active in quantitative modeling, consider holding a series of workshops to promote appreciation of this approach. These workshops could focus, for example, on acquisition of appropriate ecological and physical data, on methods of analysis such as new multivariate statistical methods not presently used in biological oceanography, or on development of models of specific ecosystems. The group was not able to reach an agreement that any one of these methods would be the most effective means of stimulating the use of modeling techniques in biological oceanography.

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Fluctuations in Superconductors

Many of the unique properties of superconductors, such as zero resistance, quantized flux, and Josephson tunneling, may be applied with extraordinary sensitivity to the measurement of voltages, magnetic fields, and infrared radiation. Superconducting tunneling devices may even provide the world's voltage standard. Are the sensitivity limitations of superconducting devices limited by intrinsic or extrinsic noise? Can a study of these noise processes help us to understand more about the physics of superconductors?

The Conference on Fluctuations in Superconductors was held at the Asilomar Conference Grounds, near Monterey, California, 13 to 15 March 1968, in order to consider problems of noise in superconductors. The conference was sponsored by the Office of Naval Research and the National Aeronautics and Space Administration.

Richard Ferrell (University of Maryland) discussed the fluctuation dissipation theorem, illustrating the way in which fluctuations can occur and the manner in which they are driven by external sources (a film illustrated the collapse of the Tacoma Narrows Bridge as a result of wind-driven fluctuations). As other examples of fluctuations he also discussed how gravitational waves could drive the quadrupole mode of the earth and the effect of light-scattering on an antiferromagnet.

In his talk on thermodynamic fluctuations, Ronald Burgess (University of British Columbia) emphasized that thermodynamic fluctuations do occur in superconductors (one might naively expect that superconductors should exhibit no thermal noise). All sources of energy must be included in an attempt to relate fluctuation power to the thermodynamic power per mode ($1/2kT\Delta\nu$). Using the two-fluid model, Burgess showed that in a superconducting ring the energy is the sum of contributions from the magnetic field, supercurrents, and normal currents. Burgess developed a Langevin equation to calculate the fluctuations of the wave function Ψ, the complex order parameter of the Ginzburg-Landau theory. There was much discussion on how the stochastic forces should be introduced into a Langevin equation. Burgess stated that the independent forces were those for the real and imaginary parts of Ψ; others felt that the amplitude and phase of Ψ might possibly be better choices.

The use of weak links and Josephson junctions as a quantum phase detector was discussed by James Mercereau (Ford Scientific Laboratories, Newport Beach, Calif.), James Zimmerman (Philco Aeronutronics, Newport Beach, Calif.), Lorin Vant-Hull (Ford Scientific Laboratories, Newport Beach, Calif.), and Bruce Ulrich (Ford Scientific Laboratories, Newport Beach, Calif.). Figure 1 shows noise data obtained with a superconducting interferometer. The properties of wide junctions were discussed by Douglas Scalapino (University of Pennsylvania), Allen Goldman (University of Minnesota), Michael Stephen (Rutgers University), and John Clarke (University of California, Berkeley). Wide junctions exhibit a pattern of critical current as a function of magnetic field which is quite different from that of the diffraction pattern shown by narrow junctions. Some of the special properties of the a-c Josephson effect, such as line width and plasma oscillations, were discussed by William Parker (University of California, Irvine) and Arnold Dahm (University of Pennsylvania).

Collective modes, particularly those of vortices in Josephson junctions, were discussed by Douglas Scalapino, Alexander Fetter (Stanford University), and Michael Stephen. The noise spectra of a Josephson junction can be represented as sums over the strengths of contributions of the various quasiparticles. Therefore, from a knowledge of what types of modes are possible, one can tell where to expect peaks and other dramatic behavior in noise spectra.

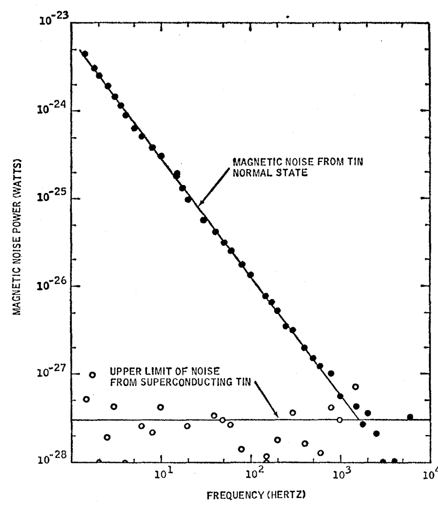

Fig. 1. Direct measurement of the change in the frequency spectrum of electronic thermal noise at the superconducting transition (L. L. Vant-Hull). Open circles represent measurements on superconducting tin, and solid circles represent measurements on normal tin. Experiments utilized a superconducting interferometer to determine the magnetic field produced by these thermal noise currents. The total noise power under the curve corresponds to 60 percent of the thermal energy at the sample temperature of 3.8°K; the remainder occurs below 1.5 hz. The observed power spectrum for normal tin is the result of the frequency-dependent skin depth.

Flux flow noise was the subject of talks by Frank Chilton and Gerard van Gurp (Phillips Research Laboratories, Einhoven, Netherlands). Flux flow occurs in many different kinds of instruments which contain superconductors. Flux flow noise is much larger than Johnson noise in metals in the normal state. The question of why the noise is so large and variable in one experimental geometry as opposed to another was considered. Some of the noise may be related to temperature fluctuations, as van Gurp has shown by the observed reduction in temperatures below the lambda-point of helium where the temperature stability is improved.

Interpretation of the observed noise spectra seems possible but puzzling. Van Gurp achieved reasonable agreement with his data by assuming a model of random and independent voltage pulses from each fluxoid (flux vortex). Chilton pointed out, however, that the pulses should not be considered independent but rather as part of a lattice which, if sufficiently extensive, could reduce the noise spectra.

Still another category of fluctuations in superfluids is critical-point fluctuations. Although these can be observed in helium, as Tyson showed, critical-point fluctuations in superconductors appear to be of theoretical importance only, because the temperature must be within about 10^{-8} °K of the transition temperature in order for one to observe these fluctuations in superconductors.

Fluctuations and the behavior of small systems, such as whiskers or microbridges, were discussed by James Langer (Carnegie-Mellon University), Ronald Parks (University of Rochester), and Watt Webb (Cornell University). Small systems offer more opportunity for observing fluctuations, since the fluctuations are approximately inversely proportional to length. An interesting debate resulted over the question of how closely one could determine the depression in the critical temperature ΔT_c by measuring resistance. Parks analyzed some simulated data which indicates an error of a factor of from 2 to ∞. Webb cited evidence that the error was probably of the order of tens of percent, although he conceded that considerable care in sample preparation and measurement techniques would be necessary for such precision.

Michael Fisher and John Reppy (Cornell) described an analog to flux flow resistivity in superconductors—the decay of superflow in helium. The time dependence of this decay is logarithmic in the same way as for flux creep in superconductors.

As with many "first" conferences in a newly developing area of research, one is struck most by what is not known rather than by what is understood. Fluctuations in superconductors appear to be sometimes much larger than fluctuations in normal systems, but they also are often much smaller. However, the types of noise which occur in superconductors appear to be similar to those in normal systems. Thermal, shot, and flicker noise all occur in superconductors, and no noise source has yet been shown to be unclassifiable in terms of noise mechanisms of normal systems.

The proceedings of the conference have been published. Copies are available from the authors and from the U.S. Defense Documentation Center, Building 5, Cameron Station, Alexandria, Virginia 22314.

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Immunological Tolerance

An international conference on immunological tolerance, sponsored by the Extramural Programs of the National Institute of Allergy and Infectious Diseases and arranged by Maurice Landy, was held at Augusta, Michigan, 18–20 September 1968. The topic of each of the six half-day sessions of the meeting was outlined by a designated speaker, whose presentation was followed by an open discussion period averaging about 3 hours. As the number of participants was limited to 42, a very free and rapid exchange of ideas and information was possible.

One theme permeating each session was that a unifying mechanism which explains satisfactorily both immunological tolerance and antibody synthesis will be found. The participants seemed convinced that tolerance can be understood only in terms of immunogenicity, and that the process of antigen recognition is central to the induction of immunological tolerance. Yet how the same substance can induce both tolerance and antibody synthesis—even simultaneously—is not understood. It may be that antigens that are freely diffusible in body fluids are tolerogens, whereas those that are phagocytosed are immunogens. But, as was brought out by several discussants, this interpretation cannot account for immunological tolerance induced by particulate antigens, such as erythrocytes or polymerized flagellin.

The long-held idea that tolerance is the result of antigen-overloading has been shattered by the discovery of "low-dose" tolerance—the induction of tolerance by repeated injections of minute amounts of antigen. According to Nossal, extremely small amounts of flagellin, 10^{-14} molar, when given to rats repeatedly, readily induces immunological tolerance. An interesting difference between the low- and high-dose forms of tolerance is that the immunochemical specificity of the former is greater than that of the latter.

At least two kinds of lymphocytes were implicated in the immune response by several participants. Although antibody-synthesizing cells seem to originate from marrow lymphocytes, mice lacking lymphocytes derived from the thymus form antibodies poorly. However, when both marrow and thymic lymphocytes are present, antibody synthesis proceeds normally. It is unknown how these two kinds of lymphocytes "cooperate." Mitchison postulated that thymic lymphocytes trap antigen by means of a hypothetical immunoglobulin, "IgX," but no physical evidence of an antigen-concentrating mechanism in these cells has yet been obtained.

Another two-cell system, lymphocytes and macrophages, was discussed intensely. The immunogenic material contained in RNA-antigen complexes extracted from the macrophages of immunized rats was found by Gottlieb to be a peptide that contained only 15 amino acids. How this finding will affect the notion that the tertiary structure of an antigen is required for its immunogenicity remains to be determined. Since the immunizing antigen was the T-2 phage, it is evident that considerable processing is carried out by macrophages. Braun presented his theory that an RNA, derived from macrophages and acting as a nonspecific depressor, may activate lymphocytes; antigen bound to the RNA "guides" it into the appropriate stem cell of antibody-forming clones. Whatever "processing" may be ultimately, there was no general agreement that it is essential for antibody synthesis, and until more direct evidence has been obtained, disagreement on the role of the macrophage in the immune response is likely to continue.

Two interesting experiments dealt with the role of carriers in immunity. In the first, it was found that strain-13 guinea pigs, ordinarily unresponsive to dinitrophenol-polylysine, formed antibodies to that antigen when it was coupled to a carrier, bovine serum albumin. However, when strain-13 guinea pigs were rendered tolerant of that carrier, they failed to respond to dinitrophenol-polylysine-bovine serum albumin. In the other example, it was found that cells primed only to the carrier moiety of a hapten-protein conjugate increased the responses of irradiated mice to challenge with the complete conjugate. These experiments imply a role for carriers beyond that of a simple *schlepper*; but how they function in the immune response remains unclear.

Considerable efforts are now under way to induce tolerance in vitro. Several experimental systems were described, all of them dependent upon repopulation of heavily irradiated syngeneic "test" animals with lymphoid cells supposedly rendered tolerant in vitro. All of these models suffer the major drawback of antigen carry-over to the irradiated host. Unless this technical difficulty is eliminated, most of the participants were unwilling to accept