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Book Review: *Frontiers of Nonequilibrium Statistical Physics*

Frontiers of Nonequilibrium Statistical Physics. G.T. Moore and M. O. Scully, eds., NATO ASI Series. Plenum Press, New York, 1986.

As I see it, the reviewer of a proceedings volume such as this has two responsibilities. The first is to inform the potential readers of the technical content of the volume. The second is to give an honest opinion on the merit of the papers presented at the meeting, including an evaluation of the probable worthwhileness of reading the proceedings at all. The first task is somewhat simplified in the present case beause Moore and Scully thoughtfully collected the papers into topical sections and provided a picoreview of each section. I have taken the liberty of using their comments below, often without modification.

The seven chapters which open the book are concerned with concepts and analytic machinery which are used to understand and make predictions about the statistical behavior of physical systems. These basic ideas include: measurement and meaning, space-time, probability, information, the principle of maximum entropy, quantum processes, and distribution functions and bifurcations. These lectures often address the philosophical issues that are usually glossed over in a traditional physics curriculum.

The frontiers in some disciplines move more slowly than in others. In quantum mechanics the frontier has jumped about quite a bit over the past 50 years but with no real change in its position. However, certain aspects concerned with its foundation and interpretation are thought to be incomplete, unsatisfactory, or contradictory by many scientists. In 1935 Einstein, Podolsky, and Rosen questioned the completeness of the existing formulation and in so doing left the physics community with the EPR problem addressing the simultaneous measurement of noncommuting observables. Over the years this problem has motivated a number of alternative formulations of quantum mechanics, principal among them being a number of hidden variable theories. Hidden variable theory is, of course, a classical model of the physics-of-the-very-small intended to provide a

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deeper understanding of quantum phenomena. Over a half-dozen papers in this volume are devoted to these topics. It should be noted that these discussions are mathematically simple to follow, but their physical interpretations are subtle and the reviewer often found himself rereading paragraphs to find the elusive point.

Indeterminism in classical statistical mechanics has long been thought to reflect our ignorance of initial conditions and more recently that it may also be associated with chaos. In quantum statistical mechanics indeterminism seems to be unavoidable even in principle. The inequalities discovered by Bell, which are satisfied in a very wide class of hidden variable theories, are not valid in quantum theory. Their violation has been observed experimentally and is discussed.

A number of papers deal with new techniques developed for the treatment of fluctuations, irreversibility, and chaos in quantum systems. The techniques are, without exception, imaginative and mathematically sophisticated, and their individual validity is impossible to assess from a single paper in a conference proceedings.

Another collection of talks was concerned with quantum optics. Masers and lasers have provided an important tool for the study of statistical phenomena in physics. Quantum optical experiments have demonstrated properties such as phase transitions, symmetry breaking, bistability an multiple stability, and chaotic regimes of operations. Much study has been made of the statistical properties of radiation, and has led to concepts such as photon antibunching and squeezed states. Production of such states, in which fewer fluctuations in one quadrature are found than in a coherent state, has been suggested as a means to enhance the signal-to-noise ratio in sensitive optical measurements, such as interferometers to detect gravitational waves or ring-laser gyroscopes. The 147 pages devoted to these topics are a potpourri of physical phenomena blossoming in the area of quantum optics.

The final section of the proceedings is general, with nearly 100 pages covering subjects ranging from Darwinian evolution to Josephson junctions.

I liked most of the lectures published in this volume, say about 75 %. They were thoughtfully prepared and presented on often controversial topics from a particular perspective, and therefore much could be learned even from those in which the authors were clearly off the mark. The remaining 25 % were divided about equally into those talks that the authors did not consider worth the time to write up coherently, those that were so highly speculative that the criteria by which to evaluate them was unclear, and finally a small group of papers in which the information density was so great that a small monograph would have been more appropriate than a short paper. In short, there was a greater percentage of good papers at this conference than at most, where by good I mean well-written papers addressing interesting physical phenomena whose understanding would have far-reaching physical implications.

I recommend this volume to anyone interested in statistical physics and the many guises under which "noise" influences physical processes. The reader must be willing to do some work; the mathematics is sometimes sophisticated, and where it is not, the physical ideas usually are. This is a volume for the reseacher and the advanced graduate student, but not the faint of heart.

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