Thinking thus reflects several advances in an already exciting field. It is well worth reading.

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Statistical Mechanics

Long-Time Prediction in Dynamics. Papers from a workshop, Lakeway, Tex., March 1981. C. W. HORTON, JR., L. E. REICHL, and V. G. SZEBEHELY, Eds. Wiley-Interscience, New York, 1983. xviii, 496 pp., illus. $85. Nonequilibrium Problems in the Physical Sciences and Biology.

To what extent is the Laplace ideal of a deterministic, mechanistic universe operationally useful? Are there conceptual barriers to predicting the future course of a dynamical system from current information? Answers presented in this volume of proceedings are in four sections, reasoning from the general to the specific. The first section, designated Statistical Mechanics, avoids both thermodynamic and narrowly technical aspects associated with the term, concentrating rather on the underlying framework of an ensemble of dynamical trajectories. This subject is a natural vehicle for discussion of the sensitivity of a system configuration to uncertainty in its prior state or states and leads to the now familiar classification of ergodic, mixing, and K systems and so on. A theme running through this section is the relationship between predictability and reversibility. Lebowitz describes how the irreversible Boltzmann equation limit for a dilute hard sphere gas is lost as the permissible initial ensemble required for its validity contracts in time, Misra and Prigogine operate within a solution set in which future-directed correlations are omitted once and for all, and Grad focuses on the full Boltzmann equation hierarchy to indicate how dynamical systems organize themselves in defiance of initial information. Goldstein surveys conditions under which an achieved stationary measure takes on the classical Gibbs form, and Ford analyzes the concept of randomness from the viewpoint of algorithmic complexity.

In the second section, the development of effective stochastic behavior is examined in much greater detail by reference to explicit dynamical systems. Helleman, MacKay, and Greene do this in the context of iterated area-multiplying two-dimensional maps, the first two authors by a continual rescaling (renormalization) that preserves the form of the dynamics and the last by a Cayley representation of 2 × 2 matrices. It is the parametric dependence of such maps that is in question, and the Feigenbaum cascade of period doublings as fixed points become unstable is brought out very clearly, as is convergence to the traditional one-dimensional logistic map when the transformation is dissipative or area-contracting. A transition is then made to continuous-time Hamiltonian dynamics of systems that can be regarded as perturbations of integrable systems presented in angle-action form. Integrability persists, confined to (Kolmogorov-Arnol'd-Moser) phase-space tori, which can disappear as the perturbation amplitude increases. The complementary regions are the home of chaotic trajectories. Escande examines by renormalization a two-variable case (with two competing attractors) masquerading as a time-dependent one-variable Hamiltonian, eliciting a fractal pattern of disappearing tori. Salat and Tataronis show that, for a linear oscillator with quasi-periodic frequency, phase space is integrable either everywhere or nowhere. Lieberman and Tennyson proceed to more than two degrees of freedom, where the KAM tori cannot isolate chaotic regions, now represented by an "Arnol'd web" developing from the zero-perturbation resonance hyperplanes. They discuss the wandering of trajectories via Arnol'd diffusion and modulational diffusion (due to joining of chaotic regions), as well as the effect of noise.

The remainder of the volume is devoted to an array of specific physical problems in which long-time behavior is crucial, starting at the end of the second section with discussions of stability of satellite motion by Szebehely and Vicente and proceeding to a number of studies motivated by problems in plasma physics and accelerator design. Grebogi and Kaufman, and Dubin and Krommes, introduce the Littlejohn noncanonical variable formalism to handle the effect of resonant perturbations on charged particle motion, and Ott shows how stochastic rays can increase accessibility to plasma heating waves. Horton discusses plasma turbulence from a diagram renormalization viewpoint, and Molvig *et al.* develop a stochastic reference model in a Lagrangian flow representation to treat this problem. The genesis of coherent soliton motion is examined by Ichikawa *et al.* in the context of Alfvén waves and by Hyman *et al.* for energy propagation in an α-helix protein.

A final section focuses on beam-beam interaction, with Kheifets analyzing modulational diffusion via the Chirikov criterion for fusion of stochastic layers surrounding resonances and Tennyson treating the same phenomenon from the viewpoint of resonant streaming. Bountis *et al.* reduce cylindrical beam collisions to a two-dimensional map, precluding the possibility of Arnol'd diffusion. The section concludes with an application by Rechester *et al.* of path integral techniques to the Chirikov-Taylor standard map in the presence of noise.

In summary, these proceedings succeed very well in immersing the reader in an active and stimulating field. They are certainly sketchy and are more to be read than studied. But the reader who allows himself or herself to be swept along in the flow of erudition will pick up a good intuitive feeling, a number of valuable techniques, and a desire to deepen his or her understanding by consulting the copious references with which the book is adorned.

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Hummingbirds

The Hummingbirds of North America. PAUL A. JOHNSGARD. Smithsonian Institution Press, Washington, D.C., 1983. 304 pp., illus., + plates. $35.

Hummingbirds rival the F-16 in nonstop flight range and navigational accuracy but are cheaper to operate and ecologically beneficial as well. The hummingbird family, the Trochilidae, is one of the four largest bird families, 342 species by Johnsgard's count. Hummingbirds originated in the tropics of the Western Hemisphere. The 23 species that breed in North America pollinate at least 161 species of plants. Most of the hummingbirds in nine species breeding north of Mexico are migratory; the greatest distance traveled is about 5000 kilometers from Mexico to coastal Alaska by some populations of the rufous hummingbird.

Manifestations of interest in Audubon's "glittering fragments of the rainbow" range from casual observation of hovering at sucrose-water feeders to exploitation of their unique characteristics as subjects of basic biological research. The problems that extremely small body size presents for homeostasis are confronted daily by hummingbirds. Their feeding habits are quantifiable, most of their energy coming from "plants that