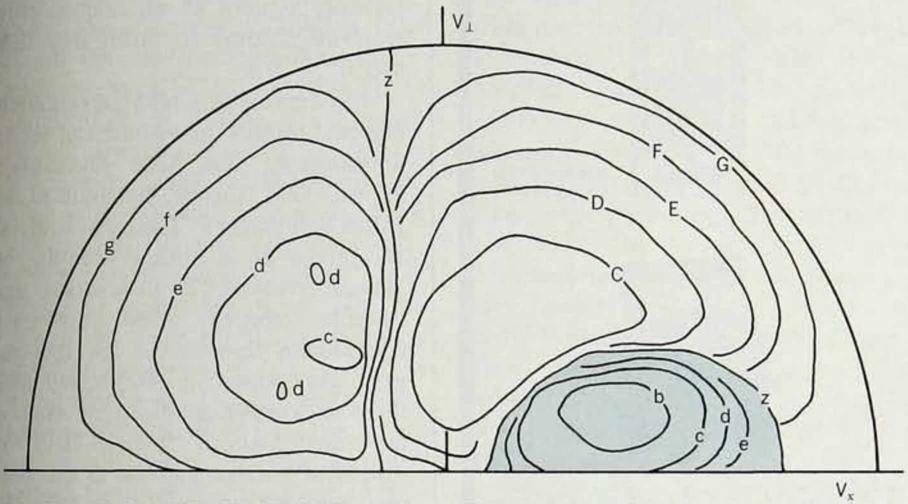
of Illinois, the Boltzmann group organized the workshop on Monte-Carlo solutions of the Boltzmann equation. The first two days of the workshop were devoted to basic considerations in the design of the Monte-Carlo method; the technical problems that have been solved in making the method work properly; the techniques that have led to convergence of iterative solutions of the Boltzmann equation; studies of statistical, quadrature and cutoff errors; and the methods of monitoring the large, relevant volume of computer output.

The last part of the program dealt with new Boltzmann problems and new computers. David Kuch of the department of computer science at the University of Illinois described ILLIAC IV—a very large parallel computer designed in the department and scheduled to operate in 1970. His discussion made it possible to consider in some detail the suitability of such a computer for applying the Monte-Carlo method to more complex problems, such as those involving internal degrees of freedom, mixtures of gases and several independent variables.

Now that more experts in kinetic theory and numerical methods are familiar with the Boltzmann work at the University of Illinois, we hope that the Monte-Carlo results will become more useful in various ways, both to these experts and to other research people interested in nonlinear problems in kinetic theory.



LINES OF CONSTANT VALUE of the collision integral for the center of a Mott-Smith shock wave in a gas of elastic spheres. The region in which molecules decrease in number is in color. A = 0.3, B = 0.1, C = 0.03, D = 0.01, E = 0.003, F = 0.001, G = 0.0003, H = 0.0001, z = 0, b = −0.1, c = −0.03, d = −0.01, e = −0.003. Collision integral measures local departure from equilibrium. —FIG. 2

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The workshop was organized in the Coördinated Science Laboratory at the University of Illinois. The research on rarefied-gas dynamics conducted in the laboratory is supported in part by the Joint Services Electronics Program and in part by the Office of Naval Research.

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Particle Physicists Look for Dynamics

No new symmetries were proposed, and no new groups emerged to be grappled with, at the fifth Coral Gables conference on symmetry principles at high energy that was held last January at the University of Miami. But there was a sense of satisfaction that at last we are coming to grips with dynamics, the traditional business of physics. Progress towards this goal *via* symmetry, the direction emphasized at the Coral Gables meetings, has seemed to be relatively slow, partly because successes a year later have been taken for granted while failures remain to haunt us. I do not mean to minimize in any way the progress achieved in the meanwhile by the approach that begins with analyticity, unitarity and crossing symmetry of scattering amplitudes, and leads to dispersion relations, bootstrap, Reggeism and perhaps, thus, on to symmetry.

Locklainn O'Raifeartaigh (Institute for Advanced Study, Princeton), in his summary and review of combined space–time interval symmetries, emphasized the point of view that symmetries can lead us to dynamics. He discussed the infinite-component wave functions that were proposed in the early 1930's by Ettore Majorana and revived about a year ago by Yoichiro Nambu. O'Raifeartaigh contended that the last four years' development, involving such diverse approaches as Murray Gell-Mann's relativistic quarks and his current algebra, the $\tilde{U}(12)$ and $SL(6,c)$ groups, the Yukawa bilocal-field theory, as well as many other approaches, all lead inevitably to infinite-component wave equations. Among possible applications, assuming the equations could be solved, one should immediately have mass spectra, electromagnetic form factors, decay rates for strong decays, saturation of the current algebra at infinite momentum with single-particle states, and a way to solve the relativistic quark model. The approach is, therefore, very ambitious and, correspondingly, beset with many difficulties. One of these difficulties has been that a mass spectrum is obtained in which mass values of the states decrease with increasing spin, in contradiction to the observations. More recently it has been possible to prescribe the mass spectrum desired; that is, to introduce it into the problem *a priori*. Obviously, if this is true one loses an important prediction. In addition, there appears to be considerable doubt that acceptable (that is, mathematically stable) solutions of the equations exist corresponding to a particular class of particles, for example mesons alone, so that one may be forced to tackle the truly formidable task of obtaining *all* the particle states in order to have any solution at all. Nevertheless that does not mean that a great deal cannot be learned in the attempt.

Stability criterion. A related, though much simpler, case was discussed by Arthur Wightman (Princeton) from the axiomatic viewpoint. He exhibited a criterion for the stability of the acceptable solutions valid for finite-component wave equations such as the Rarita–Schwinger equations of spin-3/2 particles. These equations usually have unphysical solutions in addition to the desired physical ones, and these solutions are likely to appear in final states of a scattering problem even though they are forbidden to appear in the initial states by supplementary conditions. Wightman showed that a sufficient condition for the stability of a true interacting situation is that they be stable in an external electromagnetic field. André Martin (CERN) gave the other axiomatic result of the conference, a proof of superconvergence relations holding for arbitrarily large spins.

Accompanying Gell-Mann's current algebra another mainstream of recent development has been phenomenological field theory, exemplified by Julian Schwinger's "Theory of Sources" and given an important stimulus by Steven Weinberg's observation that suitably chosen phenomenological Lagrangian theories, in the tree-diagram approximation (that is, retaining those Feynman graphs that contain no closed hadronic loops), yield the results of current algebra in the soft-pion approximation (that is, with the pion four-momentum made equal to zero). Very important in the application to physical processes is the assumed meson dominance of currents: The conserved vector isospin current is dominated by the rho meson (first proposed by John Sakurai), and the partially conserved axial-vector current is dominated by an axial-vector meson (identified as A_1, mass 1080 MeV) and the pion.

Julian Schwinger (Harvard) provided some further developments of his "Sourcery," starting from a Lagrangian based on chiral symmetry and effectively applied with the help of "source diagrams," which resemble space–time Feynman diagrams but have the feature that only real (as opposed to virtual) intermediate states are employed, as in dispersion theory. With his approach, he showed how it is possible to make contact with the results, for example, of S-matrix theory and to define, let us say, a pion–pion-scattering phase shift. In proceeding from low-energy symmetry properties (chiral $SU(2) \times SU(2)$) to high-energy predictions the key principle used is that of unitarity (conservation of probability).

Strange quarks. Bruno Zumino (New York University) discussed the other type of phenomenological Lagrangian theory (Weinberg's), which has been extensively developed during the past year. An important result of

Norman Kroll, Tsung Dao Lee and Zumino (construction of a Lagrangian in which the neutral-vector mesons are the source of the electromagnetic field) permits a consistent theory of meson dominance of the currents to be formulated. Thus the *canonical* commutation relations of meson fields, the so-called field algebra, provides also a current algebra that is, however, more restrictive than that of Gell-Mann and can therefore give additional consequences. Zumino discussed the nontrivial problem of extending chiral SU(2) $\times$ SU(2) to chiral SU(3) $\times$ SU(3). In a quark model this extension would be equivalent to introducing the strange quark. The point is that in nature chiral SU(2) $\times$ SU(2) is a "bad" symmetry, which breaks down to the "good" SU(2) or isospin symmetry. On the other hand since SU(3) is almost as "bad" a symmetry as the unbroken chiral SU(3) $\times$ SU(3), there is more ambiguity in deciding how the breaking should occur. In the breaking process the fields that transformed nonlinearly under the group are supposed to turn into linear representations of the smaller group, and this general problem has been understood by Sidney Coleman, Wess and Zumino and was reported by the last author.

Herman Munczek (Northwestern) presented a related, though different, phenomenological Lagrangian based on the meson dominance of currents. Munczek and I have produced essentially a theory of mixing of the pion and the A_1 meson, as suggested by the partially conserved axial-vector current hypothesis, that uses the rho dominance of the vector current and, using parameters fixed by the rho and A_1 meson decay widths, achieves a finite mass difference of the charged and neutral pions that agrees with experiment.

Kinematic analyses. Two of the results reported dealt with work that was, in the broadest sense, kinematical; no specific model was involved for the interaction. The first was Pais and Trieman's analysis, presented by Abraham Pais (Rockefeller), of the Kl_4 decays, from which they conclude that pion–pion phase shifts can be unambiguously inferred from the experimental data when sufficient data become available. The second was Feldman and Matthews's work on covariant angular-momentum analysis, useful for Regge-pole theory, presented by Paul Matthews (University of London). The latter work uses the helicity projection of the Bargmann–Wigner angular-momentum tensor, which simplifies the work to such a degree that they have named this quantity "felicity." The analog of the helicity-flip amplitude, according to Gordon Feldman, they intend to call "felicity slip."

Louis Michel (Inst. des Hautes Études Scientifique) addressed himself to the group-theoretical characterization of the Cabibbo theory of weak interactions, a problem also briefly touched upon by Nicola Cabibbo (University of Rome). Behram Kursunoglu (University of Miami) proposed a theory of leptonic multiplets that predicts some new leptons not yet observed. On the experimental side Melvin Schwartz (Stanford) reviewed the charge-asymmetric decays of K_2^0; William Willis (Yale) summarized the decays of strange particles and W. Galbraith (University of Sheffield) spoke on the decay of K_L^0 to two neutral pions.

Finally a new theory of CP violation in weak interactions was proposed by Kazuhiko Nishijima (University of Tokyo). In this theory the *fundamental* hadronic weak interaction is odd under CP and has a surprisingly large dimensionless coupling constant of the order 10^{-3}. The ordinary hadronic weak interaction is then supposed to be of second order (with coupling constant 10^{-6}), conserving CP, and the two-pion decay of the long-lived K meson is supposed to be of third order, accounting for its CP-odd character and its reduced rate.

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The conference was organized, at the Center for Theoretical Studies of the University of Miami, by Behram Kursunoglu. The proceedings will be published by Benjamin.

This year's conference was the last in a series of five; next year a new series will begin, entitled "Fundamental Interactions at High Energy."

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Radiation Effects in Semiconductors

In 1947 observations at both Purdue and the Oak Ridge National Laboratory showed that germanium and silicon suffer profound modifications of their electronic behavior when exposed to 10-MeV deuterons or radiation in a nuclear reactor. A flourishing research field is now devoted to radiation effects in semiconductors.