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News

MEETING REVIEW

International Union of Pure and Applied Physics Conference on Statistical Mechanics, March 29–April 2, 1971 University of Chicago, Chicago, Illinois

This conference followed the one held in the Fall of 1968 in Kyoto, Japan. Twenty major papers were presented concurrently with sessions of short contributed papers. The major presentations began with a talk by Stephen Smale on the modern mathematician's approach to dynamical systems theory. He illustrated the techniques with reference to nonlinear electric circuits. He said that one could begin with the many-dimensional Kronecker space describing all possible (unrestricted) states of the system and carry through a systematic reduction to yield a "natural" and more tractable manifold on which the system trajectories lie. D. Ornstein described modern ergodic theory. J. Lebowitz in his talk (dedicated to G. Uhlenbeck) gave a lively discussion with two premises: first, modern dynamical theory (such as discussed by Smale and Ornstein) has a great deal to contribute to statistical mechanics; second, physicists know little about modern dynamics. Sinai has recently shown that the hard sphere gas is ergodic (more precisely it is a "mixing system" after Hopf). This is a significant finding. Lebowitz explained some of the implications of such a result for time-displaced correlation functions and for one-dimensional systems in particular. Rene Thom delivered an erudite paper on the general structural features of the abstract spaces defined by many-dimensional differential systems. Some time and a skilled expositor will surely be needed to ready such complicated material for the physicist's consumption.

Equilibrium systems were approached in a systematic way, starting with R. B. Griffith's survey of exact results. These dealt primarily with the existence of thermodynamic (intensive) properties for infinite systems, exemplified by the work of Ruelle. Others have even carried the proofs through for quantal systems with Coulomb forces. On the practical side, the uniqueness of the solutions of the Kirkwood–Salzburg equation has been proven along with the convergence of the associated virial expansion. The early arguments of Peierls on the existence of phase transitions have been refined and extended in the *C*-algebras* for infinite systems. Critical indices were discussed by R. Brout, who showed that a number of useful results can be generated using physical cluster expansions. F. W. Cummings and E. Feenberg discussed quantum liquids. It would be interesting to see how the general theory of moments, successfully used by R. G. Gordon and others, could be applied to yield more concise bounds on quantities related to the structure function studied by Feenberg. J. Percus gave a very interesting paper on what could be done by working directly with reduced distribution functions and density matrices. He began with a well-chosen and simple illustration and then went on to discuss lower bounds for energies and free energies of N-body systems. Since this year's bound may evolve into next year's calculational technique, we can only hope that progress will continue in this area. L. Verlet, in a similar vein, showed how far one can go starting with a reference fluid of known properties and perturbing the potential until it matches the one desired. His work and that of H. C. Andersen show that accuracy of the order of a percent or better for quantities of interest is now obtainable.

P. Resibois began the discussion on transport and nonequilibrium properties. He stressed the fact that hydrodynamics can be a very useful tool in handling microscopic properties, e.g., for studying nonanalytic density expansions, limiting behavior of the Van Hove function, etc. His major result was that hydrodynamical modes and their eigenvalues can be expressed entirely in terms of *one-body* distribution functions. He treated the van der Waals fluid as an example although some renormalization was necessary in that special case. K. Kawasaki gave a rather systematic review of the structure of the mode–mode coupling theory for studying transport properties near critical points. At the 1968 meeting, Kadanoff listed a number of successes and failures of the theory. Kawasaki explained that a number of the "failures" have since been rectified by carefully excluding from the interpretation of experiments all data from the nonhydrodynamical regime. R. Zwanzig discussed nonlinear Langevin equations and the associated Fokker–Planck formalism. The question of renormalization arose, i.e., do we observe "dressed" or "bare" modes in real systems? A. Rahman showed molecular dynamics results for large k and ω, outside the normal hydrodynamic regime. He could fit his results very well by simple continued fraction forms containing a few moments. The practical problem of calculating useful transport coefficients for real liquids using kinetic equations was dealt with by T. Davis.

There were some special papers of unusual interest presented that did not fit into the categories above. Turbulence theories deal with the "statistical mechanics" of the Navier–Stokes equations, which are of course nonlinear. The decidedly non-Gaussian or "intermittent" character of turbulence is evidence that the simple theories will not be adequate. R. Kraichnan reviewed the many complicated approaches that have been brought to bear on the problem. The final answers are not in yet. Other large sets of nonlinear equations, such as occur in models in population biology, were discussed by E. Montroll in his inimitable style. Some of this has since appeared in the April 1971 issue of *Reviews of Modern Physics*. R. Landauer discussed analogies between nonlinear circuits and phase transitions. Biology was discussed first by J. Cowan, who dealt with the reliability in large neural nets which might be achieved by "contracted" organizations (lumping of variables). These can be described by a suitable Fokker–Planck formalism. A quite fascinating talk was given by a physicist-turned-biologist, M. Cohen, who discussed theories of development (growth, division, and differentiation of cells). Movies of the development of cellular slime molds were shown in which one could easily see "organizational waves," periodic in space and time, propagating through the masses of amoebae.

Contributed papers, about 70, were given concurrently with the major talks. This caused some obvious conflicts but the shortcomings were partly overcome by the availability of a complete set of long summaries of every paper at the beginning of the conference. Approximately 250 people attended the conference with about 70 coming from outside the U.S. and Canada.

After such a major conference one can ask, where is statistical mechanics headed now? Critical point phenomena should continue to attract interest. The long-time anomalies recently discovered by Alder and Wainwright can also be studied for angular momentum relaxation, for example. The work that has been done to date shows that microscopic and macroscopic (hydrodynamical) description can be profitably combined.

In the past, statistical mechanics has been particularly successful in carefully exploiting very simple models (e.g., the Ising model or hard sphere gas). In the future there is going to be far more emphasis on computer simulation of model systems. Such work in the past has emphasized atomic fluids but more attention will now be devoted to molecular fluids (including liquid crystals) and Coulomb systems. The computer results should enhance the development of generalized kinetic equations, generalized hydrodynamics, and even the theory of turbulence. The major advantages of the computer are that the model can be specified independently of any existing physical system (the modeler plays God) and all aspects of the system's behavior from the microscopic to the macroscopic level are observable ("infinite resolution"). There are practical limitations of present-day computers which restrict the number of particles or variables in a system and the time interval over which they can be followed. This leads to one almost fundamental limitation on these techniques, *viz.*, their inability to simulate many-body quantum systems. Surely a Grand Prize awaits the person who discovers how to simulate quantum systems.

I feel that the goal of statistical mechanics should be that of systematically obtaining contracted descriptions of systems which serve either to correlate data or allow direct calculation and comparison with real or simulated systems. Two aspects of this program have received a good deal of attention: (1) Obtaining formal contracted descriptions. These are not normally soluble as they stand. (2) Obtaining useful self-contained equations which allow numerical solution. There is a final task which remains: (3) Generating procedures for going *systematically* from the "formal" to the "useful" description. For example, given the Navier–Stokes equations describing turbulence, or the Hamiltonian of a spin system we do not yet have a *systematic* way of obtaining simpler useful equations which we can rely on for numerical results of a known accuracy. Perhaps at the next meeting we will see progress on these matters.

The conference was certainly a success and thanks go to the local organizing committee of S. Rice, J. Light, and K. Freed. They were even so thoughtful as to include Chicago's first pleasant spring-like day of 1971 as the third day of the conference.

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Copies of the paperbound volume of abstracts (about 70 abstracts averaging 4 pages each) are available to interested persons at a cost of $3.00 each. They may be obtained by sending a check, payable to the University of Chicago, to Professor Stuart Rice, James Franck Institute, University of Chicago, Chicago, Illinois 60637. The Proceedings of the Conference, which will contain the 20 invited papers, will be published later by the University of Chicago Press.