Symmetries at Coral Gables

We meet in a calmer atmosphere this year, said the opening speaker J. Robert Oppenheimer, at the January Coral Gables conference on symmetry principles at high energy. He was referring to relativistic versions of SU (6) that generated much excitement at last year's Coral Gables conference, an excitement that gradually subsided, under criticism, during the year. The symmetry theories, as Oppenheimer remarked, have enjoyed a considerable phenomenological success, to be compared with an almost total lack of fundamental understanding. A possible clue lies in the mysterious, so far unobserved and perhaps nonexistent, quarks or other fundamental triplets. Theories based on quarks (see PHYSICS TODAY, Feb. page 44) disregarding wholly difficulties in handling the dynamics, give valuable results and are in this sense reminiscent, so the opening speaker thought, of Bohr's theory of stationary states.

Yoichiro Nambu (Chicago) discussed application to nonleptonic decays of hyperons of a formalism first developed by him and his collaborators in 1962. It makes the bold assumption that the strong interactions possess chirality (or γ_5) invariance to obtain a lowest approximation to the relation between a given process and that same process with the emission of an additional low-energy pion. Nambu calls this approximation "soft-pion emission" in analogy with the soft-photon emission that accompanies all electromagnetic processes in the continuum and is relatively easy to calculate with quantum electrodynamics. Although originally applied to photopion production, its present application to nonleptonic hyperon decays gives corrections to the well known pole approximation. Asymmetry parameters and decay rates agree rather well with experiment, an exception being the decay $\Sigma^+ \to p + \pi^0$. Similar results have been obtained independently by M. Suzuki and M. Sugawara using current commutator methods.

Weak interactions. Nicola Cabibbo (CERN) delivered a review paper on the progress of the last two years in the theory of the weak interactions. The most recent, and probably the most interesting result has been the success of Adler and Weissberger in applying current-commutation relations of chiral SU (3) $\times$ SU (3), which are obtainable from the quark model, to calculate the renormalization of the strangeness-nonchanging weak axial-vector coupling constant. Cabibbo also discussed the experimental evidence bearing on the determination of the parameters appearing in the phenomenological weak current, that is, in the so-called "Cabibbo current." A comparison of nuclear beta decay with meson decay into leptons suggests that the "angle" θ_A, a parameter characteristic of the strength of the axial-vector strangeness-changing current, is different from the θ that enters in comparing beta and mu decays.

Nicholas Samios (Brookhaven) gave a review of boson resonances in which he pointed out that by the most conservative standards, only the 0^-, 1^+, and 2^+ meson nonets are well established. He reviewed their properties and remarked on the near universality (in mass-squared units) of the spacing between the unmixed $I = 1$ and $I = \frac{1}{2}$ nonet members, and on the apparent mixing of the $I = 0$ members, characterized by mixing angles of 30, 40 and 10 deg, respectively, for the 2^+, 1^- and 0^- nonets. The best value of the omega-meson width is now 13.4 ± 2.0 MeV, somewhat larger than previously given. Also, it is now believed that the phi meson has an appreciable branching ratio into $\rho + \pi$, of the order of 30%.

David Frisch (MIT) reviewed the extent to which "classical" symmetries of quantum electrodynamics (C, P, CP, PT, etc., and assumptions like equality of electron and proton charges) have been tested. One conclusion was that on the basis of low-energy experiments, quantum electrodynamics is valid to distances as small as 2×10^{-14} cm or smaller. His slogan: "QED—97% effective when used regularly."

Hadrons. It has been widely recognized that hadron systematics can be derived from quark models, special assumptions about the quark-quark and quark-antiquark forces implying higher symmetries for the hadron internal states. Whether these higher symmetries should be, or can be, assumed to hold for the dynamical interactions of hadrons is at present a question of intense interest. Gell-Mann and his collaborators, for example, have derived commutation relations of quark current densities from a field theory of quarks and have proposed that the space integrals of the hadron current densities should obey the same relations. H. J. Lipkin (Rehovoth), discussed a very simple model that takes quarks more seriously, an independent quark impulse approximation in which the quarks in the hadrons (two for mesons, three for baryons) are assumed to scatter independently when two such complex systems collide. Somewhat surprisingly, if only SU (3)-invariant interactions are assumed in this model, the "good" (that is, experimentally valid) predictions of SU(6) can be obtained. In particular, calculating the forward scattering amplitudes, simply related to total elastic cross sections, Lipkin and his collaborators obtain the so-called "Johnson-Treiman relations" between K-meson–nucleon and pi-meson–nucleon scattering.

Murray Gell-Mann (Cal Tech), without doubt the physicist who has added most to our understanding of internal symmetries of fundamental particles, emphasized that local, causal relativistic quantum fields may not be necessary for doing physics but that the currents that can be formed with these fields are local observable quantities. He then discussed ways of applying the equal time current commutation relations to relate observable quantities such as form factors and total cross sections. Useful sum rules can be obtained this way, as shown by Adler, Weissberger, and Fubini and Furlan, by taking matrix elements of the commutation relations between states at infinite momentum. This leads to the problem, at present under study, of how to describe symmetries of internal hadron states, when taken to infinite momentum, bearing in mind that in a quark model, for example, there will be quark spin and orbital angular momentum that can mix under Lorentz transformation.

Magnetic monopoles. In an interesting paper Julian Schwinger (Havard) discussed the old problem of magnetic monopoles. From gauge invariance he showed first that $eg/\hbar c$ is an integer (g is the elementary magnetic charge in suitable units). Dirac had previously obtained the weaker result that this quantity should be a half integer. Schwinger's result has as one consequence that if e and g are at rest, the system possesses an integral, rather than half-integral angular momentum along the line joining them, a situation somewhat less jarring to the intuition. Finally, he showed that, contrary to the recent assertions of others, a Lorentz-covariant electrodynamics can be formulated with inclusion of magnetic monopoles.

The conference concluded as the previous two Coral Gables conferences have, with a summary talk by Yuval Ne'eman (Tel Aviv). Pointing out that during the past year we had begun to take a less abstract view of the generators of groups, he mentioned three way in which group theory is now being used: (1) to classify hadron states, (2) to provide operators to connect states, which form algebras relating transitions, and finally, (3) to provide symmetries of the dynamics, when the operators commute with important pieces of the Hamiltonian. It does not matter which form of dynamics (quarks, bootstraps, etc.) is eventually adopted.

Laurie M. Brown
Northwestern University

IEEE ultrasonics symposium

Rapidly growing research, applications and future possibilities made an impressive picture at the annual ultrasonics symposium sponsored by the Institute of Electrical and Electronics Engineers. Leading subjects were nonlinear effects, acoustic-electric energy exchange, transducers, amplifiers, delay lines and biomedical applications.

Nonlinear effects. Robert N. Thurston (Bell Labs), discussing third-order elastic constants and their relation to nonlinear processes, provided an introduction to a number of papers dealing with nonlinear elastic effects in acoustic-wave propagation. Since nonlinear elastic moduli provide the means for interchanging acoustic energy with thermal phonons, one must know their values to determine thermal-acoustic losses. When angular frequency ω times thermal relaxation time τ is greater than unity, the direct exchange can be followed, and Paul G. Klemens (Westinghouse) showed that for shear waves loss is proportional to frequency and to the fourth power of absolute temperature. He presented evidence that for longitudinal waves and lowest temperatures the increase should be proportional to the ninth power of temperature; dependence changes to fourth power at higher temperatures. Experimental results by John de Klerk (Westinghouse) indicate agreement with this result in silicon dioxide, lithium fluoride and calcium fluoride.

When $\omega\tau < 1$, individual modes cannot be followed and the interaction is in the nature of a phonon viscosity. With recently measured third-order moduli for sodium chloride, potassium chloride and yttrium-iron garnet—presented by D. E. Eastman—a formula derived by W. P. Mason found good agreement with measured ultrasonic losses.

Sonic-electric exchange. Electrons can damp acoustic waves by interchange of acoustic energy with electron energy, and dislocations dragged through the crystal are also damped by the "effective" viscosity of these electrons. This effect is the origin of a nonlinear attenuation, which, as discussed by R. W. Shaw and W. P. Mason, is different in normal and superconducting states.

A major effort is generation of higher-frequency acoustic waves. The highest frequencies discussed at the December symposium in Boston were about 70 gigacycles/sec (70×10^9) reported by P. E. Tannenwald and J. B. Thaxter, who use surface-wave excitation in quartz. Cadmium-sulfide and zinc-oxide thin-film transducers, discussed in a number of papers, can be