Fractals

Continued from page 28

still points in the space enclosed by the Koch curve, for instance, that are not part of the curve. A fractal is thus not really one-dimensional and not really two-dimensional. It hovers in a never-never land somewhere between. For fractals "length" had to be redefined, and a formula was developed for the so-called Hausdorf length that gives a measure of distance independent of the wiggles that keep increasing as the scale gets smaller. "Dimension" has to be regarded in such a way that fractions are permissible, and each fractal curve gets its own number. The dimension of the Koch curve, for example, comes to about 1.26.

Fractals were first applied in a number of situations where there are spatial or temporal characteristics reminiscent of the qualities of fractals: mapping, musical composition, the bonds and bends of macromolecules. The applications Johnston reviewed, turbulence in thermonuclear plasmas and the power spectrum of the sun, represent a move to the analytical side of mathematics rather than the directly geometrical.

Analysis deals with numbers and the elements that go with numbers to make up expressions and equations that can be manipulated according to the rules of arithmetic, algebra, calculus, etc. Analytical expressions are a less cumbersome and more versatile means of expressing and predicting relationships between different quantities than are geometric figures. Fractals can be expressed analytically in the form of series, Johnston says.

A mathematical physicist looks for an expression that has mathematical qualities analogous to the physical characteristics of the system for which a theory is sought. If such a mathematical expression exists, it may make a good description of the physics. If the mathematics can be shown to represent accurately the important numerical relationships in the physical system and to predict future changes in the important quantities, it may become the basis of a good theory of the physical system.

For turbulent motions in thermonuclear plasmas an equation with fractal characteristics may fit, what Johnston calls the "notorious Weierstrass equation," or rather an amended version called the Weierstrass-Mandelbrot equation. The Weierstrass-Mandelbrot equation connects the main quantities of interest in analyzing turbulent motion: frequency, amplitude and space. To give Johnston's definition, it is "the trigonometric sum of the geometric spacing of frequency with amplitude," all this expressed in numbers.

The solutions of the Weierstrass-Mandelbrot equation form a series of equations to which different fractal dimensions may be assigned. If these solutions are graphed, they come out spiky, full of sharp corners. They have a kind of accordion-pleat appearance. For these equations fractal dimension measures the degree of roughness, the number and sharpness of the abrupt changes in the quantity being calculated, which are represented by the spikes in the graph.

In these graphs, as Johnston points out, there's "never a straight line." That characteristic is highly reminiscent of turbulent motion: "It's intrinsically nonlinear," Johnston says. These solutions to the Weierstrass-Mandelbrot equation seem to apply to turbulence in other ways, Johnston says. They seem to be erratic, but they are actually governed by a very few control factors, and at some critical point they show a transition from smoothness to roughness that is reminiscent of the onset of turbulence in a physical system.

Frank Peseckis of Columbia University was thus inspired to suggest a new way of analyzing turbulence in plasmas. The old way is to separate the motion into two components, a slowly varying average part and a rapidly varying random part. Instead of separating into slow and fast, Peseckis suggests using smooth and rough as the criteria: A smoothly varying part and a fractally varying part. The steps that follow the separation are to calculate the development of the two parts and how they affect each other. A principal goal, says Johnston, is to calculate transport coefficients, that is, the rates of movement of particles and energy through the turbulent plasma. The transport coefficients would be determined by the fractal dimension of the turbulence at the particular location where someone wanted to know them. If it works, this could provide some handy rules for calculating how a particular degree of turbulence affects the characteristics of a plasma (temperature, density and confinement) that are crucial to fusion experiments. It's got a way to go till it proves itself.

Meanwhile, similar kinds of analyses are being applied to analogous systems, the power spectrum of the sun, for instance. The power spectrum relates the amount of power emitted by the sun at any given frequency to that frequency's place in the succession of frequencies. The quantities of interest here are similar to those of the turbulent plasma and the solar radiation is produced by a system that has many analogies to the turbulent plasmas studied on earth. Theoretical analysis of the solar spectrum is proceeding along similar lines.

Once fractals got into the solar system they were bound to extend the area of their influence. Johnston mentions that efforts are also underway to use fractals in developing a theory for the distribution of asteroids in the asteroid belt. This is a topic that traditional gravitational theory finds very difficult to handle. Fractals have been considered a far-out topic in mathematics. With astrophysics their applications are far out too. ☐

BOOKS

BOOKS is an editorial service for readers' information. To order any book listed or any U.S. book in print please remit retail price, plus 50¢ handling charge for each book to **Book Order Service,** Science News, 1719 N Street, N.W., Washington, D.C. 20036. All books sent postpaid. Domestic orders only.

THE ART OF THE ENGINEER—Ken Baynes and Francis Pugh. Presents the history and beauty of draftsmanship, as expressed in engineering drawings that span more than two centuries. Each drawing is accompanied by text that describes the development of the skills of draftsmanship in a rapidly developing technology. These drawings, originally produced for purely functional and mechanical purposes, can be appreciated on a humanistic level. Overlook Pr, 1981, 240 p., color/b&w illus., $75.

CAUSE, EXPERIMENT AND SCIENCE: A Galilean Dialogue Incorporating a New English Translation of Galileo's "Bodies That Stay atop Water, or Move in It" — Stillman Drake. The dawn of modern science began with a quest for laws of nature based on experiment and measurement. One of the first printed books to herald that new approach is presented here in modern English. Drake's purpose is to throw light on the sudden rise and spread of general as well as professional interest in experimental science during the 17th century. U of Chicago Pr, 1981, 237 p., illus., $20.

THE HERPES BOOK— Richard Hamilton. The herpes virus is one of the most prevalent viral diseases. To most infected people it brings discomfort in the form of blister-like sores. Herpes does not respond to any currently known form of therapy; once a person is infected, the virus remains for life. This book provides basic information about herpes, tells how to cope with the virus and how to prevent or minimize its possible complications. Originally published in hardback in 1980. JP Tarcher (HM), 1981, 206 p., paper, $4.95.

THE LARGE INTESTINE: Its Role in Mammalian Nutrition and Homeostasis— O.M. Wrong et al. For the research worker the volume draws together the current knowledge in this area. Includes a large bibliography. Wiley, 1981, 217 p., illus., $24.95.

MAJESTIC LIGHTS: The Aurora in Science, History and the Arts— Robert H. Eather. The aurora is the visible manifestation of the turbulent magnetic and electrical environment around our planet — the only effect man can observe with his unaided senses. Chronicles the mysteries and myths, the poetry and legends, the esoteric and aesthetic lore of the aurora, together with the science of this fascinating phenomenon. Am Geophysical, 1981, 323 p., color/b&w illus., $49.

THE PHYSICIANS' DRUG MANUAL: Prescription and Non-prescription Drugs — Rubin Bressler et al., Eds. This book, intended for the general reader, presents the actual drug information tables that physicians use in their daily practice of medicine as well as material written especially to help the lay reader understand the more technical information. These facts are intended to reinforce the information provided by your doctor and pharmacist. Doubleday, 1981, 1213 p., color illus., $17.95, thumb indexed $19.95.

SUPER INSULATED HOUSES AND DOUBLE ENVELOPE HOUSES: A Survey of Principles and Practice— William A. Shurcliff. Describes and compares these two types of houses in general terms. Specific houses are described in detail. Explains the main principles used, questions the merits of individual design features, suggests possible improvements. Lists the main organizations and individuals involved in this type of building. Brick Hse Pub, 1981, 182 p., illus., paper, $13.95.