

scientists fear or that the consequences will not be severe enough to warrant action now.

Bennett takes those two positions head on. He makes a convincing case for the reliability of temperature data and our climate records, which show that the world is indeed warming. He shines a light on how cherry-picked data are often used by skeptics to downplay the rate of global warming. He then examines the possibility that the warming could be natural—for instance, from changes to the Sun. What I loved about the chapter is that Bennett doesn't pull punches. He calls a spade a spade, and he quickly and carefully exposes the illogical positions of some of the best-known climate contrarians. At the same time, he does a great service to his readers by engaging them in a dialog rather than lecturing. Bennett's dialog, driven by questions and supported with accurate science, leads to persuasive and clear conclusions.

With the science clearly established, the author moves to discussions of climate models, including analysis of their

strengths and weaknesses. He also explores regional climate changes, effects beyond simple temperature changes, and both positive and negative consequences that we can expect in the future.

It is rare for an academic to write a book that is such a joy to read. *A Global Warming Primer* is one of the exceptions. Although my favorite parts of the book are its explanations of climate change science, many readers will most enjoy the last two chapters, which focus on

solutions and our legacy. In quick order Bennett covers energy conservation, clean energy sources, and geoengineering mitigation. He also discusses the political and economic roadblocks to enacting sound energy and climate policies. He ends by making it personal: His final chapter is titled "A Letter to Your Grandchildren."

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Energy from Nuclear Fission

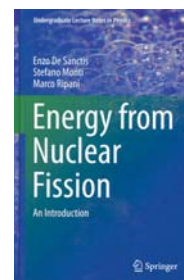
An Introduction

Enzo De Sanctis, Stefano Monti, and Marco Ripani

Springer, 2016. \$59.99 (278 pp.). ISBN 978-3-319-30649-0

From the birth of nuclear physics to the thousand-megawatt nuclear reactors that power cities today, there stretches a great arc of technological maturation. In the early days of nuclear research, Ernest Rutherford dismissed the harnessing of nuclear energy as "moon-

shine." But Leo Szilard's bathtub brooding about chain reactions, Lise Meitner and Otto Frisch's famous Christmas walk in the snow, and Enrico Fermi's critical "pile" at the University of Chicago have led us to a new



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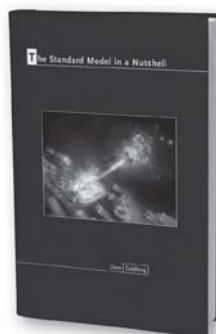


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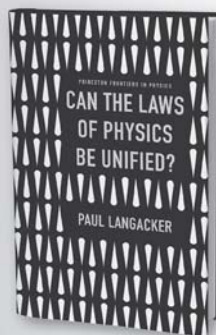


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world, to an industry that operates 450 reactors worldwide. With maturity comes complexity, however, and the generation and use of fission energy creates challenges both technical and social.

In *Energy from Nuclear Fission: An Introduction*, authors Enzo De Sanctis, Stefano Monti, and Marco Ripani survey their subject in a novel manner. The authors are able to draw from their own wide-ranging experience with nuclear science. De Sanctis is a director of research emeritus at Italy's National Institute for Nuclear Physics (INFN); Monti, a nuclear engineer and former scientific secretary at the International Atomic Energy Agency; and Ripani, a senior scientist at the INFN. The volume has two parts; it is, in effect, two books. The first "book" is a 150-page technical tutorial devoted to the relevant nuclear physics. It is aimed, the authors claim, at bright undergraduates. The second is a 100-page survey of the engineering challenges associated with nuclear energy. The section is almost entirely independent of the previous material, uses few equations, and could be read by an interested citizen with little science background.

The first part of *Energy from Nuclear Fission* is titled "Nuclear Physics and Radioactivity." The first chapter begins at the beginning, with the Greek philosophers Democritus and Leucippus, credited with developing the first notions of the atom. The authors then move on to a conventional overview of energetics, including discussions of mass defects, stability, and the Q values of reactions. The chapter concludes with an appealing section on nuclear abundances.

The next chapter is devoted to radioactivity. It begins by describing the several decay processes that characterize the phenomenon and then turns to many associated issues, including the penetrating power of several radiations and "softer" but important topics associated with dosimetry, biological effects, and applications in industry and clinical medicine. Indeed, room is found for comments on the controversial linear no-threshold proposal and on hormesis. In the rather amusing table 2.6, which is devoted to "activity," the health risk associated with exposure to 0.1 millisieverts of radiation is shown to be about the same as for eating 40 tablespoons of peanut butter or spending two days in

New York City. That table alone earns the authors their royalties. The rich section ends with a discussion of radiocarbon dating.

What is striking about the book is the quality of the writing and the presentation of material. The graceful prose makes reading their book a pleasure. The sections are illustrated with graphs, pictures, and worked examples and are supplemented with problems to challenge the reader. There is also the curious practice of attaching birth year and place and death year and place to every scientist mentioned in the text—for example, Ernest Rutherford (Brightwater, New Zealand, 1871–Cambridge, England, 1937). The topics chosen are lively and interesting. One encounters, for example, proton–proton fusion, the mass defect that follows the collision of two lumps of plasticine, and the life of the Sun.

The book is aimed at an undergraduate audience, and readers will not need an extensive mathematical background to understand the material—there is not a whiff of quantum mechanics. Most challenging, perhaps, is the authors' decision to plunge into simple differential equations and devote seven pages to the topic of sequential radioactive decay and its mathematics.

The third, final chapter in part 1 centers on fission and chain reactions. It is rich in nuclear physics; for example, the thorium fuel cycle appears in detail. But part 1 contains only a minimal treatment of nuclear-reactor physics. It is, perhaps, a difficult topic to treat without introducing the challenging mathematics of diffusion processes in space and energy, but its inclusion would

have enriched the chapter. The authors employ the mathematics of sequential decay to treat xenon poisoning, but they miss the opportunity to tell the story of John Wheeler, Enrico Fermi, and the poisoning of the Hanford Site's B Reactor. The same mathematics might have provided a more mature discussion of delayed neutrons and reactor dynamics than the text contains.

Part 2 of *Energy from Nuclear Fission* brings the reader to the world of nuclear engineering and is a self-contained essay on the state of the industry. This second "book" is encyclopedic and perhaps deserves its own review. The authors quickly introduce the full nuclear-reactor zoo, with its many species and their associated technologies. The essay moves on to cover reactor generations I–IV and their features—mining, milling, fabrication, and storage; the management of the four types of radioactive waste; and safety and security. The six levels of the International Atomic Energy Agency's International Nuclear Event Scale are explained and displayed handsomely, and 10 of the most relevant reactor accidents are described in some detail.

This fine book's most notable flaw is, perhaps, the absence of an index. Though some readers may feel that a reference book without an index is no better than a doorstop, there are mitigating features in this case: The table of contents is quite detailed, and the book includes a helpful glossary of two dozen pages.

In sum, *Energy from Nuclear Fission* is a unique, rich, and valuable resource.

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Lyapunov Exponents

A Tool to Explore Complex Dynamics

Arkady Pikovsky and Antonio Politi

Cambridge U. Press, 2016. \$84.99 (295 pp.). ISBN 978-1-107-03042-8

The title of Edward Lorenz's 1972 American Association for the Advancement of Science talk, "Predictability: Does the flap of a butterfly's wings in Brazil set off a tornado in Texas?," elegantly conveys the hallmark of chaotic dynamics: sensitive dependence on initial conditions. The "butterfly effect" has captured the public's

imagination; it has been used as the title of three motion pictures and the name of an Australian hard rock group.

Public perceptions and misperceptions aside, how do physicists provide a quantitative description of sensitive dependence on initial conditions? The answer to that challenge is given in *Lyapunov Exponents*.

