the electromagnetic field. Though the chapter titles are deceptively old-fashioned, the contents are refreshingly modern. Other laudable aspects include the examples, which tend to be physically interesting and relevant, unlike the more common, mathematically oriented cases. Furthermore, Bekefi and Barrett provide quite a few completely worked-out problems, illustrating the test in question. References to more detailed treatments are abundant. The use of MKS units is helpful to the majority who are "brought up" with them. Factors in formulae are sometimes labelled by words (for example, 8.62) that help the conceptual understanding of the various pieces. One of the appendices is a complete listing of a FORTRAN program to simulate the motion of a charged particle in a certain electromagnetic field. It will surely be a helpful tool in teaching. Unfortunately, it cannot be modified to accommodate general fields because the program plots the analytic solution rather than solves the equations of motion.

My reservations about this book lie mainly in two aspects: the lack of special relativity and the presence of conceptually misleading information. I can see that relativity is not applicable to the most common experiences. Yet, the electromagnetic wave is never non-relativistic. Apart from this complaint, relativistic examples *are* dragged in, without warning and with relativity taken for granted! Perhaps the authors expect the students to have been introduced to relativity in a previous "semester of mechanics and . . . electricity and magnetism."

Apart from simple misprints and mistakes (for example, "the electric field . . . one meter from a point charge of one coulomb will equal one newton per coulomb" on page 191), the book contains several unfortunate remarks that, I believe, could send students astray. As examples, I raise two specific points here. On page 303, Bekefi and Barrett strongly suggest that the two degrees of freedom associated with electromagnetic waves are the electric field and the magnetic field. A mode associated with a degree of freedom can be excited *alone*. For an electromagnetic wave, it would be difficult to have only the electric field be non-zero. On page 233, between equation (3.102) and the next, any ordinary mortal student would take the word "superposition" as a principle for the Poynting vector. On further analysis, it is clear that two Poynting fluxes can be superposed if the electric (and magnetic) field of one is parallel to the magnetic (and electric) field of the other. In the book's example, this is the case and, so, the equations are true. For the sake of "mathematical unsophistication," the authors have gone, perhaps, too far. There are other dangerous situations in which they issue no warning concerning the uniqueness of the case. The user should be wary of the "obvious" and tempting generalizations. A new edition should take the student along a less precarious path.

To summarize, I would recommend this text to those who have already developed a clear picture of electricity and magnetism and who have built a strong foundation in its understanding. As a resource book to supplement the usual dull treatment of electricity and magnetism, it is excellent. I doubt, however, that *typical* physics majors would have a whole semester to dwell on these fascinating applications *in addition* to solidifying the groundwork on electricity and magnetism. Given the time and quality of students, I would prefer to use the more "old-fashioned" Feynman lectures. The latter, in a different sense, are also luxury items.

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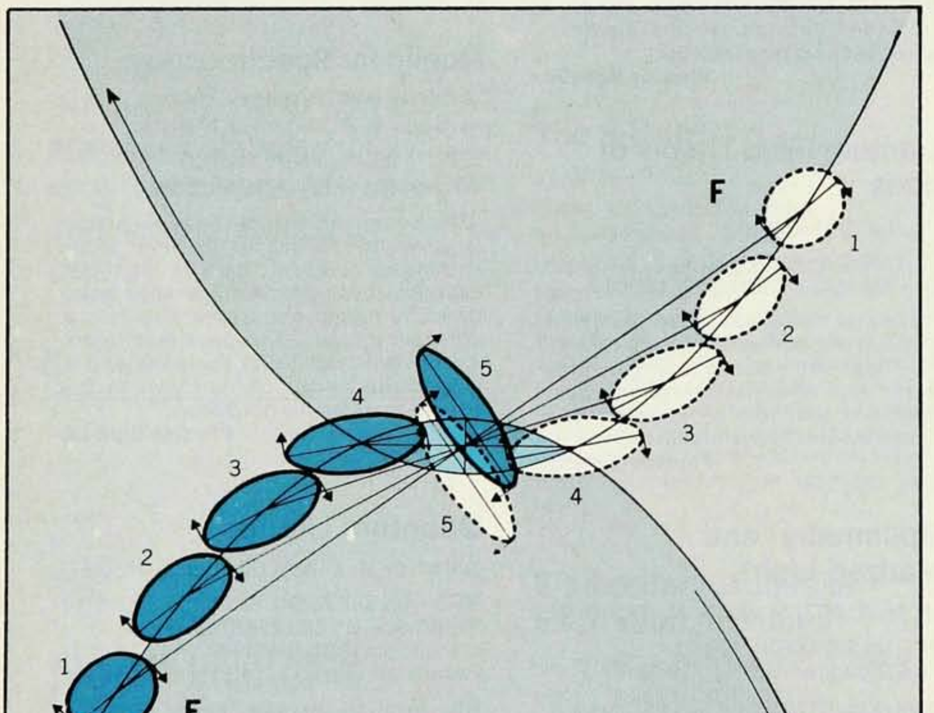
Planets and Planetarians: A History of Theories of the Origin of Planetary Systems

S. L. Jaki
266 pp. Halsted (Wiley), New York, 1978. $16.95

Planets and Planetarians is the first book to trace the history of ideas on the formation of planetary systems from the time the subject was first discussed among the ancient atomists to the present day. As a synthetic history of ideas it is an ambitious and laudable attempt of a kind more often needed; it compares, analyzes and criticizes the theories as they appear in the primary sources. The book concentrates on the crucial assumptions and basic problems in each theory rather than on mathematics, and may be understood easily by the non-scientist interested in the history of scientific ideas.

Stanley L. Jaki is an historian of science who has written extensively in the history of cosmology and physics. With an impressive mastery of the primary sources in Latin, French, German and English, he details the classical Epicurean and Lucretian vision of the evolution of worlds through the random coalescence of atoms; Kepler's Platonic search for a geometric order among planetary distances; Descartes's vortex cosmology resulting from the mechanical interactions of particles subject to specific laws of nature; and Newton's censure of Cartesian vortices based on his own physical laws and on the



A planetary system would evolve, according to the American geologist Thomas Chrowder Chamberlin, from a spiral nebula produced after the near approach of two stars. The diagram above, which originally appeared in the *Astrophysical Journal*, **14**, 35 (1901), shows the increasing elongation and speed of rotation of the two stars during such an encounter. Stanley L. Jaki discusses the cosmogonies of Chamberlin and others in his *Planets and Planetarians*, reviewed on this page.

perceived necessity of "God's arm" to form the solar system as it is presently observed. He traces the evolution of the fascinating 18th-century dualistic theories of William Whiston and George Louis Leclerc de Buffon requiring the grazing collision of a comet with the Sun to originate the planetary masses, and demonstrates how theories have since oscillated from the monistic accounts of Kant and Laplace (the nebular hypothesis), to the dualistic accounts of Forest Ray Moulton and Thomas Chrowder Chamberlin (the planetesimal hypothesis) and Harold Jeffreys and James Jeans (the tidal theory of close-star encounters), and back again to the variations on the single rotating medium theory of Raymond A. Lyttleton, Hannes Alfvén, Carl Friedrich Freiherr von Weizsäcker and their successors. All of these discussions deal not only with the theories themselves, but with the reception they were accorded by contemporaries. To have woven all of these ideas into a readable and accurate work is no small accomplishment, and Jaki has done this well.

Superimposed on this valuable history is a more subjective and controversial theme that pervades the book: that metaphysical reasoning has had a profound effect on theories of planetary origin, that in large measure such theories have not been a product of the scientific method, and that there has been a "long chain of unfounded assertions that the final solution has been secured" (page 2). More specifically, Jaki argues that there has been an "instinctive commitment" to filling the universe with intelligent beings—an example of the idea of plenitude proposed by the historian Arthur O. Lovejoy 40 years ago in *The Great Chain of Being*—and that the desire for a multitude of planetarians has favored theories that result in a high frequency of planetary systems in which intelligent life might abound. Because of this metaphysical influence, "all theories were plagued either by the dubious technique of assuming what was to be explained or by a baffling oversight of the bearing on the question of some basic physical laws" (page 2).

The sweeping generality of this statement, and the approach adopted in attempting to prove the influence of extraterrestrials on terrestrial theorizing, are disturbing. The latter claim especially is based largely on the 20–20 vision of hindsight, a vision that can often make past theories seem ridiculous. Thus Christiaan Huygens's discussion of extraterrestrial intelligence is labelled a "comedy" (page 56); Whiston shows a "readiness to build castles" in the air (page 90), and Kant's theory reveals "wishful thinking" and produces "farcical implications" (page 119). A scientist's remarks, that his theory of planetary origins points to the existence of many possible inhabited planets, are supposed to "speak for themselves" in demonstrating his prejudice (pages 231–32), and the 20th century has been an "era of sleights of hand producing planetary systems in every nook and cranny of the universe" (page 245).

While proverbial hand-waving arguments are by no means unknown in science—and the author demonstrates that this field has its share—Jaki has failed to prove convincingly that hands have been waved consistently in a conspiracy in the name of extraterrestrial intelligence. The history of ideas of extraterrestrial life need not be held up to ridicule, but is most beneficially studied from the more positive point of view as a watershed in the history of thought, whereby Man first realized that he might not be unique in the universe, and investigated that possibility using science as far as it carried him, and then metaphysics and the imagination. Metaphysics undoubtedly does play a role both in the extraterrestrial-life debate itself, and as it relates to theories of planetary formation. Its role in science as a whole was treated by Edwin A. Burtt in *The Metaphysical Foundations of Modern Physical Science* (1924), by Norwood Russell

Hanson in *Paterns of Discovery* (1958), and by Thomas Kuhn in *The Structure of Scientific Revolutions* (1962). As evidenced by the controversy that still swirls around the latter work, the extent of the role of metaphysics in science is exceedingly difficult to determine.

It is not beyond the realm of possibility that the conscious or unconscious prejudices that Jaki—a Benedictine priest—deplores in scientific research have, consciously or unconsciously, crept into his own historical research. Although the result enlivens the work, the reader should beware that the history of science may be no less controversial than science itself. In the end the reader comes away from the book with an appreciation of the problems in the field. And, unsatisfactory theories notwithstanding, we live in an era when the truth may soon be known about the actual existence of the planets, if not the planetarians.

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Linear Systems, Fourier Transforms and Optics

J. D. Gaskill
554 pp. Wiley, New York, 1978. $24.95

The Fourier transform has won an important place as a point of departure into many branches of physics, branches as diverse as waves, electric circuits, quantum mechanics, probability and even computation. Consequently transform methods have earned increasing attention in late undergraduate and early postgraduate courses. Indeed the Fourier transform is one of the few links that electrical engineers have in common, now that it is perfectly possible to receive a PhD in information science or computer science without encountering electromagnetic theory. So the role once played by James Clerk Maxwell has now partly been handed on to Joseph Fourier.

Optics is one of the fields that is rewardingly explored with transforms. For example, although geometrical ray tracing through lenses is rather separate, lens design as such is certainly one of the topics that has benefited. The by-now familiar modulation transfer function or MTF, which describes the fidelity of transmission of spatially sinusoidal patterns through a linear-optical system, is the same thing (in a higher dimensionality) as the hi-fi-amplifier response curve that we all desire to have as flat as possible up to a roll-off frequency that is as high as possible. Clearly the MTF as a tool for thinking with optical systems is superior to the old-fashioned resolving power stated in lines per inch. The optical transfer function, of which the MTF is merely the modulus, is even better. The recent introduction of Fourier concepts into optics has been via electrical engineering just as Jack Gaskill is himself an electrical engineer by origin and is now Professor of Optical Sciences at the University of Arizona. Of course, Fourier concepts always existed in some corners of optics—witness Michelson's Fourier spectroscopy and Abbé's theory of image formation in the microscope.

What Gaskill has done is to provide a textbook that combines the background of linear-system theory and the necessary skills of manipulating Fourier transforms and convolutions that are relevant to image formation in optics. The emphasis on two-dimensional things is unusual in system-theory texts but of course exactly what is wanted for imagery.

A very readable book is the result. Gaskill has given much care to presentation, his illustrations are clear and he devotes plenty of comfortable digression to the whys and hows. Although equations appear on practically every page, the content is not at all forbidding.

Gaskill, who shares with me an interest in notation as a means to clarity, makes free use of rect x, comb x (for an infinite string of unit impulses) and other similar examples in current use including sinc $x \equiv (\pi x)^{-1} \sin \pi x$, whose definition he attributes to me. I have to report that I got it from P. M. Woodward. Gaskill innovates freely but transparently as with cyl x, the unit cylinder function, and somb r, the "sombrero" function known elsewhere as jinc $r \equiv (2r)^{-1} J_1(\pi r)$, the circular relation to "sinc." Just as the "sinc" function is the function that contains cosine components of all frequencies up to a certain cutoff with equal amplitude and nothing beyond, so the "jinc" function, or, in Arizona, the "sombrero" function, contains spatial cosine components (corrugations) of all frequencies up to a certain cutoff, with equal amplitude in all orientations. These apparently *ad hoc* inventions come into their own when "rect" and "sinc" prove to be Fourier transforms, "comb" is its own Fourier transform and "cyl" and "jinc" are a Hankel-transform pair. The utility of these standardized functions has been well established in the fields of conversation, of reasoning out problems in your head and of writing readable algebra.

In the last third of the book Gaskill treats optical subjects using the tools developed. Fresnel diffraction, which comes first, is a simple phenomenon in terms of Fourier analysis. First there are the spatial frequencies comprising the aperture distribution, assumed given, that attenuate exponentially without change of spatial phase. The other spatial frequencies propagate without any attenuation at all, each with its appropriate angle of incidence. Thus the diffraction pattern on any plane parallel to the aperture is deducible by reassembling the spatial components with spatial phase