

BOOKS

NEO Impacts: Some Solid Analysis and Some Extreme Projections

Rain of Iron and Ice: The Very Real Threat of Comet and Asteroid Bombardment

John S. Lewis
Addison-Wesley, New York, 1996.
236 pp. \$25.00 hc
ISBN 0-201-48950-3

Rogue Asteroids and Doomsday Comets: The Search for the Million Megaton Menace That Threatens Life on Earth

Duncan Steel
Wiley, New York, 1995. 308 pp.
\$24.95 hc ISBN 0-471-30824-2

Reviewed by David Morrison

Statistically, on any given day there is an asteroid or comet fragment of at least 10 m in diameter passing the Earth within the orbit of the Moon. Depending on the density and velocity of the projectile, the kinetic energy would, if the projectile hit the Earth, approach a megaton of explosive power.

Public concern is increasing, and in the past five years a half-dozen major scientific meetings have been held to discuss near-Earth objects, or NEOs, and the hazard they pose. Both the US Congress and the Parliament of the European Union have placed their concern about the impact hazard on the legislative record. NASA has carried out three studies of strategies for dealing with the NEO impact threat. Now we have two book-length treatments of the impact hazard, both writ-

ten for the nonprofessional but scientifically literate reader by scientists who have played significant roles in defining the impact threat and proposing ways to deal with it.

John Lewis, author of *Rain of Iron and Ice*, is professor of planetary science at the University of Arizona and one of the leading proponents of the use of asteroidal resources for long-term space development. His book is written primarily for the lay audience, but it also contains original information and suggestions directed toward scientific colleagues who study NEOs professionally. Undoubtedly, this is the best book written to date on NEO impacts, offering an outstanding introduction to the field for lay readers and scientists alike.

Lewis covers all the relevant issues of the nature of NEOs, the impact history of the solar system, the contemporary impact hazard and possible defenses against incoming comets and asteroids. His writing style is compact, clear and comprehensive. In addition to his solid coverage of the basics, Lewis probes three areas that are often neglected in discussions of this subject: (1) He clearly places Earth impacts in the broader context of the solar system, with extensive discussion of the lessons learned from the cratering histories of the Moon, Mercury and Venus; (2) he places emphasis on the long history of eyewitness reports of terrestrial bolides, meteorite showers and atmospheric detonations, many of which have done considerable damage, including substantial human casualties—evidence that is overlooked or rejected by most workers in the field; and (3) he uses current models of impact flux and impactor entry physics to “reconstruct” ten different Monte Carlo, one-century scenarios, with vivid details of individual impacts and their damage, to illustrate the variety of impact events.

Generally speaking, the Earth’s atmosphere protects us from impactors having energy less than about ten megatons; below this energy, most comets and stony asteroids fragment and detonate at such high altitudes that there is no surface blast damage. However, Lewis gives more attention than have others to the effects of impacts

in the megaton range by relatively slow-moving objects, which he believes can also endanger small areas. Nevertheless, he concludes, along with most of us who have examined the hazard in any detail, that the greatest statistical risk is from objects that are large enough to cause global ecological damage. This threshold for global catastrophe is at an energy of about a million megatons, corresponding to an object diameter of roughly 2 km. At and above this threshold, impacts could kill billions of people and put the survival of civilization at risk.

One of the most interesting features of the impact danger is that the greatest risk is associated with the larger and rarer events, those that take place on roughly million-year timescales. Next in level of severity are smaller, ocean impacts that generate tsunamis, and below that are the explosions, like the 1908 impact in Tunguska, Siberia. Even though a 15-megaton event like Tunguska could destroy a city, we can expect such a hit on a city only about once in ten millennia, and the statistical risk is therefore orders of magnitude smaller than that of other more familiar natural disasters. Fortunately, the larger impactors are also the easiest to discover and predict, leading to relatively cost-efficient strategies for greatly reducing the risk of such impacts.

Duncan Steel, author of *Rogue Asteroids and Doomsday Comets*, is well-known worldwide as a leader in NEO searches, a researcher on the orbits of meteor streams and a writer of popular books and articles about the NEO impact risk. Steel covers the same basic issues as does Lewis. Given his professional background, Steel’s book is especially strong in its discussions of asteroid searches and dynamical issues. Roughly the first half of the book is on a par with Lewis’s and can be recommended with equal enthusiasm.

In many other places, however, Steel departs dramatically from the mainstream to advocate the positions associated with a small group of British neo-catastrophists. Consequently, the book is interlarded with neo-catastrophist ideas, such as Victor Clube’s attribution of a wide range of historical events (including the Dark Ages and

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the Reformation) to varying rates of meteoric phenomena. In dynamics, Steel espouses the extraordinary idea that "the main [asteroid] belt is not being depleted to supply meteorites and Earth-crossing asteroids, but quite the opposite." Steel asserts that the main belt is growing, thus reversing "time's arrow." Elsewhere he devotes many pages to an original theory that Stonehenge is a monument inspired by a rain of meteors and comets over prehistoric England. Perhaps some of these unorthodox ideas are deserving of serious scientific discussion, but their inclusion as fact in a popular-level book detracts significantly from its overall value.

The contrast between these two books is thought provoking. Both are well written, are by reputable scientists, cover essentially the same topics at the same level and were released by major publishers within a few months of each other. Yet one is accurate and authoritative, while the other digresses so frequently into speculation that it cannot be trusted as a reliable source of information.

Modern society has a preoccupation with calamity and a growing intolerance for risk in any form. Since public concern over impacts is fueled by the appearance of bright comets (such as Hale-Bopp in the spring of 1997), the well-publicized 1994 collision of the comet Shoemaker-Levy 9 with Jupiter and continuing reports of asteroidal "near misses," we can expect more books on this topic in the future. Sooner or later, we may well have to assess the value and efficacy of proposed defensive systems. It may also become essential to ask how the risks inherent in maintaining a nuclear asteroid defense system compare with the actual threat it is designed to mitigate. Lewis's book provides an excellent starting point.

Quantum Field Theory in Condensed Matter Physics

Alexi M. Tselik
Cambridge U. P., New York,
1995. 332 pp. \$74.95 hc
ISBN 0-521-45467-0

Quantum field theories have long been used in condensed matter physics to describe the quantum physics of many electrons interacting with each other, with phonons and with random disorder potentials. These applications of quantum field theory underpin much of our modern understanding of the electronic properties of solids and are ably

summarized in the influential and well-known texts by Alexi Abrikosov, Lev Gorkov and Igor Dzyaloshinsky, Alexander L. Fetter and John Dirk Walecka, and Jerry Mahan, among others.

Recent years have seen an explosion of more "crafty" applications of quantum field theory. These circumvent the insurmountable difficulties that often frustrate a direct approach by starting from partially phenomenological, low-energy effective field theoretical models. The phenomenological approach has an important historical root in the spin models used for the low-energy properties of magnetic insulators. The power of this approach is evidenced by recent advances in our understanding of, in particular, low-dimensional electron and spin systems.

The increasingly nimble use of diverse field theories in describing condensed matter physics systems has generated a need for monographs that provide a more expansive view of quantum field theory than do traditional condensed matter "many-body theory" texts. Several books have appeared recently in response, including Assa Auerbach's *Interacting Electrons and Quantum Magnetism* (Springer-Verlag, 1994), Eduardo Fradkin's *Field Theories of Condensed Matter Systems* (Addison-Wesley, 1991) and most recently Alexi Tselik's *Quantum Field Theory in Condensed Matter Physics*. All these books present nonperturbative approaches to interacting electron systems, approaches that are motivated in part by theoretical efforts to understand high-temperature superconductivity. All of these books develop formulations of interacting spin models, a topic not addressed at all in most traditional texts, and they contain extensive discussions of the physics of low-dimensional quantum antiferromagnets. Together they provide a valuable resource for students and active researchers in condensed matter theory.

Tselik has attempted to produce a book that is somewhat more comprehensive than its immediate antecedents. The book starts with a discussion of the path integral formulation of quantum field theory for bosons and fermions. This section includes brief general presentations of diagrammatic perturbation theory for bosons and fermions, as well as an extensive discussion of violations of the Landau Fermi liquid theory in metals due to the exchange of transverse photons between electrons. This is followed by an introduction to various field theoretical formulations of interacting spin models. In applications, the emphasis in this section is on the physics of spin-liquid systems. For me, the book succeeds most impressively in its final

section, which addresses the physics of $(1+1)$ -dimensional quantum models and the corresponding two-dimensional classical statistical mechanics models. Emphasis here is placed on explaining the use of conformal symmetry in many of these models.

Tselik's stated objective for this book is to familiarize condensed matter physics students, and researchers who have not been active in this area, with recent achievements in quantum field theory. By this measure, his exposition is admirably successful. The treatment of the more traditional condensed matter many-body perturbation theory is not, by either the author's estimation or my own, sufficiently thorough for this book to serve as a stand-alone replacement for the classic texts.

The presentation of conformal symmetry applications is equally terse but will, I believe, serve well for readers seeking a quick and casual introduction. I suspect that the book will, as intended, find its greatest value in bridging the gap between courses based on one or another of the standard texts and the current research literature on low-dimensional electron and spin model systems. The author's breezy writing style brightens the text, and his amusing sketches of some active researchers provide occasional welcome diversion.

I expect my copy to become one of the more ratty items on my bookshelf.

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Molecular Physics and Elements of Quantum Chemistry: Introduction to Experiments and Theory

Hermann Haken
and Hans Christoph Wolf
Translated by William D. Brewer
Springer-Verlag, New York, 1995.
406 pp. \$49.50 hc
ISBN 0-387-58363-7

Molecular Physics and Elements of Quantum Chemistry is a graduate or advanced undergraduate textbook written by two prominent German molecular physicists: Hermann Haken is a theorist who works broadly in radiation and relaxation; Hans Christoph Wolf is a spectroscopist with wide interests in organic molecules and solids. Since molecular science becomes physical chemistry or chemical physics in the US, their physics perspective re-