ters of galaxies like the Coma Cluster may form the other extreme.

Other reports and comments confirm the general impression that the study of evolution of galaxies is now in an early stage of development comparable to that of the study of stellar evolution in 1935. There is an evolutionary pattern evident in the various correlations and sequences, and possibly in the variety of peculiar galaxies. More observations are needed to fill in the gaps indicated by theoretical studies, and new instruments were discussed for such purposes. Three new spectrographs have been built for the larger telescopes in the southern hemisphere (at Pretoria, South Africa, Cordoba, Argentina, and Mt. Stromlo, Australia). Leo Goldberg described far ultraviolet spectra down to x-ray wavelengths obtained by rockets fired above the earth's atmosphere. The Canadian "Alouette" satellite will carry a radio telescope above the ionosphere for measurements at frequencies down to 1 Mcy/sec, and the NASA Orbiting Astronomical Observatory program may have a 100-inch optical telescope in space by 1975.

THORNTON PAGE
Van Vleck Observatory, Wesleyan University, Middletown, Connecticut

References

1. Proceedings of the congress will be published by Academic Press in 1965 in *Transactions of the International Astronomical Union*, vol. 12.
2. "QSO's, the brightest things in the universe," *Astron. Soc. Pacific, Leaflet 421* (1964); *Proceedings of the Symposium on Gravitational Collapse*, E. L. Schucking, Ed. (Univ. of Chicago Press, Chicago, 1964).
3. "Proceedings of the Conference on Instability of Systems of Galaxies," *Astron. J.* **66**, 533 (1961).
4. E. Holmberg, *Arkiv Astron.* **3**, 387 (1964).
5. T. Page, *Astrophys. J.* **136**, 685 (1962).

High-Energy Physics

At the 12th International Conference on High-Energy Physics which was held in Dubna, Russia, 5–12 August, a most exciting report was presented by J. Cronin and V. Fitch (Princeton) giving evidence for the apparent nonconservation of CP (C, charge reflection; P, parity or spatial reflection) in K_2^0 decays. The experiment was carried out in a simple and elegant manner at the alternating-gradient syncrotron accelerator at Brookhaven National Laboratory and consisted in observing that K_2^0's (the long-lived particle mixture of K^0 and $\bar{K}^0$ mesons) decay into π^+ and π^- mesons with a charged-particle branching ratio of $2.0 \pm 0.4 \times 10^{-3}$. Earlier

experiments had established an upper limit for this decay mode, which is forbidden by CP invariance, of approximately 1/300. Since the invariance of all known interactions under the transformation TCP (T, time reversal) has not been challenged (TCP invariance predicts equal mass and lifetime for particle and antiparticle), the violation of CP invariance also implies the violation of time reversal invariance for the weak interactions. This result will surely trigger a new round of difficult experiments in the search for time reversal noninvariance in other weak decay interactions. No theoretical papers on this subject were presented, but there was much speculation during informal discussions concerning the incorporation of terms that will allow for time reversal noninvariance into existing weak-interaction theory. These ideas included weak-interaction terms of the types (i) $\Delta S = -\Delta Q$ (Sachs), (ii) $\Delta I = 3/2$ (Amati) (S being strangeness, Q being charge, and I being isotopic spin), or (iii) "currents of the second kind" (Cabibbo). Since the meeting, several theorists have offered explanations for this new result which suppose a new type of long-range interaction coupled to hypercharge (+1 and −1 for K^0 and $\bar{K}^0$, respectively), much weaker than the β-decay interaction and even weaker than gravitation. Such a new force would have little impact on other elementary particle behavior but could have cosmological significance.

Detailed talks on experimental aspects of the weak interactions were presented by A. K. Mukhin (Dubna) on nonstrange particles and by I. V. Chuvilo (Dubna) on strange particles. All data presented on other aspects of weak interactions were consistent with current theoretical ideas which include: universality of the coupling of muons and electrons, lepton conservation, conserved vector current, the strangeness-changing leptonic decays satisfying the $\Delta S + \Delta Q$ and the $\Delta I = \frac{1}{2}$ rules, and finally nonleptonic decays satisfying the $\Delta I = \frac{1}{2}$ rule. The Cabibbo theory of weak interactions that relates the neutron β-decay to the hyperon β-decays by way of the SU_3 symmetry of strong interactions is consistent with the data. A special report on neutrino physics was presented by G. Bernardini (Centre Européen de la Recherche Nucléaire). The beautiful experiment on high energy neutrino interactions conducted at CERN for the past 2 years has confirmed the existence of two neutrinos, ν_e and ν_μ, which couple to

electrons and muons, respectively. The search for a charged intermediate vector meson that decays into (μ^+, ν_μ) or (e^+, ν_e) has been unsuccessful. A lower limit for the mass of 1.8 Gev has been set for this theoretically conjectured particle that is supposed to transmit the weak interaction between pairs of spin ½ particles.

The review by N. Ramsay (Harvard) of electromagnetic interactions revealed no violation of quantum electrodynamics up to momentum transfers $\sim$ 1 Gev/c. The mysterious muon continues to behave exactly as an electron in all observed electromagnetic interactions [including μ^-, μ^+ pair production (Friedman) and $\mu^- + p \rightarrow \mu^- + p$ scattering (Tinlot)]. No theoretical ideas exist that explain the large mass ratio $(m_\mu/m_e) = 207$. Electron scattering cross section experiments on protons at the Cambridge Electron Accelerator continue to display a smooth fall off with increasing momentum transfer, $\leq$ (7 Gev/c)^2 (Wilson, Harvard).

A myriad of experimental results on strong interactions of p, n, $\pi^\pm$, $K^\pm$, $\bar{p}$, Λ and $\Sigma^\pm$ particles on protons were presented. Talks by Yu. M. Kazarinov (Dubna) and S. J. Lindenbaum (Brookhaven) on $\pi - n$ interactions (up to and above 1 Gev), S. Ya. Nikitin (Moscow) on pion resonances, R. Armenteros (CERN) on strange-particle resonances and D. Miller (Berkeley) on strange-particle physics, could hardly do justice to the material. The hope that the analytic properties of the S matrix coupled with simple Regge trajectory hypotheses could explain cross sections in the region of 10 to 30 Gev is not borne out by experiment. New experiments at CERN, Harwell, and Brookhaven confirm the existence of a substantial real part in the $p - p$ scattering amplitude at high energies (first found by a Russian group at approximately 8 Gev a few years ago). A similar real part is also found in (π,p) elastic scattering (Lindenbaum) and allows for the possibility of testing dispersion relations (based on microscopic causality) in the energy regime of 10 to 20 Gev. Several new N^* resonances at energies ranging up to 2825 Mev have been discovered (Kycia), and the properties of many other N^* resonances have been elucidated. Among the meson resonances, the existence of a ninth pseudoscalar meson, X^0, of mass 960 Mev has been well established [Samios (Brookhaven), Kalbfleisch (Berkeley), and Ticho (U.C.L.A.)]. Other new resonances include B(1215

Mev) → ω π; A_2(1310 Mev) → ρ π, $K\bar{K}$ with spin and parity 2^+, and many more controversial objects, called A_1, C, E, H, κ, etc., whose existence as well as spin, parity, and decay modes are not well established. As for hyperon resonances, the existence of Ξ^* (1810 Mev) has been confirmed, and the Y^*_1 (1660) has had its parity changed from plus to minus. It is clear that the world of elementary particles and resonant states is richer than most physicists had imagined, and much more work is needed.

The idea of M. Gell-Mann and Y. Neeman that the strong interactions obey an approximate symmetry called SU_3 has brought some order into the picture. The crowning point of the success of this theory was the prediction of the Ω^-, a hyperon with hypercharge $Y = -2$. Two examples were found a few months ago by a team at Brookhaven, and these were reviewed in a convincing fashion by Samios. The success of this theory has led to many new theoretical extensions (SU_4, $SU_3 \times SU_3$, . . .) and exciting speculations, most of which were reviewed by Salam (Imperial College). The low mass, strongly interacting particles, have been assigned to SU_3 group representations of dimension 1, 8, and 10. However, as the name suggests, this theory also allows for fundamental triplet representations. Many theorists, including Gell-Mann (California Institute of Technology), Schwinger (Harvard), Van Hove (CERN), and others not at this meeting have conjectured that these triplets are the fundamental building blocks out of which matter, as we know it in the form of nucleons and pions, is composed. These speculations have triggered a new experimental search for such triplets (either of fractional charge or integral charge). To date, this search at existing accelerators has been unsuccessful, but the idea is sufficiently attractive to last a long time. The heavier the mass, of course, the higher the energy needed to produce these objects. The answer to the crucial question concerning the order of magnitude of the mass expected varies among the "experts" from about several Gev to very heavy ($\approx$ 100 Gev). In the latter case, even the next generation of high-energy accelerators will not suffice as a source, but there remain cosmic rays.

The Russian physicists were wonderful hosts at this meeting, and their energetic efforts to get revised manuscripts promptly into the hands of the

translators (Russian and English were the official languages) suggest that the proceedings will also be published without too much delay. A 13-hour boat trip down the Volga and a 4½-hour evening entertainment were also provided. The length of these entertainments were well matched to the length of the physics sessions.

GEORGE SNOW
Department of Physics and Astronomy, University of Maryland, College Park

Forthcoming Events

November

12–14. **Paleomagnetism**, 2nd U.S.–Japan seminar, U.S.–Japan Cooperative Science Program, Univ. of California, Berkeley. (J. Verhoogen, Dept. of Geology and Geophysics, Univ. of California, Berkeley)

13–15. American Inst. of **Professional Geologists**, 1st annual, Denver, Colo. (AIPG, W. A. Newton, Public Information Committee, P.O. Box 836, Golden, Colo. 80402)

13–15. **Clinical Scientists** Assoc., annual, Washington, D.C. (ACS, F. W. Sunderman, Jr., Univ. of Florida, College of Medicine, Gainesville 32603)

14–19. American Acad. of **Ophthalmology and Otolaryngology**, Chicago, Ill. (W. L. Benedict, 15 Second St., SW, Rochester, Minn. 55901)

14–21. Pan American **Medical Women's** Alliance, 9th congr., Los Angeles, Calif. (E. M. Hohl, 1234 N. Vermont Ave., Hollywood, Calif.)

15–17. Water in the **Arid Zones** of the Old World, symp., Halle an der Saale, East Germany. (Deutsche Akademie der Naturforscher Leopoldina, August-Bebel Str. 50 a, Halle an der Saale)

15–19. American Soc. of **Agronomy**, Crop Science Soc. of America, Soil Science Soc. of America, annual, Kansas City, Mo. (L. A. Richards, Amer. Soc. of Agronomy, 677 S. Segoe, Madison, Wis.)

15–19. Society of **Exploration Geophysicists**, Los Angeles, Calif. (C. G. Ferris, E. V. McCollum & Co., 515 Thompson Bldg., Tulsa, Okla.)

16. **Ammonia Metabolism**, symp., Brooklyn, N.Y. (D. M. Kirschenbaum, Dept. of Biochemistry, State Univ. of New York, Downstate Medical Center, 450 Clarkson Ave., Brooklyn 3)

16–17. **Basic Sciences**, 3rd annual conf., New York, N.Y. (A. Gelbart, Yeshiva Univ., Amsterdam Ave. and 186th St., New York)

16–19. Gulf and Caribbean **Fisheries** Inst., conf., Ocho Rios, Jamaica. (Executive Secretary, Gulf and Caribbean Fisheries Inst., 1 Rickenbacker Causeway, Miami, Fla. 33149)

16–19. **Magnetism and Magnetic Materials**, Minneapolis, Minn. (J. B. Goodenough, Lincoln Laboratory C182, Lexington, Mass. 02173)

16–20. Interagency **Chemical Rocket Propulsion** Group, Mechanical Behavior Working Group, 3rd annual, Redstone Arsenal, Ala. (T. H. Duerr, AMSMI-RKP, Redstone Arsenal, Ala. 35809)