

FINDING SELF-SIMILARITY IN A WORLD OF COMPLEX SYSTEMS

Fractals, Chaos, Power Laws: Minutes from an Infinite Paradise

Manfred Schroeder
Freeman, New York, 1991.
429 pp. \$32.95 hc
ISBN 0-7167-2136-8

Reviewed by Kurt Wiesenfeld

There is a trend among physicists when confronted with a complex phenomenon to describe it as a self-consistent whole, rather than a collection of neatly independent—and ultimately simple—pieces. While there is no consensus on the best way to quantify complexity in general, we think of fractals as representative of spatial complexity and chaos as the hallmark of temporal complexity. Scientists have pursued these subjects diligently in recent years, and the ideas that have emerged carry a great deal of allure and power. The subject has also generated more than its share of buzzwords and a library's worth of coffee-table picture books.

In the preface to his latest book, Manfred Schroeder writes that "the unifying concept underlying fractals, chaos and power laws is self-similarity." Complex systems then are not random aggregates but have an internal order in which pieces of the systems are, roughly speaking, miniature copies of the whole. Schroeder draws together an impressively diverse set of examples to show us that nature is absolutely full of self-similarity. The book will not convince the skeptical reader of the inevitability of this world view. The willing reader, however, can sit back and enjoy an all-encompassing, irrepressibly enthusiastic tour, ranging from psycho-

physics to quasicrystals, from gambling strategies to Bach concertos, from the construction of Cantor sets to the design of concert halls.

The book is appropriate for the scientifically inclined, an audience comfortable with reading *Scientific American*. Schroeder, a physicist who holds over 40 patents and is also the author of a book on number theory, touches on a great many topics, and the book tends to jump around rather than follow a steady progression. Happily, there is a good deal of cross-referencing, which is useful for the reader who can't resist turning instantly to the sections on beating roulette or the Cantor-set sundial.

The teacher looking to spice up an undergraduate course with an occasional lecture on frontier topics can find suitable overviews of percolation, cellular automata, real-space renormalization and chaos in the logistic map. The book is also a nice source of quotable quotes (for example Pauli's "If a theoretician says 'universal' it just means pure nonsense") and beautifully popular examples, like the mode locking between a frustrated pedestrian and city traffic signals. Also thrown in are bizarre historical footnotes, including descriptions of a devious and deadly cavalry maneuver used by Genghis Khan, the astonishingly public birth of the Holy Roman Emperor Frederick II and Leibniz's invention of the binary number system while waiting to see the Pope.

As notable as the book's broad sweep is the author's good-natured, humorous presentation. The style is casual rather than technical, playful rather than pedantic. Schroeder has an obvious love of language, which he displays by way of amusing anecdotes, occasional alliteration and (lookout!) numerous puns. He also tends to go overboard in connecting as many "big ideas" as possible, so that some allusions—to, for example, global warming, dinosaur extinction, cosmic strings, dark matter and superconductivity—come across as gratuitous.

This may annoy some "serious-minded" readers, but for others it will probably help to convey the high level of excitement associated with the scientific frontier.

Because the depth of treatment is highly variable, the book has something for everyone. For example, the precocious undergraduate who devours James Gleick's popularization *Chaos: The Making of a New Science* (Viking Penguin, New York, 1987) and craves a more meaty follow-up should tackle Schroeder's book cover to cover. The scientist who is somewhat familiar with the standard examples of fractals and chaos can dip into the book here and there. And even the expert is bound to come across several unfamiliar examples. In all cases, extensive references to the technical literature enable motivated readers to pursue those subjects that particularly excite their imagination.

Nuclear Structure from a Simple Perspective

Richard F. Casten
Oxford U. P., New York, 1990.
376 pp. \$59.00 hc
ISBN 0-19-504599-5

The topic of this book, nuclear structure, is currently enjoying something of a revival. This renaissance is due mainly to the discovery in 1986 of super-deformed nuclei. Although the developments in this area have occurred too recently to be included in this book, they provide an excellent reference for many of the underlying concepts in nuclear structure theory.

One hopes that nuclear structure physics will attract more interest in the 1990s than it did in the 1980s, and Richard Casten's book provides a beautiful and very physical presentation of some of the essential material. Casten is a senior nuclear physicist at Brookhaven National Laboratory. His group has probably done more than any other in studying the experi-

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mental consequences of the interacting boson model for nuclear spectroscopy. Thus he is uniquely well qualified to write this book. A recent book that covers similar material is *The Nuclear Shell Model* (Springer-Verlag, New York, 1989) by Kris Heyde. Earlier well-known books with similar titles were written by Niels Bohr and Ben Mottelson, P. J. Brussard and P. W. M. Glaudemans, Amos DeShalit and Herman Feshbach, and DeShalit and Igal Talmi. However, the emphasis in all these books is to teach the reader how to do shell model calculations. Casten's objective, as he states in the preface, is to help people get an intuitive understanding of what is going on, and in my opinion, he has succeeded very well.

Casten's book is divided into four parts. The introduction deals with some simple concepts necessary for any understanding of nuclear structure. One such concept, for which it is not so easy to find a simple discussion, is the problem of mixing between two states. There is also a short summary chapter containing a brief survey of nuclear systematics. The last part of the book is rather short and contains a brief discussion of some selected experimental techniques that bear on the questions discussed in this book.

The second part of the book deals with the shell model. It contains a nice discussion of the effect of simple residual interactions such as a delta interaction on the spectrum of two- and multiparticle configurations. Some of the features of the spectra can be understood on classical grounds, as the book discusses in some detail.

It is, however, the third part—on collectivity, phase transitions and deformation—that may include the most original contributions of the book. Here Casten deals with general features of collective motion, including the connection to configuration mixing. Casten discusses the Nilsson model in some depth, but from a very intuitive point of view. Also covered is the Coriolis interaction, which plays a very important role in rotational spectra—especially in high spin states. The structure of collective vibrations is also treated.

One thing not covered is the microscopic basis of any of the models used, say, in terms of realistic interactions. The author points out, however, that many of the interesting features of nuclear spectra do not depend very much on details of the nucleon-nucleon interaction between free nucleons, but rather are more dependent on general properties of the

mean field and on pairing effects. The discussion of the interacting boson model, which forms a long section of the book, is very nicely presented. The reader with little previous experience will doubtless learn the essential things about the first version of the interacting boson model, generally called IBM1.

It is well known that nuclear deformations require the action of both neutrons and protons. Nuclei with single closed shells show vibrational structure but no ground-state deformations. A newer version of the IBM—known as IBM2—takes this into account, but it is not mentioned in this book. On the other hand, the author certainly addresses the phenomenology of varying N and Z on nuclear spectra and transition rates. In fact, the so-called $N_p N_n$ scheme, a very useful parameterization of shell effects, was largely developed by the author and is discussed here. I believe the IBM2 could provide more of a microscopic basis for this very successful scheme than can the IBM1.

In summary, this book is highly recommended for anyone who wants to get a better intuitive understanding of low-energy nuclear structure physics. This includes people working in the area, as well as students in a graduate nuclear physics course.

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Dangerous Thoughts: Memoirs of a Russian Life

Yuri Orlov

(Translated from the
Russian by T. Whitman)

William Morrow, New York,
1991. 348 pp. \$21.00 hc
ISBN 0-688-10471-1

Yuri Orlov, human rights advocate, Soviet dissident and currently a professor of physics at Cornell University, was released in 1986 from "internal exile" in Siberia as part of an exchange between the Soviet Union and the United States involving Orlov and two accused spies. Thus Orlov was released to the West, after serving seven years at hard labor and three years in exile and after leading a full and difficult life in the Soviet Union.

In *Dangerous Thoughts*, Orlov tells of his life in the Soviet Union. And what a life he had: a child during the Stalinist times (witnessing hushed conversations between adults and the disappearance of teachers and friends), a wartime laborer on T-34

tanks, an army officer, a student, a member of the Communist Party, a professor, a dissident, a prisoner and an exile. As he describes in this fine book, he experienced nearly every layer of Soviet society; he would "like readers to see in this book a picture of millions and millions of other lives, as well as glimpse the Russian tragedy of the twentieth century."

Although Orlov's description of his life prior to his break with the Communist Party in 1956 is quite interesting, his subsequent experiences are what make the book such exciting reading. He openly supported Andrei Sakharov beginning in 1972, had key involvement in founding the Moscow Chapter of Amnesty International in 1973, formed the Helsinki Watch group in Moscow in 1976 (which led to the formation of similar groups in other countries), was arrested in 1977, underwent KGB questioning for a year, and was then imprisoned, tortured and finally exiled. The reader will find the book educational, fascinating and tragic.

Western physicists worked on behalf of Yuri Orlov during his painful years. In addition to individual efforts, there were organized efforts through the Orlov Committee at CERN and Scientists for Sakharov, Orlov and Shcharansky (known as SOS) based in Berkeley. I took part in some of these endeavors: Within three days of Orlov's arrest I had organized a telegram of protest, which was signed by over 100 prominent scientists. I also remember an incident in 1983, when I put up a petition at the International High Energy Accelerator Conference at Fermilab, asking for a change of venue of the next meeting, scheduled to be held in the Soviet Union in 1986. The Soviet delegation protested against this action to Leon Lederman. He told them, "This is a free country and anyone can put up anything on a bulletin board." The Soviets' response was, "We have a free country too, but we don't allow things like that."

Orlov's autobiography, besides being inspiring, is a delight to read, for the scenes, experiences, adventures and ordeals are presented in a tasteful, modest and literate way. The reader will find him or herself becoming ever more involved with and sympathetic toward the author, hoping that he will win out, not only for personal reasons, but because all of us want Soviet society to become just and rational. We "hope beyond hope," in Orlov's words, that this "adolescent of history will become a healthy, normal nation."