

physical processes in the events that unfold as the universe evolves.

In an attempt to make the story of the universe accessible to the reader, Krauss uses an oxygen atom to give a microscopic point of view to the evolutionary processes. In the early universe, this oxygen atom exists simply as its constituent nucleons, which become 12 hydrogen atoms and a helium atom as a result of Big-Bang nucleosynthesis. Then these constituents participate in star formation, but Krauss takes them through several scenarios before they become fully synthesized into ^{16}O . The oxygen atom is presented during the formation of the solar system and manages to be part of the processes occurring in Earth's atmosphere, oceans, and rocks. But this participation is somewhat limited, until Earth develops its oxygen atmosphere and the atom can participate in life's respiratory cycles. In the long run, the Sun heats up, expands, and the atom is blown into space, where it can participate in further adventures. A remarkably versatile atom!

Viewing the course of the universe through the eyes of an atom is a clever idea, but I don't think Krauss carries it out as successfully as he had hoped. Krauss concentrates on telling the story of universal evolution, and from time to time he tells us in a paragraph or two how this affects his atom. Thus the atom is not really central to the theme of the book. In fact I found it a distraction, partly because the participation of the atom in the events is artificially contrived, and I found the events themselves—from creation to extinction—much more interesting. In the book these events just happen, for the most part, and I think many readers would like a little more explanation of why they happen. Why does a star expand when it finishes burning hydrogen in the core, for example? At the level of physics understanding assumed by Krauss, I think that some indication could have been given of how physical processes like this work. But I will be interested in a review of this book by someone who has had just those one or two courses of college physics, to see if that reader feels the same way.

The book contains only three illustrations, diagramming the gathering of a dense gas of quarks into bound clumps as the gas expands. Although Krauss exhibits a mastery of smooth, vivid, and colorful language in his word pictures, many of his explanations would have been much clearer if they had been accompanied by real illustrations.

Despite such carping, I must endorse this book as a good example of the attempts that should be made to educate the public in scientific matters, to show that science is interesting in its own right, and to deal with the complexities of modern science in all of their interdisciplinary glory. Krauss tells us of his efforts to expand his own understanding of the planetary, geological, and life sciences as he prepared to write the book. As far as I can tell, he became, in the process, quite current on the thinking at the frontiers of these subjects. The only area in which I found his work deficient concerned the attempts to date the events in the formation of the solar system, including Earth, using the extinct radioactivities. There are many more of these radioactivities now known than Krauss describes, and some of them indicate that things went much faster than he indicates.

It is said that the future of physics lies in understanding complexity. But there is no magic shortcut. The physicist must identify all the important processes and find which ones govern the behavior of a system. Then the principal properties of that system will usually become clear. To a considerable extent that is what Krauss has done here, but the physical reasoning is in the background, and only the conclusions are presented as an entertaining story.

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Solar and Stellar Magnetic Activity

Carolus J. Schrijver
and Cornelis Zwaan
*Cambridge U. Press, New York,
2000. \$80.00 (384 pp.).
ISBN 0-521-58286-5*

The study of solar and stellar activity is currently one of the most vibrant and interesting fields of astronomy. Solar physics is being revolutionized by many surprising discoveries from the SOHO (Solar and Heliospheric Observatory) space satellite, launched jointly by the European Space Agency and NASA, and from NASA's Transition Region and Coronal Explorer (TRACE) mission. The observations from these missions are being eagerly examined, interpreted, and modeled by a new generation of lively young solar researchers, especially in Europe, but also in the US.

Stellar observations are becoming not only more numerous but also

increasingly sophisticated, leading to the discovery of many solarlike phenomena (such as spots, flares, prominences, activity cycles, and global oscillations) on other stars. The detailed properties of these processes are being investigated in parameter regimes that are quite different from those on the Sun.

It is, however, astonishing that many fundamental properties of the Sun are not yet understood. These include the generation of magnetic fields by dynamos; the heating of the outer atmosphere (the corona); the acceleration of the solar wind (the particle outflow from the Sun); the power source of solar flares; and the trigger mechanism of great solar eruptions—coronal mass ejections. Study of each of these basic phenomena is crucial to an understanding not only of how they occur on other stars but also how our dynamic universe works in all its richness and diversity.

The key factor at the root of all these processes is the magnetic field and its subtle nonlinear interaction with the matter of the universe, most of which is in the plasma state.

In *Solar and Stellar Magnetic Activity*, Carolus J. Schrijver and his former thesis supervisor, Cornelis Zwaan, have produced a splendid book that reviews our current understanding of many key topics in solar and stellar activity. Tragically, Zwaan died soon after the manuscript was finished. He had been one of the leading figures in forging the so-called solar–stellar connection and understanding how solar phenomena occur on other stars. Schrijver is one of the leading solar–stellar physicists in the US.

The strength of the book lies in the clear overview it provides of activity both on the Sun and on other stars, from an observer's viewpoint. It describes the physical processes at work without going into the mathematical details. Its particular forte is in its detailed description of the complex behavior of magnetic fields in the solar surface; that behavior drives a host of dynamic phenomena in the overlying corona. The book also reviews authoritatively the various components of stellar activity, such as starspots, activity cycles, and the evolutionary stages of stellar activity.

The area to be covered by any overview of this subject is enormous; inevitably, a few topics cannot be fully treated. For in-depth accounts of stellar magnetic field theory, the reader is advised to complement the Schrijver–Zwaan book with Leon Mestel's *Stellar Magnetism* (Oxford U. Press, 1999),

Eugene N. Parker's *Cosmical Magnetic Fields* (Oxford U. Press, 1979), and *Lectures on Solar and Planetary Dynamos*, edited by M. R. E. Proctor and A. D. Gilbert (Cambridge U. Press, 1994).

Solar and Stellar Magnetic Activity is highly recommended for solar-stellar graduate students, for solar physicists wanting to learn more about other stars, and for stellar astronomers who are unfamiliar with recent developments relating to our Sun.

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Laser: The Inventor, the Nobel Laureate, and the Thirty-Year Patent War

▶ Nick Taylor
Simon Schuster, New York, 2000.
\$27.50 (304 pp.).
ISBN 0-684-83515-0

The brief title, *Laser*, is not descriptive of the contents of Nick Taylor's book. The extended title, *Laser: The Inventor, the Nobel Laureate, and the Thirty-Year Patent War*, doesn't quite do it either. The contrast between the motivation of the inventor, R. Gordon Gould, and the scientist-scholar and Nobel laureate, Charles H. Townes, is emphasized throughout this book. But the book's main purpose seems to be to tell the story of the life of Gould—one piece of the laser story remaining to be told.

Joan Lisa Bromberg wrote a well-balanced, scholarly account of laser history, *The Laser in America* (MIT Press, 1991). The life story of Townes is readily accessible in two recent autobiographical volumes, *Making Waves* (American Institute of Physics, 1995), and *How the Laser Happened* (Oxford U. Press, 1999). They carry the main historical line very well. But it is interesting and important to augment the historical perspective with Taylor's account. It is not a scholarly work, but is rather a fast-moving story of the life of Gould, the inventor of the laser, who, in his mid-thirties, was an older-than-average graduate student at Columbia University in the mid-1950s. Gould was working on a doctoral thesis involving optical pumping of thallium atoms, under the supervision of Polykarp Kusch.

In November 1957, Gould had his original ideas about a laser, a word he first coined at that time, and of many possible applications of such a device.

He had those ideas witnessed and notarized. He quit Columbia University in the spring of 1958 without obtaining a doctorate and joined forces with a small research company known as TRG. On the basis of Gould's ideas, TRG obtained a major research contract from the Advanced Research Project Agency to develop one or more types of lasers. This project was classified because of the laser's many potential military applications. On the basis of Gould's previous involvement with communist ideas, mainly inspired by a former girlfriend, he was denied security clearance and effectively barred from working on his own invention.

The story continues with a somewhat bewildering array of venture capitalists, patent lawyers, and several companies intent on purchasing Gould's patent rights. Gould was never embittered by the lack of recognition, but he firmly believed in his invention and continued, over three decades, to fight for financial remuneration. He managed to remain actively employed, first at the Brooklyn Polytechnic Institute and later with a small technology company. He enjoyed sailing and traveling. The description of a succession of female friends and wives provides a welcome break from the continuous string of legal and financial issues. The later court proceedings, during which Townes and Peter Franken appeared as witnesses, are described in some detail. It must have been a source of great satisfaction to Gould that, at age 80, he could celebrate, with his early colleagues from TRG, both his final patent-court victories and the publication of Taylor's book.

The book is easy to read, if one is not perturbed by a number of obvious inaccuracies. On page 40, one reads, for example, "The American Physical Society, a sort of Royal Academy for physicists. . . ." On page 51, it is stated that James Gordon, Herbert Zeiger, and Townes published the first successful operation of their ammonia beam maser in *Physical Review Letters*. Actually it was a letter in *Physical Review* of 1954; *Physical Review Letters* was started several years later. There is a one-liner on I. I. Rabi on page 41 that reads, "Rabi was short, about fifty-two, but in no other way was he diminutive." One wonders what is so diminutive about that particular age.

Other well-known scientists who played a role in laser history are mentioned briefly, but usually not more than a few random tidbits are provided.

And it seems odd to me, at least, that I was unable to find even one tidbit about my own electromagnetic pumping patent on the three-level maser. The book is aimed at a wide general audience interested in the scientific endeavor and in the social, human, and legal aspects of the pursuit of patents. Laser specialists, physicists, and other scientists will also enjoy reading the story of Gould, which simply had to be told.

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An Introduction to Turbulent Flow

▶ Jean Mathieu and Julian Scott
Cambridge U. Press, New York,
2000. \$90.00, \$39.95 paper
(374 pp.). ISBN 0-521-57066-2,
ISBN 0-521-77538-8 paper

Some 20 years ago, an instructor of a turbulence course had a limited choice of textbooks. Even the selection of monographs that could be used to supplement one's notes was not very large. Now a number of books are available. I count that number to be between 20 and 40, depending on how generously I include some special-purpose books. One explanation is clearly that this vast subject is getting further attention because of the strengthening of its ties to mainstream physics and modern mathematics.

Turbulence has excited—though sometimes only fleetingly—the interest of diverse groups of people, ranging from field theorists to practicing engineers, and it is no longer possible to include in a single book all the major developments that have resulted from this interest. Another intrinsic reason for the multiplicity of books is that consensus regarding the significant and essential topics does not exist among those familiar with the field. Different books, emphasizing different aspects of the subject that are at different levels of maturity, are therefore an inevitable consequence.

The authors of *An Introduction to Turbulent Flow*, Jean Mathieu and Julian Scott, have had extensive research and teaching experience in turbulence at their home institution (L'Ecole Centrale de Lyon) and elsewhere. They have drawn on that experience to produce a textbook meant primarily for graduate students in engineering, applied science, and applied mathematics. Their aim is to provide the students with solid grounding in physical ideas, orders of