the olefin, that is, effective transfer from an $H_9O_4^+$ species.

Other investigations into the structure of water have been on the basis of electrolytic conductance measurements. The proton has an abnormally high conductance, and the variation of conductance with temperature and pressure throws light on the mechanism of conduction. Two papers were presented on this topic by E. U. Franck (Baden Institute of Technology, Karlsruhe) and G. J. Hills (Southampton University). It was generally concluded that proton migration occurs principally by charge transfer to, and reorientation of, free water molecules. The rate is determined by the rotation of a water molecule in the field of the hydrated proton to a position in which it can form a hydrogen bridge to the hydrated proton.

I left this conference with the feeling that in this branch of chemistry many workers are successfully concerned with the application of new physical techniques to essentially old problems.

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Mathematical Sciences

Elementary particle physics, many-body problems, and mathematical topics of interest to physicists were the main topics discussed at the 3rd anniversary symposium of the Institute of Mathematical Sciences, Madras, India, 3–12 January 1965.

In the introductory lecture Victor Weisskopf (CERN, Geneva) presented a broad survey of the current situation in elementary particle physics; the most dominant trend in this field is toward the concept of symmetry. To demonstrate the value of a historical perspective, he traced how the concepts of rotational symmetry and symmetry under permutation of identical objects from the realm of atomic physics not only explain many of the properties of the atom but also explain the properties of nuclei when augmented by the concept of isotopic spin symmetry. In the case of elementary particles, we have, in addition, the hypercharge symmetry; the combination of this with isospin is the SU_3 symmetry. He mentioned the experiments at CERN in search of "quarks," the hypothetical building blocks of the observed strongly interacting elementary particles and the weak vector bosons. Other experiments have tested the hypothesis of a cosmic force; they were advanced to explain the small violation of conservation of parity in weak interactions. Weisskopf concluded with some speculations on the lepton spectra. His quotation from Newton's *Optics* at the beginning of the lecture was startlingly apt for what followed.

Ph. Meyer (Orsay, France) summarized his work on the conserved vector-current hypothesis in relation to broken symmetries. Assuming that the violation of SU_3 invariance can be described by a local Lagrangian, which transforms like the member of an SU_3 multiplet with isospin and strangeness equal to zero, he proved that the first-order correction to the vector-decay amplitude, in the limit of zero-momentum transfer, can be accounted for by using unrenormalized coupling constants, but with wave functions corresponding to the physical masses. The success of the application of SU_3 symmetry to weak interactions in the Cabibbo theory was discussed by Alladi Ramakrishnan (Matscience, Madras). T. K. Radha (Matscience, Madras) reviewed the various models which oppose conservation of parity. She also mentioned a calculation (which she has carried out with Meister) on the electric dipole moment of the nucleon; this calculation assumes the maximum possible violation of conservation of parity. Another topic related to weak interactions was dealt with in a talk on μ-capture from nuclei, by V. Devanathan (University of Madras). Virendra Singh (Tata Institute of Fundamental Research, Bombay) first discussed the multiplet assignments of various observed particles in the SU_6 scheme (in which the internal symmetry group for the hadrons is combined with the ordinary spin), and then derived various sum rules for the relations among the masses of the hadrons. The sums agreed closely with the observed masses.

The concept of an equivalent potential in quantum field theory and S-matrix theory, and the use of a nonlocal potential in calculations in elementary particle physics formed the subject matter of three talks. R. Blankenbecler (Princeton University) showed how to obtain upper and lower bounds for the phase shifts and the K-matrix elements in nonrelativistic problems. He then extended these ideas to the relativistic case where, starting from the Bethe-Salpeter equation and multiparticle states, a potential can be constructed in a nonperturbative fashion. Application of the method to the ρ-meson bootstrap problem does not lead to any self-consistent solution. L. A. P. Balazs (now visiting the Tata Institute of Fundamental Research, Bombay) discussed a generalization of the work by Charap and Fubini; the potential is constructed by requiring that it reproduce the relativistic amplitude at any energy. The energy is obtained by calculating the absorptive parts in the crossed-channel reactions for increasingly larger values of the momentum transfer by iterations with the strip approximation to the Mandelstam representation. Starting from a nonlocal potential corresponding to a repulsive interaction, A. N. Mitra (Delhi University, Delhi) explained how a detailed examination of the phase shifts, with the potential in a Schrödinger-type equation, can lead to an understanding of some of the pion resonances. K. Dietz (CERN) presented a model for peripheral interactions below 10 Gev in which the K-matrix elements for quasi-two-particle reactions are replaced by the corresponding Born terms. The remaining K-matrix elements for higher particle final states are assumed to have a statistical distribution with zero mean value.

J. Lukierski (University of Wroclaw, Poland) considered the renormalizability of theories of particles with spin greater than or equal to one (which, with a single exception, are traditionally considered to be unrenormalizable). Conditional projection operators can restrict the number of components of a tensor field, constructed for a given spin theory, to the maximal spin subspace only if the subsidiary components obey free-field equations. However, with the unconditional projection operator (in which the subsidiary components do not obey the free-field equations), one has to add a set of massless fields whose metric must be negative in order to obtain a covariant propagator. This also leads at the same time to less stringent renormalizability conditions. Illustrating this for the neutral vector meson fields, Lukierski showed how the usual requirement of current conservation need not be invoked to demonstrate the renormalizability of the theory. The possibility of renormalizing theories, previously considered unrenormalizable by use of Caianiello's

approach involving pfaffians and hafnians, was suggested by N. R. Ranganathan and R. Vasudevan (Matscience, Madras). M. Gourdin (Orsay, France) gave a compact formula for covariant calculation of the matrix element of electron scattering from a target of arbitrary spin. K. Venkatesan (Matscience, Madras) explained how the notion of a group representation breaks down for certain values of the group parameter in the case of complex angular momentum.

There were several discussions on the many-body problem and on mathematical topics. C. de Dominicis (Saclay, France) dealt with the quasi-particle formulation of quantum statistics, which is based on partial summations in diagrammatic expansions, and discussed the relation with the Landau theory of Fermi liquids. P. T. Landsberg (University College of Cardiff, Wales) reported on a method for obtaining sum rules for any system, given the Hamiltonian of the system and the main variables desired to appear in the sum rules. Alf Sjolander (Göteborg, Sweden) gave an account of the concept of lattice waves, or phonons, and described in detail the inelastic neutron-scattering technique and theory, which are the only methods presently used in experimental determination of phonon-dispersion curves and polarization directions.

Marshall H. Stone (University of Chicago) emphasized the need for inquiry into the techniques of model construction in the various mathematical sciences and the role of the mathematician in this respect. Harish Chandra (Institute for Advanced Study, Princeton, New Jersey) told how to solve the difficult problem of constructing the characters for noncompact, semi-simple Lie groups. S. K. Srinivasan (Indian Institute of Technology, Madras) briefly outlined some recent developments in stochastic point processes. In his concluding remarks, Alladi Ramakrishnan evaluated the various topics discussed at the symposium.

The symposium proceedings will be published later this year by Plenum Press, New York, as volume 4 of *Matscience Symposia on Theoretical Physics*. This is part of a continuing series of the proceedings of both the Matscience Summer School lectures and the Matscience Winter Anniversary Symposia.

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