Book Reviews

The State of Low Temperature Physics

Quantum Liquids. Papers presented in Erice, Italy, June 1977. J. RUVALDS and T. REGGE, Eds. North-Holland, Amsterdam, 1978 (U.S. distributor, Elsevier, New York). x, 328 pp., illus. Cloth, $36.95; paper, $21.75.

Quantum Fluids and Solids. Proceedings of a symposium, Sanibel Island, Fla., Jan. 1977. SAMUEL B. TRICKEY, E. DWIGHT ADAMS, and JAMES W. DUFTY, Eds. Plenum, New York, 1977. x, 474 pp., illus. $47.50.

The discovery of superfluidity in ^{3}He in the fall of 1971 by Osheroff, Richardson, and Lee heralded a period of feverish activity for low temperature physicists, which has culminated in a detailed understanding of this remarkable substance. The appearance of *Quantum Liquids*, the proceedings of a conference held in Erice, Sicily, and *Quantum Fluids and Solids*, the proceedings of a conference held on Sanibel Island, Florida, both covering the whole field of quantum fluids, provides an opportunity to assess the developments in this field in the past seven years.

The picture of the superfluid phases of ^{3}He that has emerged is one of rather formidable complexity, stemming primarily from the tensor nature of the superfluid order parameter. If one realizes, moreover, that the superfluid transition occurs below 3 millikelvins, one might expect experimental work to have been restricted to a small number of laboratories and progress to have been rather slow. According to Richardson's paper in the Erice volume, however, at the latest count 20 experimental groups had achieved the superfluid transition, and it is fair to say that the equivalent of 50 years of research on superconductivity and superfluidity were telescoped into seven years with ^{3}He.

The initial phase of development involved applications of lessons learned in superconductivity (microscopic weak- and strong-coupling Bardeen-Cooper-Schrieffer theory, phenomenological Ginzburg-Landau theory), magnetic resonance, Fermi liquid theory, and the quasiparticle theory of superfluid ^{4}He. These topics are reviewed in the Erice lectures by Leggett (theory) and Richardson (experiment) and are the subject of a number of papers in the Sanibel proceedings. More recently, a new class of problems has been addressed, such as the existence of superflow and the classification of spatial configurations of the order parameter in realistic geometries. These subjects are treated by Mermin in both volumes and in the Sanibel proceedings by a number of other authors (Anderson and Palmer, Maki, Buchholtz and Fetter, and others). Here the tensor order parameter leads to the existence of a vast array of different "textures" that bear many analogies to those present in liquid crystals. The difficulty of visualizing the properties of spatially dependent complex 3 by 3 matrices means that many of the simplest configurations are most easily understood by applying nontrivial theorems in topology. The connection between these exciting theoretical developments and experiments on ^{3}He seems a bit tenuous at the moment, but there is at least a theoretical tie-in with subjects of interest in other fields of physics (solitons, kinks, instantons, dislocations, disclinations, vortices).

Besides treating superfluid ^{3}He, which takes up somewhat less than half of each book, the papers in both books treat a collection of other topics and can be divided into three broad categories. The first includes papers dealing with critical phenomena, the development of which is another major achievement in the physics of condensed matter in the past decade. The quantum fluids community has remained somewhat orthogonal to this development. Those experimentalists who have studied the lambda transition as a critical point are an exception. An example is provided by a detailed paper by Ahlers in the Erice proceedings on static critical exponents in ^{4}He. It is hoped that the paper will not be lost from view to the critical phenomenon specialists who are Ahlers's natural audience. On the other hand, the inclusion of this paper in a book on quantum fluids serves to emphasize the fact that the lambda point and the tricritical point in ^{3}He-^{4}He mixtures have evolved from being the most mysterious aspects of superfluids to being those that present the most spectacular agreement between experiment and theory. I hasten to add, however, that this agreement does not extend to all critical properties, a notable exception being the Brillouin scattering experiments described by Greytak in his Erice paper.

The second category of papers in these volumes is concerned with what can be described as consolidation and refinement of our knowledge of quantum fluids and solids. The Erice volume, for example, includes a detailed study of the elementary excitations in ^{4}He, and in ^{3}He-^{4}He mixtures, by neutron (Cowley) and light (Greytak) scattering experiments as well as by theoretical methods (Ruvalds and Zawadowski). These papers give a rather complete view of our present understanding, although they could have profited from better coordination of the experimental and theoretical parts (especially Zawadowski and Greytak).

The last category of papers deals with those subjects that are not yet fully mature but that one might hope will develop rapidly in the near future. An example, I believe, is the study of helium films on various substrates, discussed in an excellent paper by Dash in the Erice volume and in an interesting paper by Rutledge *et al.* as well as in a number of other papers in the Sanibel volume. In fact, it is a testimony to the vitality of this field that the discussion of two-dimensional superfluidity by Dash is already out of date both experimentally and theoretically. On a more speculative level, there are interesting reviews in the Sanibel book of exotic quantum fluids and solids, such as spin-aligned hydrogen, ^{6}He, and superfluid solids. Finally, neutron scattering in ^{3}He and ^{3}He-^{4}He mixtures and the study of elementary excitations by other means in very dilute mixtures seem to me to promise significant progress in the years ahead.

The advantage of holding conferences in Florida in January and on the shores of the Mediterranean in June is that one has access to a very high caliber of lecturers and participants. The intellectual level of both books is therefore quite high, and I believe there is much for specialists to learn from both of them. The Erice volume seems to me to make more sense as a book because it contains review articles that provide a reasonable

introduction to a number of topics. One general criticism I have of such efforts, which also applies here, is that figures are usually lifted from other publications and are not adequately captioned. The Sanibel volume contains 50 papers (of an average length of eight typewritten pages), and at $47.50 it can barely be expected to be bought by individuals or even by many libraries. This is especially true in view of the considerable competition from a large number of other books and reviews on ^{3}He that have appeared recently. In my opinion proceedings such as these are more appropriate in a journal, where more flexibility exists as to the length of each contribution.

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Ecology of Ants and Termites

Production Ecology of Ants and Termites. M. V. BRIAN, Ed. Cambridge University Press, New York, 1977. xviii, 410 pp., illus. $41. International Biological Programme 13.

On most occasions the national committees of the International Biological Program, which were active from 1964 to 1974, gave their principal support to major biome studies. They placed much less emphasis on individual groups of organisms, even those that exert a heavy influence on the ecosystem. An exception was made in 1966 when the IBP section concerned with productivity of terrestrial communities decided to devote a special project to social insects because "in semi-arid savannah, steppe, prairie and heath habitats (particularly those in the tropics) both ants and termites abound and are unquestionably of great importance in ecosystem functioning." The results, reported in the book under review here, represent one of the more solid achievements of the IBP.

The confidence of the organizers in the ants and termites was without doubt well placed. Some of the facts cited by Brian and his coauthors will be startling even to those already inured to the prodigious qualities of these insects. In most habitats, in most parts of the world, there are on the order of 1 to 100 million ants and termites per hectare. They constitute 1 to 15 percent of the animal biomass in various grassland localities in North America, Europe, and Africa and over 20 percent in the single site in the Amazon rain forest thus far subjected to quantitative study. It is difficult to take more than a few steps anywhere in the world without treading on an ant; a moistened sugar cube thrown onto the ground at random in warm weather will usually attract foragers from one or more colonies within minutes. The impact of these insects on their ecosystems is correspondingly great. In their studies of a typical Polish meadow, A. Kajak and his co-workers found that 32 percent of newly emerged flies, 43 percent of leafhoppers, and 49 percent of lycosid spiders were captured and eaten by the ants belonging to the single genus *Myrmica*. In some places much of the biomass is organized into small numbers of virtual superstates. Single colonies of fungus-growing ants (*Atta*) and termites (*Macrotermes*) contain over a million workers. One colony of driver ants (*Dorylus*) was estimated to have 21 million workers. The highest recorded reproductive potential among insects is held by queens of the termite *Odontotermes obesus*, the single progenitrices of very large colonies. Two independent counts yielded oviposition rates of 26,208 and 86,400 eggs per day (one egg every one to three seconds), a production that presumably continues for years.

Production Ecology of Ants and Termites is strongly oriented toward methodology and facts: the mensuration techniques and data of species diversity, population size, dispersion pattern, population dynamics, metabolism, and energy flow. Because of the great diversity in natural history among their individual species, ants and termites affect virtually every kind of multicellular organism in terrestrial habitats, making even a complete outline of their ecology an impossible task. The authors, however, have selected certain appropriate features for close attention. One is the elaborate symbiosis between the attine ants and macrotermitine termites and their respective fungi. Both kinds of insects gather leaves or other cellulose-bearing materials and permit the fungi to digest them in subterranean gardens. The termite mutualism receives the greater attention in the present volume and is especially well reviewed in a chapter by J. P. La Fage and W. L. Nutting. The termites utilize the fungi at least in part to degrade lignin and hence to expose larger quantities of cellulose for their own use. This symbiosis has permitted the macrotermitines to exploit a greater variety of plant materials, an adaptation that appears to be a principal source of their great numerical success in the Old World tropics. (The mycological side of the relationship has been presented in an elegant monograph by Roger Heim, *Termites et Champignons: Les Champignons Termitophiles d'Afrique Noire et d'Asie Méridionale*, Société Nouvelle des Editions Boubée, Paris, 1977. Heim, who holds the chair of cryptogamic botany at the Muséum National d'Histoire Naturelle, Paris, has for the first time laid out in detail the phylogeny, classification, and life cycles of the fungi, all of which belong to the agaricaceous genus *Termitomyces*. His book will serve as a valuable aid to further research by entomologists on the biology of macrotermitines.)

Production Ecology of Ants and Termites is one of the indispensable guides for future studies on these social insects. Yet despite its large bibliography—approximately 1000 titles, of which more than 80 percent were published in the past 20 years—the work it summarizes is no more than a modest beginning. Only a tiny fraction, much less than 1 percent, of the more than 10,000 ant and 2000 termite species have been considered in any detail. And, as the authors themselves are clearly aware, little effort has been made to relate the raw numbers produced by the ecosystems studies to the idiosyncrasies of social behavior and environmental adaptations of individual species. Thus the behavioral ecology of social insects stands as one of the most promising special fields of study for the immediate future.

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Mathematical Ethology

Quantitative Methods in the Study of Animal Behavior. BRIAN A. HAZLETT, Ed. Academic Press, New York, 1977. x, 222 pp., illus. $12.50.

Ethologists interested in evolution have emphasized modal patterns of behavior; behaviorists interested in mechanisms have minimized variability with precisely controlled experiments. Only recently have there been concerted attempts to develop a methodology for analyzing behavioral variability in animals interacting with each other and their environment.

The present volume consists of six papers each of which expounds a different mathematical approach to behavioral variability. Two concerns permeate the papers: the meaning of variability around modal patterns, and the formulation of models to pose new questions. The au-