucleus may even not be related in a simple manner to the structure function of a nucleon. At any rate, the results of the muon experiment of the group EMC show that the ratio $F_2^{Fe}/F_2^{D_1}$ as a function of x in the region up to $x \approx 0.7$ falls off roughly linearly, by nearly 30%, which is difficult to understand with in the framework of the existing ideas about the nucleus. If this is not an error, then it is a very interesting discovery.

New, more accurate experimental data on the structure function of the photon were presented (the groups JADE and TASSO). These data are interesting in that here QCD predicts not only the behavior of the structure function with respect to Q^2, but also the dependence on x at fixed Q. The best agreement with QCD is achieved with $\Lambda_{\overline{MS}} \approx 200$ MeV.

A more complex hard process is the production of massive lepton pairs $\mu^+\mu^-$ in hadron-hadron collisions. It is well established that this process proceeds through the annihilation $q+\bar{q} \to \mu^+\mu^-$; the structures in the cross sections are due to production of J/ψ and Υ resonances. This permits an independent determination of the distributions of antiquarks in nucleons, which agrees with the distributions obtained from deep inelastic scattering with accuracy up to factor $K \approx 2.2$, as well as a determination of the distribution functions for unstable particles (pions and kaons). For example, the distributions of valence and sea quarks in the pion have the form $xu_V^{\pi}(x) \sim x^{0.38\pm0.04}(1-x)^{0.94\pm0.06}$ and $xu_S^{\pi}(x) \sim (1-x)^{5-8}$, respectively (the group NA-3). However, the distribution of gluons obtained using the fusion model for production of J/ψ resonances has the form $xG^{\pi}(x, m_\psi) \sim (1-x)^{1.9\pm0.3}$ (the group SISI) and, just as for the proton, they carry about 50% of the total momentum(the group NA-3).

A few words about the K factor, which characterizes the discrepancy between the parton model and experiment. There are strong grounds for supposing that its origin in QCD is the exponentiation of the principal part of the rather large radiative correction to the annihilation subprocess.

New data obtained by the group ABC on production of direct photons in pp collisions at $\sqrt{s}=63$ GeV up to transverse momenta $p_T=11$ GeV/c were presented at the conference. With allowance for the K factor ($K \approx 1.7$), these data are also in good agreement with QCD. However, it should be noted that the accuracy which had been achieved here evidently does not permit a positive observation of the logarithmic decrease of $\alpha_s^2(p_T)$, to which the cross section for the parton subprocess $q\bar{q} \to \gamma g$ and $qg \to q\gamma$ is proportional. Since this process is one of the most interesting ones, its study is currently occupying three other experimental groups at CERN (AABC, CCOR, and RBCN).

We turn now to production of hadrons with large transverse momentum. To begin with, we must note here the observation of another inherent element of QCD as a gauge theory—a direct gluon-gluon interaction, which manifests itself in two facts:

1) An unusually large growth (by three orders of magnitude) of the inclusive cross section for production of pions with $p_T \approx 10$ GeV/c in going from ISR energies ($\sqrt{s} \approx 60$ GeV) to the energies of the $p\bar{p}$ collider ($\sqrt{s}=540$ GeV), observed by the groups UA-1 and UA-5 (Fig. 2).

Qualitatively, this can be explained by the rapid growth of the number of gluons in hadrons with decrease of the ratio $x_T = 2p_T/\sqrt{s}$ ($\varepsilon d\sigma/dp \sim p_T^{-n}(1-x_T)^m$, where for the gluon-gluon subprocess $m=15$–18, whereas for the quark-quark subprocess $m=9$–10).

2) A growth of the ratio K^-/π^- as p_T decreases from 8 to 4 GeV/c (the group CDHW at the ISR); for the quark-quark and quark-gluon subprocesses, this ratio is roughly constant. Additional confirmation of the vector character of the gluon is provided by the correlation between the trigger particle with large p_T and the particles emitted in the opposite direction.

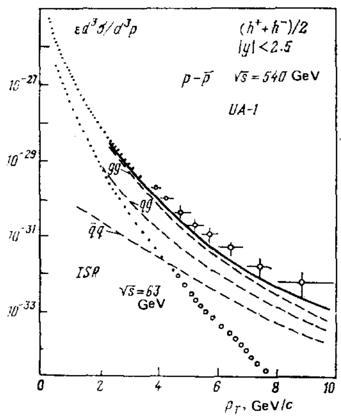

FIG. 2.

Finally, a few words about hard two-phonon processes. There are reasons for believing that it is these processes that are most sensitive to the violation of color symmetry and to the true charges of the quarks: first, because after spontaneous symmetry breaking for a virtual photon with $Q^2 \gg m_g^2$ (the gluon mass in the theory with symmetry breaking, which cannot exceed $\Lambda_{QCD} \approx 200$ MeV) the color symmetry is restored, and it therefore feels only the color-averaged (i.e., fractional) quark charge; secondly, because the observed hadrons are color singlets and a single-photon transition between two singlet states can take place only through the color-singlet part of the electromagnetic current, which is also sensitive only to the average charges.

Of the two-photon processes, the one which has been best measured is the process of $\gamma\gamma$ transition into two jets with large p_T, which has been observed using the colliding beams of PETRA (the groups TASSO, PLUTO, and JADE); however, the accuracy so far achieved does not make it possible to distinguish between the variants of QCD with broken and with exact color symmetry (Fig. 3), although the statistics that have now been accumulated offer hope of an increase in the accuracy by several times and a definitive solution of this problem in the near future.

Summarizing this section, we can say that at the present time our faith in QCD as the theory of the strong interaction of quarks and gluons is the result of many semiquantitative correspondences for a wide range of diverse phenomena and many predictions which have proved to be correct. Leaving aside esthetic arguments, from the specific features of QCD we have: a) definite confirmation of the vector character of the gluon (the angular distributions of jets in three-jet events of e^+e^- annihilation and decays of quarkonia, correlations in processes with large p_T, the anomalous dimensions in deep inelastic scattering, and the spectroscopy of quarkonia); b) definite confirmation of a direct gluon-gluon interaction (the rapid growth of the cross section for production of hadrons with large p_T, and the behavior of the ratio of the yields K^-/π^-); but we scarcely have: c) confirmation of asymptotic freedom, $\alpha_s \sim \ln^{-1}(Q^2/\Lambda^2)$ (the violation of scaling in deep inelastic scattering may be a consequence of only the nonzero anomalous dimensions of the structure functions); and we are completely lacking: d) manifestations of the zero mass of the gluon.

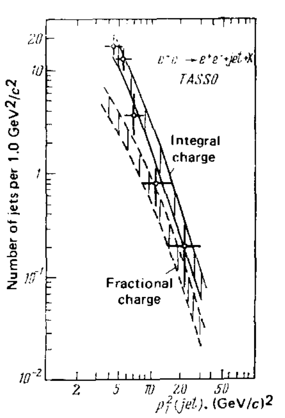

FIG. 3.

The apparatus of QCD has continued to develop during the past two years. Particularly vigorous progress has been seen in the development of QCD on lattices. It is based on replacement of continuous space-time by a discrete lattice and of the path integrals which represent observable physical quantities by multiple integrals, the latter being calculated by the Monte Carlo method on a computer. This is as yet the only regular approach which makes it possible to go beyond perturbation theory. The basis of this burst of activity is the overcoming in recent years of the difficulty associated with the introduction of fermion fields. The parameters calculated in this way for many elementary particles (masses, decay constants, magnetic moments) agree with the experimental values within an accuracy of order 50–100%. For example, $m_\rho = 780$ MeV, $m_\delta = 950 \pm 100$ MeV, $f_\pi = 200$ MeV (instead of 130), etc.

The development of old methods and the creation of new methods of summing "soft" gluons have continued, and many such methods are associated with the names of Soviet physicists. One of the effects of such summation is the above-mentioned appearance of the K factor in the cross sections for production of $\mu^+\mu^-$ pairs and direct photons. Another region of their application is the fragmentation of jets and attempts to enter the Regge region of high-energy processes.

Significant development has been seen in the use of the sum-rule technique based on the hypothesis of local quark-hadron duality, which asserts that the difference between a cross section involving a hadron and a cross section involving a quark-gluon system with the same quantum numbers, both averaged over some interval of masses s_0 with weight $\exp(-s/M^2)$, is determined by the vacuum condensate of the quark and gluon fields. Application of this method in the new region for the electromagnetic form factor of the pion has given a result in poor agreement with experiment for $Q^2 = 1-3$ GeV/c^2.

The application of QCD to hard processes involving hadrons is based on the assertion that the cross sections for hard processes factorize into the cross section for the parton subprocess, which takes place at small distances and can be calculated according to perturbation theory, and distribution of fragmentation functions (or wave functions), which are independent of the process and are associated with large distances. Doubts have recently been expressed about the correctness of this assertion for non-Abelian gauge theories, in connection with soft two-gluon exchanges between the initial hadrons. However, discussions have shown that these conclusions are evidently connected with some subtletly in the use of the axial gauge. In particular, they have not been confirmed by calculations performed in the Feynman gauge.

An important place at the conference was given to discussion of the problem of gluonium (papers by E. Bloom and D. L. Burke). It is difficult to identify gluonium because this resonance does not have pronounced characteristic features; moreover, it is "superfluous" from the purely quark point of view. Searches are usually made in the decay $J/\psi \to \gamma + R$. This channel exhibits clearly the resonances $\iota(1440)$, $\theta(1650)$, $g_T(2160)$, and $g'_T(2310)$, which are regarded as the most probable candidates for gluonium. However, comparison of the properties of the first of them with the properties of the π' (a radial excitation of the pion, discovered recently with the participation of physicists from the Joint Institute for Nuclear Reserach) provides reason to beleive that this resonance is a member of a nonet of radial excitations. Moreover, its mass is too small for gluonium from the point of view of the sum rules. It is also perfectly possible that the θ meson is either a radial excitation or a four-quark state $s\bar{s}(u\bar{u}+d\bar{d})$, or a pair of 4q resonances with light quarks. Light on this question might be shed by a more careful investigation of its partial decay channels, for example, the ratio $Br(\theta \to \eta\eta)/Br(\theta \to K\bar{K})$ (which should be <0.2 if θ is gluonium, ≈ 0.5 if it is a 4q resonance, and >1 if it is a radial excitation) and the production width $\Gamma_{\theta \to \gamma\gamma}$. The currently observed widths $\Gamma_{\theta \to \gamma\gamma} Br(\theta \to K\bar{K}) < 0.5$ keV abd $\Gamma_{\theta \to \gamma\gamma} Br(\theta \to \rho^0\rho^0) < 1.2$ keV (the group TASSO) seem to be inconsistent with the total width of the decay $J/\psi \to \theta + \gamma\,(\theta \to \rho_0\rho_0)$ with $\Gamma = 0.2 \pm 0.1$ GeV/c^2 (the group MARK-II).

As to the remaining candidates, the data on them are also as yet inadequate for definite conclusions, although it is possible that some light on the question will be shed by the observation in the reaction $\gamma\gamma \to 4\pi$ of a resonance with mass $M = 2.10 \pm 0.01$ GeV/c^2 and width $\Gamma = 94 \pm 21$ MeV/c^2, which has not been detected in two-prong events (the group TASSO).

A special session was devoted to exotic particles (axions, baryonia, dibaryons, and monopoles). The results of the discussions can be summarized as follows:

1. Axions are not seen over the entire range of energies: light axions (<200 keV) are excluded by astrophysical data, medium axions (150 keV to several MeV) by data from reactors (IBR-2 and SIN), and heavier axions by the beam-dump experiment.

2. The situation concerning baryonia (four-quark mesons decaying into $N\bar{N}$ + mesons) seems contradictory (paper by D. Bilanova).

At CERN such states have not been seen in the $p\bar{p}$ channel in the regions of mass 1936 ($\sigma < 14.5$ nb), 2020 ($\sigma < 30$ nb from the group WA-63 and $\sigma < 1$ nb from the group WA-56), and 2200 ($\sigma < 1.5$ mb), whereas at Brookhaven (BC-68) a narrow resonance ($\Gamma \leq 20$ MeV) has been seen at mass 2020 with a cross section of order 1 μb.

3. The situation concerning dibaryon resonances is also not completely clear (paper by C. Pigot). On the one hand, experiments provide evidence for a resonance $H_1^+(\Lambda p)$ at mass 2129 with width $\Gamma \sim 10$ MeV. On the other hand, the observed energy dependence of the peak favors the triangle diagram involving the Σ particle. However, No H_2^- resonance is seen in many investigated channels with cross section <10 nb.

4. As to monopoles, as before there exists only the candidate detected in the experiment of B. Cabrera involving a superconducting ring. Other experiments exclude monopoles with a flux 4–5 times lower than the estimate of Cabrera, but they are sensitive only to monopoles with velocities $v > 10^{-3}c$. Thus, the situation also remains unclear at the present time.

Review talks by P. Fayet, G. Georgi, and G. 't Hooft were devoted to the prospects for the development of unified theories combining the electroweak interactions with QCD. Such unifications can be constructed in various ways. It is possible to construct the basic elements of the standard theory from more fundamental constituent "preons" (the "technicolor" model). However, this almost inevitably entails light particles for example, technipions, no trace of which is seen experimentally. On the other hand, if the scale of unification is made sufficiently large, it is difficult to understand the small values of the lepton and quark masses.

A second method is to extend the symmetry to supersymmetry and supergravity. There is hope that such theories will be free of divergences. (Calculations have proved this in the three-loop approximation; there is reason to hope for a general proof.) Here, however, there is also an unavoidably large number of new particles (scalar leptons and quarks, gluinos and photinos, etc.), no traces of which have as yet been seen. Nevertheless, this theory seems so attractive that a new large group of physicists have now joined the ranks of those developing supersymmetry, and this development will take the road of further particularization of the predictions. Experiments have begun and are in preparation to test them using the operational machines. Special hopes are pinned on the new superpowerful accelerators.

An interesting prediction of many unified theories is the instability of the proton with a lifetime 10^{30}–10^{34} yr. Experimental searches for such decays are now being conducted in many countries, including the USSR, and several events which can be considered as candidates for proton decay were reported at the conference (four events from the group KGF and one event from the group NUSEX). According to these events, $\tau_p = 6 \times 10^{30}$ yr. However, a criticism was expressed at the conference, the main point of which is that the events might be simulated by a neutron from a star produced by a cosmic-ray muon in the vicinity of the detector. There was discussion of the "Rubakov effect" (Institute of Nuclear Research, USSR)—a new proposal to test unified models, related to the catalytic effect of Polyakov–'t Hooft monopoles (an indispensable element of such models) on the decay of the proton. Possessing a large interaction cross section ($\approx 10^{-26}$ cm^2), a monopole, during its passage through matter, should give rise to a whole series of decays after every 10–100 cm of its path. An advantage of the new method is that it is independent of many details of the unified theories, including the scale of unification. However, the problem of the search for such monopoles remains open.

Thus, the edifice of grand unification which is being constructed is now seen as surrounded by scaffolding and various kinds of supports in the form of Higgs and other "superfluous" particles and does not look too attractive at present. However, at the moment it is even difficult to distinguish between what is a support and what will become part of the final composition of the future masterpiece. One cannot help recalling the Paris Cathedral of Notre Dame, which was also built and rebuilt during the course of many centuries by various builders in various styles, but is now perceived as an indivisible, completed architectural structure.

A special session was devoted to the prospects for creation of new accelerators. Without dwelling in detail on specific projects, which can be found in a review by A. N. Skrinskiĭ (Usp. Fiz. Nauk 138, 3 (1982) [Sov. Phys. Usp. 25, 639 (1982)]), we merely note that the opinion was expressed at the session (L. Lederman) that in new accelerators for energies above 20 TeV it will be uneconomical to use superconducting magnets with a large magnetic field (free of iron) and that iron magnets with a superconducting winding will be more advantageous.

Translated by N. M. Queen