Rather, they want to provide the flavor of the original papers, most of which are excerpted rather than reprinted in full, and to help the reader interpret the papers within a context that was not apparent at the time the papers were written.

As a consequence, one gets a rather uncommon blending of original works colored strongly by a layer of interpretation, sometimes quite insightful and sometimes historical. It is rather like one of those music appreciation courses in which the pianist plays a passage of a famous piece and then dissects it; one ends up with less than a full picture of the whole, but generally with a much better idea of how the piece was put together and how its various parts interrelate.

Of course, within the framework of 100 years of the quantum, there is a lot of selecting to do. For this purpose, the authors make a conscious decision to limit themselves to nonrelativistic and non-field-theoretic aspects of the subject. They divide the book into four parts. The first deals with work that precedes modern quantum theory. Here they emphasize the work of Max Planck, Albert Einstein, Arthur Compton, and Niels Bohr. But they also include a prescient paper by Hendrik Kramers and Werner Heisenberg, and an explanatory paper on action variables by Karl Schwarzschild.

Part two is devoted to the classical development of the formalism of quantum theory, including Heisenberg's matrix formulation, the famous "dreimännerarbeit" of Max Born, Heisenberg, and Pascual Jordan, explaining Heisenberg's breakthrough in terms of orthodox matrix techniques and commutation relations, and P A. M. Dirac's independent reformulation of the theory, as well as Erwin Schrödinger's wave interpretation. They also discuss some of the early interpretational battles Heisenberg and Bohr had with Schroedinger. Part three is devoted to some classic interpretational questions, including Born's work on interpreting the magnitude of the wave function in terms of probability. It also includes Heisenberg's introduction of the uncertainty principle and Bohr's complementarity. Finally there is a discussion of the famous EPR (Einstein-Podolsky-Rosen) "paradox," and Bohr's answer. During the discussions, they manage to bring out the various personality conflicts involved.

The last part of the book includes modern developments such as John Bell's demonstration that one could distinguish experimentally between the EPR and Bohr points of view, the derivations of Bell's inequalities, and some of the now classic experiments such as Alain Aspect's, which tested these results and thus lent their weight to the conventional quantum interpretation. The authors also introduce the Feynman path integral as an especially important modern development.

The rest of the chapter is the only really debatable part of the book, so far as the authors' choice of material is concerned. It includes some modern attempts at alternative interpretations of the subject, and many readers would quibble at their selection. Included are papers by James Hartle, Hartle and Murray Gell-Mann, and Bryce DeWitt, on versions of decoherence and consistent-histories interpretations, because these offer a possibility of interpreting the concept of a wavefunction for the entire universe, necessary for a cosmological extension of quantum mechanics. This inclusion reflects the authors' own interest in particle physics, and although they are rather admirably constrained in their comments concerning an ultimate "theory of everything," they still seem to be somewhat infected by this particular bug, an occupational hazard for particle physicists. Other types of interpretations, such as Bohm's trajectories or many world interpretations, don't impress them as very relevant.

Finally, Duck and Sudarshan have very positive things to say about an informational interpretation of the wave function, and they discuss David Deutsch's introduction of quantum mechanical computers. However, whenever they discuss the "conventional" interpretation, they incorporate a density matrix approach and do not seem to believe that the wavefunction makes sense for an individual system. That would be the case for a frequency interpretation of probability. But one of the great strengths of an informational approach is that it gives meaning to the wavefunction for an individual system, because a single experiment can provide information about such a system. In contrast, a frequency interpretation only gives probabilities of occurrence within ensembles of systems. So their comments don't seem to me to take full advantage of the possibilities opened up by an informational approach.

At the end of the book, Duck and Sudarshan have some fun speculating about the future of quantum mechanics, although they are fully aware of the unreliability of such projections. They do have some interesting things to say about physicists themselves being partly responsible for the general lack of interest in the subject by nonphysicists.

When you have finished the book, you will have read parts of some papers that you probably would not have otherwise read, and you will have been given a guided tour through confusing territory by some wise and knowing guides. A different tour might have covered different landmarks, but you will have gotten your money's worth. Can't ask for more than that!

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Encyclopedia of Astronomy and Astrophysics

Edited by Paul Murdin
IOP (Nature Publishing Group), Philadelphia, 2001.
$650.00 set (3670 pp.).
ISBN 0-333-75088-8 (set)

This four-volume *Encyclopedia of Astronomy and Astrophysics* summarizes a great deal of what we knew in the astronomical sciences at the most recent millennium. An associated Web site http://www.ency-astro.com may keep much of it up-to-date for years to come. The contents are extensive indeed: The index alone consists of 76 pages, each with three columns of fine-type listings, and there are "nearly 700 main articles" in the words of Paul Murdin, editor-in-chief. Murdin was assisted by editorial and advisory boards comprising 33 persons, most of them prominent astrophysicists but including the celebrated amateur astronomer Patrick Moore.

The main articles are what make the new *Encyclopedia* worthwhile. They are generally by experts, who took much care in their preparation. Impressive examples are "Stellar Evolution" by Jørgen J. Christensen-Dalsgaard and "Venus: Interaction with Solar Wind," by Christopher T. Russell and Janet G. Luhmann. The degree to which the articles are illustrated and referenced, however, seems to depend on the inclination of the individual author. "Blue Stars at High Galactic Latitudes," by John S. Drilling, is less than four and one-half pages long, cites nine works published from 1965 through 1998, but is not illustrated. "Proper Motion: Optical/Infrared," by Arnold R. Klemola, runs seven pages, with two small geometric diagrams, six bibliographical citations, and a table of large astrometric catalogs with 20 footnoted references. On the other hand, articles on Saturn's rings and its satellites are heavily illustrated, but with just two or three citations in each.

The coverage of solar physics is especially thorough. There are numer-

ous articles on major topics, notably the physics and phenomena of the corona and the chromosphere, and some on more specialized subjects, such as "Polar Plumes" and "Coronal Cavities." (The latter are not to be confused with the subject of another entry, "Coronal Holes.") Finding all these articles is another matter; the reader is advised to make good use of that 76-page index. Although five main articles begin with "Coronal" and thus are grouped together, the main entries on coronal mass ejections or x-ray bright points, are in another volume, presented under "Solar Coronal Mass Ejections" and "Solar Corona: X-ray Bright Points."

The economics of producing scholarly encyclopedias are such that contributors, if they are paid at all, rarely receive what their articles are worth. So the editor recruits only those articles that authors are willing to write. There's no question as to the quality of the main articles in the *Encyclopedia*, but some obvious topics are lacking. There are cogent articles on "Dynamo Theory," "Geodynamo," and "Dynamos: Solar and Stellar," but no survey of the important topic of planetary dynamos, although they are briefly mentioned under "Planetary Magnetospheres." The work contains many superb articles on galaxies, but none on the low surface-brightness galaxies, which represent one of the hottest current topics.

The hundreds of unsigned shorter entries are a mixed bag. They range from seven lines on "Coronelli, Vincenzo Maria (1650–1718)," about the cosmographer from Venice who "made two beautiful globes for Louis XIV, 3.9 m in diameter, the biggest in the world until the present century . . ." to "Black Hole," about two-thirds of a page. They fall into various categories: Some provide simple definitions, as in entries on "Direct Motion," "Rille," and "Revolution," while others give short descriptions of well known celestial sights—"Betelgeuse," "Big Dipper," and the constellation "Columba," for example—or of important but not readily glimpsed astrophysical entities, such as the "Becklin–Neugebauer Object."

Brief articles on observatories represent still another category. Some, as in "Beijing Astronomical Observatory," include the URL of the observatory's Web site, where more information is available; others, like "San Fernando Observatory" lack this helpful feature, although the observatory has an equally fine presence on the World Wide Web. Still other categories include very short articles on individual spacecraft and spacecraft series, individual annual meteor showers, and so on.

My concern about the *Encyclopedia of Astronomy and Astrophysics* centers on the short entries. The simple definitions are no more informative than those in such handy single-volume astronomy dictionaries as Jacqueline Mitton's *Cambridge Dictionary of Astronomy* (Cambridge U. Press, 2001), which can be found on many an astronomer's or science writer's desk. Guess where I would look up those definitions: The entries on meteor showers, for example, "Eta Aquarids," lack crucial details, such as hourly meteor rates and specific occurrence dates. Much more helpful information appears in tabular form in college textbooks and numerous publications for amateur astronomers. Entries on spacecraft are sometimes disappointing too: contrast the 15-word entry on "Dynamics Explorer (Explorer 62 and 63)" in this work with the illustrated, six-paragraph entry in Robert Zimmerman's single-volume *The Chronological Encyclopedia of Discoveries in Space* (Onyx, 2000).

The biographies of living scientists in the *Encyclopedia of Astronomy and Astrophysics* are rarely more comprehensive or detailed than those available from standard sources. You can't

be misled by the work's four lines (and one word more) on "Rubin, Vera Cooper (1928–)," the contemporary investigator of velocity fields in galaxies, but neither will you be well informed on this much-honored astronomer's accomplishments. The 21-line entry on "Sandage, Allan Rex (1926–) has no room for the famous controversy over the Hubble constant in which Sandage was a central figure, or for the discovery of blue stragglers, reported in his PhD thesis. In the latter case, fortunately, what is not mentioned in the biographical entry can be found in the main article, "Blue Stragglers."

If this four-volume work were magically compressed into a single manageable volume, the myriad short entries would make more sense; the book would be "one-stop shopping" for astronomical and astrophysical reference reading. But since almost all copies of the *Encyclopedia of Astronomy and Astrophysics*, at four volumes and $650 for the set, will necessarily be found in reference libraries, why include the short entries? If you are in the library, it's a lot easier to pick up a single volume appropriate to meteor showers, Mitton's *Dictionary*, Zimmerman's *Chronological Encyclopedia of Discoveries in Space*, or a current college text. I'd still go to the library to consult the main articles in Murdin. They're a splendid resource, but his *Encyclopedia* would have been more user-friendly if the short stuff had been omitted.

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East Asian Archaeoastronomy: Historical Records of Astronomical Observations of China, Japan and Korea

Zhentao Xu, David W. Pankenier, and Yaotiao Jiang
Gordon and Breach Science, Amsterdam, the Netherlands, 2000. $115.00 (430 pp.)
ISBN 90-5699-302-X

The earliest preserved records of astronomical observations come from two principal cultures: Mesopotamia and China. The Mesopotamian records are found in cuneiform writing on clay tablets that have been recovered from the ruins of Nineveh, Babylon, and other cities in the Near East. They date primarily from the last seven or eight centuries BC, and are superior in detail and accuracy to their Chinese counterparts of the same period.

However, the Chinese records have two great advantages over the Mesopotamian material to astronomers and historians today: (i) whereas the latest cuneiform records date to the first century AD, more or less continuous records of Chinese astronomical observations are preserved up to the present, and (ii) the Chinese records are of a wider range of celestial phenomena; there is, for example, no specific interest in cyclical phenomena.

In total, East Asian sources contain more than two and a half thousand years' worth of records, providing the historian with an abundance of material to use in tracing the development of astronomy in China, and offering a long baseline of data for the astronomer to search for events that occur very rarely (such as nearby supernovas) or change very slowly (such as the Earth's rate of rotation).

Chinese astronomy can be divided into two main parts, one observational, the other theoretical. The observational material includes records of eclipses, comets, guest stars (novas), and other celestial phenomena visible to the naked eye. Because most of these could be—and were—interpreted astrologically for the emperor, Chinese astronomy was essentially an official activity, conducted by scholars employed by, and under the control of, the government. This was a double-edged sword as far as scientific progress was concerned: At some periods official interest led to the development of new theories and instruments, while at others it forced astronomy into a retrograde step. Chinese astronomy dominated East Asia up until at least the seventeenth century, and its basic methods and goals were followed, often slavishly, in Korea and Japan from the late first millennium AD.

East Asian Archaeoastronomy, by Zhentao Xu, David W. Pankenier, and Yaotiao Jiang, aims to collect all known observations of certain astronomical phenomena from East Asian sources and translate them into English. This is a laudable aim, and undoubtedly, by translating the records, the authors are opening up a field that has previously been accessible in the west to only a handful of people. However, the project is not without its dangers, as we shall see.

In choosing to concentrate solely on observations, the authors are presumably aiming their book towards astronomers rather than historians. Indeed, the astronomer can learn much from the observations collected here. For example, the past viewings of Halley's comet can be traced back to 240 BC with only the return in 164 BC missing, and the many hundreds of observations of lunar and solar eclipses provide essential information on the long-term changes in the Earth's rate of rotation.

Unfortunately, by quoting only the lines of the text in which these observations are recorded, the accounts can often be misinterpreted. In the worst case, what may in fact be a calculated event can be interpreted by the unwary as an observation. Many early eclipse records, for example, do not correspond to real events. Some are genuine predictions, but others are apparently "fake" events which, because of their astrological interpretation, were inserted into the record for political purposes. Some observations were omitted for the same reason. In order to safeguard against using such a polluted dataset, one must understand the context in which the records were written. Unfortunately, selective quotation by the authors, and their failure to provide any information about the various sources from which the records are taken, prevent this.

It is disappointing also that the authors have decided to omit most of the astrological material in the translations. Comparisons made by the Chinese astronomers between the observations they made and the results of calculations using the theories they developed are also omitted in the translations provided. This is a pity, for these both provide very interesting material for study by historians of Chinese science and its role in Chinese society.

Bearing in mind these reservations, *East Asian Archaeoastronomy* is still a useful reference book, but one that should be used with great caution, and as a starting point for locating material in the original sources, not as a definitive work in itself.

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Atom, Molecule, and Cluster Beams

Hans Pauly
Volume 1: Basic Theory, Production and Detection of Thermal Energy Beams
$82.00 (344 pp.).
ISBN 3-540-66945-0
Volume 2: Cluster Beams, Fast and Slow Beams, Accessory Equipment and Applications
$79.95 (374 pp.).
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In *Atom, Molecule and Cluster Beams*, Hans Pauly has emphasized areas in