

BOOK REVIEW

Nonlinear Phenomena in Physics and Biology. Edited by R. E. Enns, B. L. Jones, R. M. Miura and S. S. Rangnekar. Plenum, New York. 1981. X + 608 pp. Price \$75.

A linear approximation is sufficient for many problems in theoretical neurobiology — examples are subthreshold voltage trajectories in diffusion models of the stochastic activity of neurones, transients in passive electrotonic geometries, or the use of linear systems theory to describe input-output relations in single neurones or neural masses. When elements of the nervous system appear to be more than noisy, linear filters, their nonlinear behaviour may be described by adding successively higher nonlinear terms to the linear approximation. However, although the construction of the Wiener Kernel representation for a neurone may be computationally satisfying, it contributes little to understanding neuronal behaviour. In many cases — the periodic and bursting activity of excitable membranes, solitary travelling waves in axonal systems, the growth of a structured nervous system and the development of spatio-temporal patterns of activity — nonlinearity is essential, and is not just a higher order approximation.

There can be no single approach to nonlinear systems, since nonlinearity is defined by what it is not: however, nonlinear science has grown into a distinct subject, with its own journal (*Physica D — Nonlinear Phenomena*), as there is a group of peculiar behaviours that result from nonlinearity in differential and partial differential systems. These include solitary travelling waves that do not decrement, and some (solitons) that can even pass through each other without any change in shape or velocity; aperiodic behaviour from a periodically driven system, or chaotic, apparently random, behaviour from a deterministic system; bifurcations into periodic activity, and the development of stable spatio-temporal structures. These nonlinear phenomena occur throughout nature, and are especially dense in biology.

The volume "*Nonlinear Phenomena in Physics and Biology*" is the proceedings of a NATO Advanced Study Institute, held in August 1980, and contains tutorial reviews as well as research papers, and deals mainly with nonlinear waves and bifurcations. Some of the papers directly relate to theoretical neurobiology; others are of broader relevance to theoretical biology, and some deal predominantly with methods rather than applications.

The relationship between action potentials and other solitary waves is brought out in an introductory survey of nonlinear waves by Scott: this review emphasises solitons, solitary travelling waves that are not annihilated by collision, and gives a detailed presentation of Davydov's hypothesis for energy transduction in proteins by solitons. Although the action potentials that interest electrophysiologists interfere destructively, they may rest on a metabolic infrastructure of waves that interfere in a nondestructive manner. A paper on spreading depression in neural sheets (Miura) provides another example of destructive interference.

Actions potentials may be regarded as solitary travelling waves; however, they do not occur in isolation, but repetitively. Rinzel considers bifurcation into regular and bursting repetitive activity: the identification of bifurcation points and the construction of bifurcation diagrams requires extensive computations guided by the results of a qualitative analysis of simpler systems.

Of broader interest are papers on bifurcations in morphogenesis (Kauffman) and on cooperative processes in the development of the genetic code (Schuster). All the papers that deal with applications in biology describe how nonlinearity accounts for the phenomenon of interest: they describe the state of the art. What may be of greater value to theoretical neurobiologists are the papers that deal with methods, either technicalities of numerical computation, or mathematical approaches such as the inverse scattering transform, or conceptual approaches such as that of the Brussels school to nonequilibrium statistical mechanics. These papers provide some of the tools that will be used in the future development of mathematical neurobiology: in spite of its exorbitant price, this volume should not be in the libraries of theoretical neurobiologists, but on their desks.

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