

the references quoted were published after 1979; virtually none after 1983. Later work has resolved many of the issues the book describes as unresolved puzzles. These include the conflicting data on the electrical levels of Si:3d (critically reviewed and sorted out by Eike Weber, *Appl. Phys. A* 30, 7, 1983), the puzzling zero-phonon lines of GaAs:Cr observed in 1980 (reviewed by B. Clerjaud, *J. Phys. C* 18, 3615, 1985) and the failure to characterize correctly the charge states of GaAs doped with Cr, Co^{2+} or Ni^{1+} (all observed before 1981). The book may thus misguide someone wishing to contribute to the solution of outstanding experimental and theoretical problems in this field.

The book contains an excellent comparison of data obtained by different experimental probes, provides an in-depth review of magnetic susceptibilities (lacking in most other reviews) and identifies the need for obtaining data by different techniques. As such, it may become an excellent reference to the general field of deep impurities. The delightful English of the translator, Albin Tybulewicz, promises to make much of the hitherto untranslated Russian literature in this field accessible to many.

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Underwater Acoustics: A Linear Systems Theory Approach

Lawrence J. Ziomek
Academic, San Diego, Calif.,
1985. 290 pp. \$53.50 hc
ISBN 0-12-781720-4

Underwater Acoustics presents the ocean medium as a linear random filter. Along the way, it provides appropriate background material from electrical engineering and physics. This background material includes a chapter on linear, time-varying, space-varying filters, both deterministic and random; and an additional two chapters on complex spatially continuous apertures and spatially sampled arrays, which couple electrical signals to the ocean medium. Near-field and far-field (along with one-, two- and three-dimensional) apertures and arrays are introduced in these two chapters, and well-known related concepts are defined, including beam steering and focusing, directivity index and array gain, and grating lobes. A chapter on signal processing covers such topics as fast-Fourier-transform beam forming,

quadrature demodulation, bandpass sampling, ambiguity functions, common waveforms, time delays, the Doppler shift, and time-compression stretch. The final background chapter covers acoustic wave propagation in inhomogeneous media, including the WKB approximation, ray acoustics and the parabolic equation approximation.

The last chapter, on "the random ocean medium transfer function," is the book's highlight. Basic equations that couple the transmitted and received electrical signals to the transfer function of the ocean medium via the transmitted and received far-field directivity functions provide the foundation. The generalized coherence function of the ocean is a fundamental measure of a random transfer function. From this, the effects of a time-varying, space-varying, random ocean medium on small-amplitude wave propagation can be described in terms of coherence in time, in space, in bandwidth and in angle. Lawrence Ziomek derives two expressions for the generalized coherence function. One, for an ocean medium that varies only in the vertical dimension, is based on the WKB approximation. The other is based on the parabolic equation approximation for the more general ocean medium, which can vary in all three spatial dimensions.

The book's presentation is mathematical, with emphasis on general derivations that lead to common specific forms presented as special cases. Little effort is spent in discussing derived results. Such discussion would have helped the reader develop more insight into the concepts presented.

While a consistent notation is used throughout the book, its complexity at times tends to obscure the concepts. Also, because the early chapters lay the groundwork for what follows, it would have been helpful had they contained summary highlights of results. Ziomek sometimes refers to earlier results that lie right in the middle of a derivation, and rereading the derivation was sometimes necessary to recall the meaning of terms. Such highlighting would have extended interest beyond the author's primary audience of students in a classroom setting—for example, to the practicing engineer.

My overall impression is that the book would be useful as a text for those who wish to lecture on the ocean as a linear random filter and to cover the necessary background material. However, additional courses on signal processing and underwater acoustics, using more comprehensive texts de-

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voted to those topics, would provide a stronger foundation. Use of the book for self-study would be limited by the lack of insightful discussions of concepts. The book was remarkably free of typographical errors (although in chapter 7, the references to "figure 1.1-2" should be to figure 1.2-1 instead).

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The Search for Extraterrestrial Life: Recent Developments

Edited by Michael D. Papagiannis

Reidel, Boston, 1985. 579 pp.
\$64.00 hc ISBN 90-277-2113-0

In his paper in these proceedings of the first International Astronomical Union Symposium on Extraterrestrial Life, held in Boston in 1984, Harlan J. Smith, the director of the McDonald Observatory, remarks: "I regret that some notable SETI [search for extraterrestrial intelligence] critics, especially Michael Hart and Frank Tipler, were not here. We often learn, or in any event, are stimulated most, from our critics." I myself did not learn of the conference until it was over. I shall here make a few points I would have made had I been invited to the conference.

I would have emphasized the British astrophysicist Brandon Carter's new "weak" anthropic principle argument for the nonexistence of ETI. Two of the participants briefly mentioned Carter's argument, but no participant appreciated its revolutionary significance. Carter observes that the time it took to evolve intelligence on Earth is within a factor of two of the main-sequence lifetime of the Sun. Now, the former is a biological time scale, and *a priori* we would expect it to be quite different from the latter, which is an astrophysical time scale.

Carter's explanation for the approximate equality of the time scales is that the average length of time needed to evolve intelligence on an Earth-like planet is actually much longer than the main-sequence lifetime of a G2 star. Since evolution will, however, cease when an Earth-like planet's star leaves the main sequence, and since the longer evolution can proceed, the more likely it is that intelligence will evolve, the most probable time for the appearance of intelligence is near the end of the time that evolution has to operate on an Earth-like planet. Thus we would

expect approximate equality between the Sun's lifetime and the time needed to evolve intelligence. (More discussion of Carter's argument can be found in my book with J.D. Barrow, *The Anthropic Cosmological Principle* [Oxford U. P., New York, 1986].)

There was a conference session on the "Fermi paradox": If they exist, why aren't they already here? Even with our primitive rocket technology, it would take only a few hundred million years to colonize or explore the Galaxy.

Attempts to avoid the no-extraterrestrial-intelligence implications of the Fermi paradox fall into two categories:

▷ technical or economic barriers to interstellar travel

▷ moral objections to such travel or social mechanisms preventing it.

The crucial point in the second category was never mentioned at the conference: Virtually any motivation we can imagine that would lead ETI to engage in interstellar radio communication with us would also motivate them to engage in interstellar travel.

The anthropologist Ben Finney compared the various colonization scenarios with historical human migrations. He pictured the Polynesian colonizations and Ming Chinese expeditions as "stalled maritime expansions," indicating that "no specific migration has ever gone unchecked. Ecological barriers, the slowing or cessation of innovation, flagging motivation, or the opposition of those in the way of expansion have... stopped every migration or colonization movement so far." Finney inferred that interstellar colonization-exploration would stop short of the entire Galaxy.

But Finney's data indicate the opposite. The analog of the ecological-innovation barrier is the lack of a suitable robot probe, and we are near to overcoming this. With a probe, there is no natural barrier to stop a colonizing species short of the entire Galaxy. The first intelligent species to evolve sees no opposition of those in the way. Finney's data indicate that motivation flagged once the other barriers made further expansion difficult. Finney's picture of Polynesian social evolution is exactly what I predicted would be the behavior of colonizing ETI.

Many participants emphasized that the question of the existence of extraterrestrial intelligent life must be settled by experiment, not by debate. But no one has ever claimed otherwise. The question has always been, rather, *which* experiments. We have one extremely significant experimen-

tal result: They aren't here. Carter's argument has experimental implications. So does the claim that our future grasp of the cosmos is unlimited: The density of particle states must diverge with energy E , but no faster than E^2 .

There have been 50 radio searches in the past 25 years, logging close to 120 000 hours of observations. Negative radio results always lead to a call for even more expensive instruments, never to the conclusion that there's no one out there. No experiment will ever convince the ETI believers that we are alone.

Bioastronomy resembles nothing so much as parapsychology. A century of negative results has not diminished the field: More money is now being spent on ESP research than ever before.

John A. Wheeler was distressed when parapsychology was admitted as an American Association for the Advancement of Science affiliate in 1969: "Every science that is a science has hundreds of hard results; but search fails to turn up a single one in 'parapsychology.' Would it not be fair... for 'parapsychology' to be required to supply one or two or three battle-tested findings as a condition for membership in the AAAS?" He recommended that parapsychology be expelled from the AAAS.

Is it not reasonable to ask the same of "bioastronomy"? If the present NASA-funded radio search fails, is it appropriate for this "'science' without known subject matter" (in the words of evolutionary biologist George Simpson) to remain in the IAU?

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BOOK NOTE

The Birth of Particle Physics

Edited by Laurie M. Brown and Lillian Hoddeson

Cambridge U. P., New York, 1986 [1983]. 412 pp.

\$47.50 hc ISBN 0-521-24005-0;

\$18.95 pb ISBN 0-521-33837-9

The history and evolution of modern elementary-particle physics was the topic of a Fermilab symposium in May 1980. A paperback edition of the book that emerged from that symposium (first published in 1983) has now come out. Contributions by Laurie Brown, P. A. M. Dirac, Robert Marshak, Bruno Rossi, Julian Schwinger, Robert Serber and Victor Weisskopf, among others, describe their own and