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Book Review: *Statistical Physics and Chaos in Fusion Plasma*

Statistical Physics and Chaos in Fusion Plasma. Edited by C. W. Horton Jr. and L. E. Reichl. John Wiley and Sons, New York, 1984 (Nonequilibrium Problems in the Physical Sciences and Biology, Vol. II, series editors I. Prigogine and G. Nicolis).

This volume consists of 26 lectures that grew out of a workshop on *Statistical Physics and Chaos in Fusion Plasmas* held at the University of Texas at Austin in 1982. This is very much a work for the experts. Although many of the results concerning the general properties of both conservative and dissipative dynamic systems are more widely applicable than in the plasma physics context, the extensions to other fields will not be made without significant effort. This is in part due to the fact that the general features are often embedded in the technical details of the plasma problems and a certain amount of sifting needs to be done. The recurrent theme of these lectures is the interplay between coherent structures e.g., solitons and clumps, and incoherent fluctuations, e.g., chaos and turbulence, and how each can emerge from the same dynamical description.

The lectures are grouped into the following five major divisions:

Conservative Dynamics: One focus of the lectures in this section, as implied by the title, is on the properties of mappings and the transition from closed phase space orbits (KAM theory) to chaos. The second focus is on integrability as exemplified by studies involving canonical perturbation theories and on the formation and stability of solitons.

Dissipative Dynamics: These lectures are in the main concerned with the transition from regular to chaotic behavior in both continuous and discrete systems. A combination of analysis, numerical studies, and experiment are used to discuss measures of instability such as Lyapunov exponents, the structure of solutions such as fractal basins of attraction, mode–mode coupling processes, and caviton collapse forming clumps in phase space.

Kinetic Theory: The general methods of kinetic theory are reviewed in

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these lectures with special emphasis on the properties of certain instabilities. The importance of diffusive mechanisms in the evolution of fluids, plasmas and model systems are stressed. The exceptions are the somewhat misplaced lectures on fractals.

Turbulence Theory: In these lectures the standard scaling results of isotropic homogeneous turbulence are reviewed and the possible future direction of such research is indicated. The hierarchical models of turbulence such as DIA are critiqued. A drift wave in a turbulent plasma is used to study the possible relation between quasinormal statistics and a chaotic attractor. An integrable system that has soliton solutions and one that has solitary (but not soliton) wave solutions are compared and the instability of these latter solutions result in a decay to the turbulent asymptotic state.

Clumps in Plasma Physics: These clumps are strong correlations in the plasma that persist for an unexpectedly long time and resist diffusive decoupling of nearby particle trajectories. Although such clumping has not been *directly* observed experimentally, in this section the theoretical properties of this phenomenon are developed using a new diagrammatic perturbation theory for a first-principle calculation of the clump kinetic equation. Certain of the scaling properties of these clumps are examined using nonequilibrium statistical mechanical concepts.

In summary, this volume indicates how such concepts as scaling, renormalization, fractal structure, and exotic solitons enter into plasma studies and combine with the more familiar techniques of kinetic and turbulence theory. I recommend this series of lectures to anyone interested in the recent developments in the application of nonlinear dynamics to plasma physics.

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