Exploring the Cosmos and Introductory Astronomy and Astrophysics

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Charting a course between dullness and difficulty

Exploring the Cosmos

Louis Berman
477 pp. Little, Brown, Boston, Mass., 1973. $12.95

Introductory Astronomy and Astrophysics

E. v. P. Smith, K. C. Jacobs
564 pp. W. B. Saunders, Philadelphia, 1973. $15.95

Reviewed by Carl Sagan

Astronomy is one of the seven subjects of the classical trivium and quadrivium, which all educated persons were expected to know 2500 years ago. This sound insight on the significance of astronomy is reflected in many colleges today, where the subject is rapidly becoming extremely popular.

Until recently, however, many astronomy textbooks were plagued with two problems: dullness and unnecessary difficulty. The student was overwhelmed early by four different celestial coordinate systems and a deep plunge into astronomical optics—with the frontier excitement presented after page 200, if ever. A second problem is one I call the "false trivials." The most difficult task in teaching is to remember what the student does not already know: the definition of angular resolution, the idea of light as an electromagnetic wave propagating in a vacuum, or even the use of angular brackets that denote "average." Encountering a few of these ideas in a row—trivial to the author, but deeply mysterious to the thoughtful student—is enough to drive the reader to distraction, or, more likely, to comparative literature.

Equally frustrating is a semiquantitative argument that the reader, by dint of great effort, is just barely understanding, and then to have a critical step summarized as "in more advanced texts it is shown that . . ." One criterion of a successful introductory astronomy text is the avoidance of these two pitfalls.

These two books, although by no means perfect, are among the best of the new astronomy texts. Both presume no acquaintance with college-level physics. L. Berman's book requires only high-school algebra, while E. Smith and K. Jacobs have written a text that requires an acquaintance with the calculus at the level taught in good high schools.

Berman, who is not a professional astronomer, has successfully melded historical and social concerns with a very broad approach to the universe as a whole. Novelties include a full chapter on special relativity and discussions of exobiology, interstellar communication and space-vehicle technology. Some of the illustrations are fine and obtained from unusual sources (for example, the Hubble cover of *Time Magazine*). There are the now obligatory 48-inch Schmidt color photos, but the Halsman photograph of Einstein and the cover reproduction of Esher's "Another World" are almost worth the price of admission. There is some trite writing ("no longer does man look through a glass darkly," page 6), and a range of problems in presentation. A discussion of Newton's law of gravitation from Kepler's laws does not even give the student a *feel* for quantitative thinking.

The relation between frequency, wavelength and velocity of a wave is merely stated, not derived. There is a peculiar balance in the discussion: the blazing of gratings is mentioned, but the origin of dispersion is not. There

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Dipole Array

is no statement of why there are *lines* in a spectrum; the same page that includes a discussion of spectral lines shows a prism dispersing light but in the absence of a slit. The figure illustrating the Doppler effect appears to show $\Delta\lambda$ independent of λ. The reason for the emission of radiation by an accelerated charge is not explained. No distinction is made between oceanic and solid-body tides. Diffusive separation in the thermosphere of the Earth is described as "diffuse separation." We discover that cooling rather than heating of rocks releases large amounts of gas. At a time when the human population of the Earth will shortly be 4 billion souls, we are told that "a total of about 4 billion living objects have inherited the Earth at one time or another"; Berman means species. The combinatorial possibilities of DNA nucleotides are absurdly underestimated.

There is a peculiar reliance on miles, feet, the Fahrenheit temperature scale, and numbers like "sextillion." It is erroneously implied that significant heat transport occurs by atmospheric circulation on Mercury and Venus. Molecular nitrogen is announced on Mars; Jupiter is said to have "ionization belts"; synchrotron emission is unveiled for Saturn; Pic du Midi is transported to the Alps; the word "ionizes" is explained as "electrically inflames"; and the Stefan-Boltzmann, Wien and Planck radiation laws are all handed down from Mount Sinai. Red-giant electrons are called degenerate without explanation or defense of the electron. Some Stratoscope 2 flights are said to be manned. Berman has not noticed the withdrawal of the claim some years ago of ultraviolet luminosity around the star Spica. There are a fair number of misspellings including proper names (Alpher, Mutch, Penzias and Ponnamperuma), but there are good summaries of the scales of matter, time and energy, the galactic distance scales and recent lunar investigations. A removable phosphorescent star chart for night viewing is included as well. If only *Exploring the Cosmos* were not so error-ridden, its verve, enthusiasm and visual appeal would make it a first-rate introductory descriptive astronomy text. Perhaps the second edition will have major errors corrected.

Introductory Astronomy and Astrophysics, written by two professional astronomers, is more demanding of its readers. From this text it is possible to glean a fair amount of the excitement about contemporary astronomy. Its handling of some frontier areas—for example, quasars—is brief, thorough and fair to most of the disputing parties. There are some good pedagogical touches, such as a log-log plot of Kepler's third law, showing that P^2 is indeed proportional to a^3, and, while there are far too many "false trivials," there are still occasional exemplary elementary derivations, including those of the pressure, temperature and luminosity of stars. The discussion is of the traditional astronomical subjects, but very well balanced.

Chapter 1 is a little off-putting. We are informed that complex interstellar molecules such as *water* have been found in interstellar space, and that Mars is more like the Moon than the Earth. Then on the literary side, we have a discussion of the blind man and the elephant, and a concluding sentence, "Having set the stage, let the play begin!"

Among the problems: An undiscussed connection between negative total energy and bound orbits; a statement with no further elaboration that the study of fossil corals tells us something about the tidal evolution of the Earth–Moon system; a fundamental confusion, in the escape of planetary atmospheres, between equilibrium and exosphere temperatures; the erroneous contention that the rotation periods of no moons but our own are known; a "false-trivial" statement on the first test of general relativity; a curve purporting to show that lunar craters are of impact origin that nowhere shows points for volcanic craters; the omission of the 10-micron and other infrared windows when discussing regions of low opacity in the Earth's atmosphere; a definition of the atmospheric scale height, which is off by a factor of $\frac{2}{3}$, and several inaccuracies regarding the other planets of our solar system. There are a large number of "false trivials" that could readily have been rectified in a few lines—as, for example, the period/density relationship of Cepheids.

In general the book is remarkably up to date, although there is, for example, no reference to Cygnus X-1. Illustrations, such as the comparison of the Southern Milky Way with NGC 891, and an extremely instructive illustration of the winding of galactic spiral arms, are generally well done. There are attractive lunar mercator projection end papers. The authors also clearly distinguish the latin singular from plural in the widely misused terms: mare, maria; nova, novae; and nebula, nebulae. With some culling of errors and removal of "false trivials," Smith and Jacobs could become the standard introductory astronomy text for science-oriented students in the coming years.

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X rays in Atomic and Nuclear Physics

N. A. Dyson
380 pp. Longman, London, 1973. **£8.00**

In the 40-odd years since the publication of Arthur Compton's and Samuel Allison's classic work on x-ray physics (*X rays in Theory and Experiment*), workers in the field have produced an extensive and often very specialized literature. Norman Dyson's book on x rays is a good general introduction to the physics and uses of x rays in atomic and nuclear physics. The book's great virtue lies in its combination of comprehensiveness and conciseness; this is achieved by leaving out most of the applications of x rays to crystallography, solid-state physics and metallurgy, trace-element analysis and so on. (Current reviews of some of these topics may be found, for example, in *X ray Spectroscopy*, edited by Leonid Azaroff, just published.) Dyson deals primarily with the basic physical processes of x-ray production, at a level that should make it quite useful to advanced undergraduates in physics as well as a convenient reference for graduate students and researchers in any field that makes use of x rays.

The book begins with a very readable short historical introduction. While many of the phenomena and applications of x rays were known before World War II, in the last few years research physicists have again taken an intense interest in x-ray phenomena. Dyson concisely treats the current research areas of mu-mesic x rays, studies of electron momentum distributions in solids, x-ray emission induced by collisions of heavy ions with isolated atoms and with solid targets, x-ray emission from the sun and from hot laboratory plasmas for fusion research, synchrotron radiation and x-ray astronomy from sounding rockets and satellites. His own research has been in x-ray production and microscopy starting at the Cavendish Laboratory, Cambridge; more recently he has worked on studies of the Mössbauer effect and in medical and biological physics at the University of Birmingham.

His opening discussion of the intensity and angular distribution of both continuous and characteristic x rays is very extensive, perhaps to the point of tediousness for some readers. By contrast, he treats only briefly the subject of inner-shell ionization by proton and by heavy-ion impact, which often results in much larger cross sections than for electron impact at the same velocity. Dyson does point out, though, that there is vigorous work going on in this field right now. The chapters on x-ray absorption and scattering (including