Holton and Brush: A Classic Revived and Enriched

Physics, the Human Adventure: From Copernicus to Einstein and Beyond

Gerald Holton
and Stephen G. Brush
Rutgers U. P., New Brunswick, N.J., 2001. $75.00, $39.00 paper (582 pp.). ISBN 0-8135-2907-7, ISBN 0-8135-2908-5 paper

Reviewed by James Evans

Gerald Holton and Stephen G. Brush's *Physics, the Human Adventure* is a book with a long history. In 1952, Holton published his groundbreaking *Introduction to Concepts and Theories in Physical Science* (Addison–Wesley). He identified his project with the aims enunciated in a Harvard University committee report, *General Education in a Free Society* (Harvard U. Press, 1945). Holton's goal was to make science a vital part of a liberal education curriculum. His text taught plenty of physics, of course; but it also aspired to examine the nature of the scientific enterprise itself, to recount its historical development, and to introduce students to its great literature. Holton's was one of the first among a substantial number of innovative physics textbooks published in the 1950s and 1960s. It helped awaken the American physics community to new possibilities in the teaching of nonscience majors. In 1973, Stephen G. Brush produced a substantially revised second edition, incorporating a good deal of new material.

Although the 1952 edition opened a new road, it was in many ways only a "humanized" physics textbook. It began, traditionally, with chapters on one-dimensional kinematics and projectile motion before proceeding to Newton's laws. Topics treated early in the book included coefficients of friction and Atwood's machine. The text was leavened with plenty of history and philosophy of science, but the problems at the end of each chapter were mostly of the usual kind. The second edition represented a sharper turn in the new direction. The book began, more compellingly, with the big story of a new cosmology (Ptolemy, Copernicus, Kepler) to motivate a new physics (Galileo and Newton). The old book had ended with the Bohr atom. Brush attempted to extend the story to quantum mechanics and special relativity (though the relativity chapter was too heavily studded with equations to be accessible to its audience).

Physics, the Human Adventure is essentially a third edition of *Introduction to Concepts and Theories in Physical Science*. The treatment of historical and philosophical issues has grown in sophistication, reflecting both authors' maturation as historians of physics. The routine problem-solving, reduced in the Brush edition, has continued to diminish—although plenty remains. The chapter on relativity has been extended and improved. New material reflects Brush's recent work on the history of theories of the origins of the solar system. The penultimate chapter treats the expansion of the universe and the standard cosmology of the late 20th century, so that the book now opens and closes with a grand cosmological question. The final chapter, on "thematic elements and styles in science," reflects Holton's work and is a suitably general and engaging subject with which to end.

According to the authors' introduction, all chapters of the second edition have been reworked. However, comparison of the two versions shows that much of the 1972 edition has been only lightly retouched. For example, the same erroneous diagram of the Ptolemaic system appears in all three editions. The figure correctly shows the centers of the epicycles of Venus and Mercury on the line connecting Earth with the Sun, but it fails to show the radii of the epicycles of the outer planets parallel (as they must be) to this same line. Moreover, the text asserts that it was "curious" that the positions of the inferior planets were linked to that of the Sun, while the other planets "seemed to move more freely." In fact, Ptolemy mentions explicitly that, for each planet, one motion is constrained by that of the Sun and the other is free. And it was the motion of the outer planets on their epicycles in lockstep with the Sun that provided Copernicus one of his best clues. So, in fact, this edition differs from the second mainly in the new material. As before, the two grand themes are dynamics and the atom.

Who might profitably use such a book? I think it is fair to say that this remains a challenging book. The discourse is dignified, the historical and philosophical issues are serious, and the student's intellect is respected. Many of the end-of-chapter problems are so broadly framed that they might serve better as topics for class discussion than as homework assignments. It must also be said that the writing is sometimes cumbersome. This is may be too demanding a book for a general liberal-arts course at a typical American university. But it might work well in a self-selected student group—in a liberal-arts honors program, for example. The authors also suggest the book for collateral reading in a physics majors' course. Physics and engineering majors certainly would benefit, but success would require that the teacher commit perhaps one a day week to the broader conceptual and historical issues.

In spite of its imperfections, this book, in its three editions spanning half a century, is one of the great textbooks of our time. Though it is certainly not for everyone, it offers a compelling account of the development of the modern world view and a richly rewarding look at the place of physics in the Western intellectual tradition. It is a grand thing to have the new edition available.

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The Origin and Evolution of Planetary Nebulae

Sun Kwok
Cambridge U. Press, New York, 2000. $69.95 (243 pp.). ISBN 0-521-62313-8

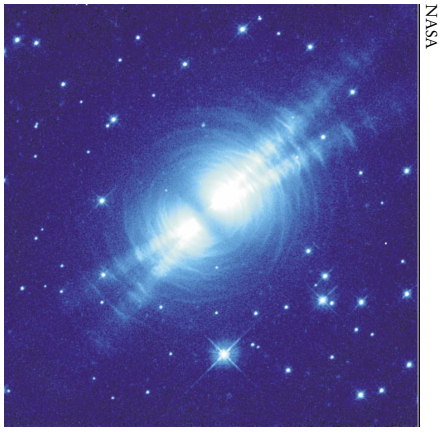
The intricate morphologies and striking symmetries of the so-called planetary nebulae—rings, helixes, and butterflies—have long made them favorites of amateur and professional astronomers alike. Their popular appeal continues to the present: The

remarkable images of these glowing gas clouds obtained by the Hubble Space Telescope (HST) are seen in textbooks, magazines, and newspapers (see http://oposite.stsci.edu/pubinfo/pictures.html).

The name "planetary nebula" is in fact a misnomer, arising from their superficial similarity (through early telescopes of poor optical quality) to the outer planets Uranus and Neptune, which gave the nebulae the appearance of small, greenish disks. Today we know that planetary nebulae represent a transitional stage in the life cycles of many stars, during which a formerly cool, distended red giant star sheds much of its mass, baring the hot stellar core, which in turn illuminates, ionizes, and heats the newly created circumstellar gas cloud. This phase lasts only 10 000–100 000 years, a mere blink of an eye in the typical lifetime of a star, which is measured in millions or billions of years.

Planetary nebulae lie at the crossroads of several disciplines (stellar, interstellar, and galactic astronomy, as well as several branches of physics). The physical state of the gas and the emerging spectrum of radiation (best described using the tools of interstellar-medium astrophysics—the study of diffuse gas in space). Yet, because planetary nebulae comprise material cast off by aging stars near the end of their lives, they carry not only the imprint of the star's initial composition but also the signatures of internal nuclear reactions and mixing processes that bring freshly-made heavy nuclei to the surface during its lifetime (stellar evolution). Planetary nebulae show us stars caught in the act of changing the composition of their environment by enriching it in stellar nuclear ashes, a one-way cosmic evolutionary process as inexorable as entropy (galactic evolution). Planetary nebulae have served as remote laboratories for matter under conditions that cannot be duplicated on Earth; from the mid-19th century to the mid-20th and beyond, they were premier sites for the study of atomic-level processes and photon–atom interactions (atomic physics). In the past two decades, they have taken on additional roles as laboratories for gas hydrodynamics (plasma physics) and as probes of the distances and masses of galaxies (extragalactic astronomy).

This slim volume by Sun Kwok, a major player in the field of planetary nebula research and the originator of the current structural paradigm (the "interacting stellar winds" scenario), represents a valuable contribution to the literature. It offers the most complete, accessible, and up-to-date entry to this subject for the newcomer with a strong general background in physics and astronomy at the advanced undergraduate level or above. It is more suitable for this purpose than the proceedings of symposia of the International Astronomical Union (the most recent is *Planetary Nebulae*, *IAU Symposium 180*, Kluwer, 1997), edited by H. J. Habing and H. J. G. L. Lamers, which are intended for the specialist. Kwok has wisely chosen not to attempt to fill the same niche as Donald Osterbrock's *Astrophysics of Gaseous Nebulae and Active Galactic Nuclei* (University Science Books, 1989) or Lawrence Aller's *Physics of Thermal Gaseous Nebulae* (Reidel, 1984), which are comprehensive reference works on physical processes in nebulae.


NASA

EGG NEBULA: Hubble photograph of a planetary nebula.

Instead, *The Origin and Evolution of Planetary Nebulae* emphasizes recent developments and the broader astrophysical context, while still including enough nebular physics to orient the novice. The book's modular arrangement enables the reader to choose between two options: Those interested in the detailed nebular physics can progress sequentially through the book, while those more interested in origin and evolution can skip directly from the introductory chapter to chapter 10.

Some minor omissions are noticeable. I would have liked to have seen more material on the neutral atomic as opposed to molecular gas, on results from polarimetry, and on the properties of white dwarfs—the descendants of the central stars of planetary nebulae. More significant is the lack of coverage of the raging current controversy over whether the bipolar morphology of some planetary nebulae is caused by the originating star having evolved within a binary system. This topic deserves its own chapter, and has recently inspired a new series of conferences under the heading of "Asymmetrical Planetary Nebulae." Two volumes are out, a third conference is planned for some time in 2002. Kwok's book would also have benefited from more careful proofreading to eliminate minor grammatical and spelling errors, some of which appear in section headings or in the spelling of author names in the citations.

Overall, *The Origin and Evolution of Planetary Nebulae* is a significant achievement, drawing together both traditional and modern ideas about the nature of planetary nebulae and their place in stellar and galactic astronomy. The reader who is inspired by the images of planetary nebulae to go beyond aesthetic appreciation, to delve into the physics and astrophysics of these fascinating structures in space, cannot do better than to start with this book.

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Solid State Physics

Mircea S. Rogalski
and Stuart B. Palmer
Gordon and Breach, Amsterdam, the Netherlands, 2000. $80.00, $45.00 paper (467 pp.).
ISBN 90-5699-272-4,
ISBN 90-5699-273-2 paper

Solid State Physics

Giuseppe Grosso and
Giuseppe Pastori Parravicini
Academic Press, San Diego, Calif., 2000. $79.95 (727 pp.).
ISBN 0-12-304460-X

Solid-state physics is an essentially modern subject intermeshed with technology and providing the basis for the explosive growth of the information age. Unlike quantum mechanics or statistical mechanics, which have origins going back a century or more, solid-state physics is a post–World War II development, dating symbolically, perhaps, from the invention of the transistor in 1947. In recent years, the sheer difficulty of imagining our life before computers has indicated the revolution that knowledge and control of the properties of materials has wrought. Indeed, not until similar control is inevitably obtained over the materials of life will a transformation of comparable magnitude take place.