

Motion in the sky: What makes the worlds go round?

Celestial Mechanics, Vol. 2: Perturbation Theory, Parts 1 and 2

Yusuke Hagihara
MIT Press, Cambridge, Mass.,
1972. \$30.00 each part

Reviewed by William Jefferys

This is the second of a projected five volumes devoted to the field of celestial mechanics. It is also the first comprehensive review of the field since Henri Poincaré wrote *Les Méthodes Nouvelles de la Mécanique Céleste* over 70 years ago. Much has happened since then, not the least of which has been the conversion of celestial mechanics from a highly theoretical discipline into a field with great practical applications, with the advent of the computer and space technology.

Yusuke Hagihara has long been a major figure in celestial mechanics. He has personally been involved in the education of a large number of Japanese astronomers, and, although he is now officially retired, he continues to do important work. It would be hard to think of an astronomer who would be better qualified to write a comprehensive survey of celestial mechanics.

This series of books is addressed to the serious worker in theoretical celestial mechanics. The first volume covered basic dynamics and transformation theory, while the volume under review concerns perturbation theory. One chapter discusses various methods for expanding the "disturbing function," which physicists know as the interaction Hamiltonian. This is one of the most difficult problems in celestial mechanics, because the expansion of this function usually converges very slowly. As a result, many methods have been developed to obtain these expansions, each with its own area of application. Hagihara discusses all of the standard methods, and includes an interesting section on convergence criteria, a topic normally ignored.



Apollo 16 lunar module returning from the surface of the moon on its way to rendezvous with the orbiting command module. Celestial mechanics has found a new importance with the growth of space exploration, and an overview of the methods that have developed is given in Yusuke Hagihara's book, *Celestial Mechanics, Vol. 2: Perturbation Theory* reviewed here.

The rest of volume 2 is devoted to various perturbation methods. Many different techniques of perturbation theory have been developed over the years by celestial mechanicians, more than in any other field of which I am aware. There are, unfortunately, no universal methods, although some are more generally useful than others. Hagihara has, of course, concentrated on the more important methods, such as Hansen's, Lagrange's, Delaunay's, von Zeipel's, Brouwer's, and Hill's methods, but he has said something, at least, about many other lesser-known methods. Some of the latter have very interesting features. He also reviews the important new Lie transform methods of Gen-ichiro Hori and André Deprit. He has spiced his discussions with numerous applications of these methods to actual problems, such as asteroids, planetary satellites, artificial satellites, and so on, most of them being concise discussions of various workers' research, taken directly from the literature.

One of the most valuable features of this book, as is true of the previous volume, is the list of references. An informal estimate yields something like 1500 books and articles cited. Most of the references are relatively recent, although Hagihara's long experience in the field has enabled him to list numerous older references of importance also.

I have few criticisms. My copy of Part 1 came with one defect, namely an extra signature containing pages 237-268. No typographical errors were detected, however. It is truly a shame that these volumes are so expensive. One feels that they should be on the shelf of everyone working seriously in celestial mechanics, but I suspect that, because of the price, many will pass this series up.

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Speaking of Science: Conversations with Outstanding Scientists

Robert A. Potter, ed.

Six cassettes. American Association for the Advancement of Science, Washington, 1972. \$39.95

What to do with the message when there's a change in the medium? When everybody is watching and listening, how shall we convey the stuff we used to read?

Considerable thought and effort are

going to tape recordings for the purpose. *PHYSICS TODAY* has had its letters suggesting that physicists follow the lead of the American Medical Association, which makes tapes that doctors can listen to as they drive from patient to patient or home to office. Physics texts, both advanced and simple, are among the books that are carefully taped and packaged at Recordings for the Blind. Now the American Association for the Advancement of Science has added an impressive set of six cassettes (about four hours' worth) called *Speaking of Science: Conversations with Outstanding Scientists* to the reels and cassettes on which it has already made available more than 100 AAAS symposiums of 1969-71.

The plan is effective. Edward Edelson and Mitchell Krauss, both broadcast journalists, conduct interviews with scientists and produce what sound like radio programs—even to the musical opening and ending. Carl Sagan speaks of space exploration, Theodosius Dobzhansky of evolution, George Rathjens of ways to peace, Mark Kac of advances in life sciences, Margaret Mead of telling the public, Jack Goldman of technology. And so on: Herbert Holloman, Athelstan Spilhaus, Arthur Kantrowitz, Herman Kahn, many others.

Some interviews are with one person at a time, and in some two or three converse as a panel. Usually the interviewers give the speakers free rein and let them tell it their way. Often, though, the interviewers lead with probing questions, and occasionally they attempt a change of course. Without much success Edelson tried to get Dobzhansky to define his concepts when he felt, as I did, that the content was becoming too abstruse.

On the whole, though, you will find the material clear and, above all, interesting. Each of the speakers looks at science, even his own speciality, in the large. What does it do for society? How does it affect the people who pursue it? What, if anything, can science as a way of life contribute to better the world we live in and its intellectual storehouse?

Margaret Mead, I found, is particularly stimulating. She calls for better programs to train science writers—such as the one at Columbia recently abandoned for want of support. The popular image of science, she says, should be changed; the scientist isn't really the man in a white coat, isolated from life around him, that the public sees. She pleads also for responsible technology: "Don't make anything until you can take it apart again." Emphatically she decries the writing of scientists and asks them to talk intelligibly in simple English. Amen. But

the sword has two edges. Obfuscating language, hard to understand, convinces the reader that the work is difficult, and that impression, many agree, is a lot of fun to create. It is even fun to create it with a donor when you convince him that anything so hard to do must be worthy of his full support. How do you remove such motivation? Perhaps by recognizing that after a couple of decades on the gravy train, we have fallen off. The donors now look for things that they can understand—dirty rivers and crowded cities.

The various disparate proposals and programs of making tapes—textbooks for the blind, papers for physicians and these conversations for fun and stimulation—invite a more concentrated effort to use the tape medium, which is now largely supported by rock bands and their listeners. Easily you can imagine a regular series of tapes to be heard as you travel on trains, planes and highways, played on the same instrument that you carry for on-the-road records and dictation. A good look at the market and some building on it might justify expenditure of some of the funds intended to improve science, scientists and communication among them.

Anyway, these six tapes are good. You will not be disappointed if you buy a set, put them on your cassette player and let them displace a couple of hours of the public broadcasting that has been called "a vast wasteland."

R. HOBART ELLIS JR

Hobart Ellis, who edited PHYSICS TODAY from 1965 to 1969, died last October; the review above is his last contribution to this magazine. An obituary appears on page 65.

The Science of Matter: A Historical Survey, Selected Readings

M. P. Crosland, ed.

Penguin, Middlesex, UK, 1971. \$4.95

The question "of what is the world made?" is certainly as old as reflective man; the answers given are nearly as varied as the men who have given them. "Of principles," say some, "of elements," say others; "of atoms" says still a third group; "of forces," claims another, or "of little bits of electricity." Each answer reflects the men who gave it, the tradition in which they worked, and their era. M. P. Crosland, reader in the History of Science at the University of Leeds, has assembled 163 selections to display some of these answers. The selections are ar-