

occultations; the theory of least squares and other methods for adjustment of observations; methods in numerical mathematics and techniques of numerical calculations.

The topics left, which are covered in one or more chapters of the present treatment, are the celestial coordinate systems, parallax, refraction, aberration, precession and nutation, variations of the local reference system, the dynamical basis, ephemerides, measurement of time, construction of observational star catalogs and a final chapter on the inertial reference system. Because of increasing precision of observations and the higher accuracy of astronomical data needed for applications such as space flight, the authors have taken care to derive exact mathematical relations before making

the approximations needed for practical purposes. Where in the older treatises the first-order approximation was all that was considered, it is now necessary in many cases to go to second- and third-order terms. Thus the book has a dryness inherent in this type of mathematics. Needless to say, the reader must be very proficient in the use of the formulas of spherical trigonometry as well as the technique of taking approximations. However, the principles and results are discussed in considerable detail. In connection with this discussion I found it sometimes hard to follow because of a paucity of diagrams which the reader will have to construct himself.

Because the book concentrates upon the basic principles and theory there are few worked examples although the

discussion of numerical values of the empirical constants is fairly complete. Thus it supplements the *Explanatory Supplement* to the *Ephemeris* published by Her Majesty's Stationery Office in 1961 where many more tables and worked examples are to be found but the basic theory is glossed over. Since one of the authors of the present treatise was also an author of the *Explanatory Supplement*, it is not surprising that both books are necessary to a complete understanding of the *American Ephemeris and Nautical Almanac*.

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Is anybody out there?

INTELLIGENT LIFE IN THE UNIVERSE. By I. S. Shklovskii, Carl Sagan. Russian portion trans. by Paula Fern. 493 pp. Holden-Day, San Francisco, 1966. \$8.95

INTELLIGENCE IN THE UNIVERSE. By Roger A. MacGowan, Frederick I. Ordway III. 416 pp. Prentice-Hall, Englewood Cliffs, N. J., 1966. \$13.50

by *Herbert Malamud*

The question of the existence of intelligent life in the universe (other than that on earth) has concerned philosophers of religion and science fiction for many years. Since the sudden birth of space travel and the resulting imminence of man's visits to other planetary bodies, the question has become of interest to other, more pragmatic personalities—hence the general popularity of flying-saucer speculations.

It is no accident that the subject has engaged the attention of Iosef Shklovskii, the imaginative Soviet astronomer who first explained the synchrotron-radiation source in the Crab nebula. A result of this attention was the appearance in 1963 of his *Universe, Life, Mind*.

Carl Sagan, presently assistant professor of astronomy at Harvard and a staff member of the Smithsonian Observatory is another who has studied

and written on the subject of possible extraterrestrial life forms. It was not a coincidence that he was struck by the book and offered to supervise its translation (by Paula Fern). Shklovskii was pleased, and the supervision became explanations and then additions and commentaries. *Intelligent Life in the Universe*, the final book, is about twice the length of the Russian original, Sagan's contributions being set off by deltas everywhere. While most books written by multiple authors have been carefully edited to hide this from the reader (except on the title page), this volume is an exception, the authors going so far as to include discussions of a few minor disagreements, leaving the reader to decide himself as to which is more likely correct.

All in all, this is an eminently successful collaboration by two authors who had, at least until the time of publication of their book, never met.

Roger MacGowan, of the Army Missile Command in Huntsville, Alabama, and Frederick Ordway of the General Astronautics Research Corporation of London have given us a more conventional collaboration in *Intelligence in the Universe*. Both, like the authors previously mentioned, have given professional attention to the problem, and have widely published in the field.

The two books are more alike than different, in many respects. Both may be described by the same outline, for example. They begin with a description of the universe, followed by an outline of stellar evolution. A description of and theories of development of planets follows this, with reasons for believing that planetary systems are more likely to be the rule rather than the exception. Shklovskii and Sagan accentuate this section more than MacGowan and Ordway do.

After this beginning comes a description of the development of life from inorganic systems and of the evolution from simple to complex and finally to thinking (presumably intelligent) life forms. A detailed description of the thinking process accompanies this section, much more detailed in the MacGowan-Ordway book. The possibilities inherent in thinking automata are also considered here.

Estimates based on reasonable extrapolations from data and on reasonable assumptions are derived for the possible prevalence of thinking forms, both biological and automatic, and an examination is made of possible empirical evidence of extraterrestrial intelligence, including possible historic or prehistoric visits to earth.

The authors then examine the question of possible communication with

us. Of various conceivable methods, radio communication is considered most practicable at present although laser methods may become so in a very few years as more powerful and less divergent lasers are developed.

All the authors except possibly Sagan are clearly optimistic that in general, intelligence does not destroy itself shortly after developing the means to do so. Sagan himself is not pessimistic enough to believe the contrary but is a bit more hesitant about making a positive assertion on the subject.

If, then, intelligences more advanced than ours exist, why have they not contacted us? Both books speculate, give various possible reasons and conclude that when we have contacted them, we will have a better opportunity to find out.

Both books can be read and understood by persons without a specialist's knowledge of astronomy, or biology, in one case, thanks mainly to Sagan's supplementary material.

In reading these books together, one has the impression that Sagan and Shklovskii wrote their book mainly for

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HYPOTHETICAL INTERSTELLAR MESSAGE due to Frank Drake. The problem is to convert this sequence into an intelligible message, knowing there was no previous communication. (*Intelligent Life in the Universe.*)

the pleasure it gave them to speculate so freely in a field where no one could successfully contradict them. This attitude, after all, is denied to most scientists in writing the more usual technical book. MacGowan and Ordway wrote, perhaps in a more serious vein, a scientific book by scientists, though speculation is not lacking. I cannot identify the specific source of this feeling of difference; it is in the back-

ground only. I might say that both books sing to the same melody; only the harmony is different.

Both were a pleasure to read, and in each case the pleasure was enhanced by the presence of the other.

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New approach to crystals

CRYSTAL SYMMETRY AND PHYSICAL PROPERTIES. By S. Bhagavantam. 230 pp. Academic Press, New York, 1966. \$9.50

by Henry M. Otte

The general scope of this book bears close resemblance to the classic one of Nye's on *Physical Properties of Crystals* first published ten years ago by the Oxford University Press. The approach is different, however, in that emphasis is placed on group theory which in Nye's book (page 122) is dismissed with the comment that it "provides a useful check on the results given by other methods. [It] . . . does not reveal which of the moduli are independent, but only the total number of independent ones." In contrast, Bhagavantam has a full chapter on groups and another one on crystallographic groups, including magnetic space groups. This is not altogether surprising in view of his interest over the past years in the application of group theoretical methods to the so-

lution of problems in crystal physics, particularly those involving the effects of symmetry on the physical properties of single crystals.

In both Bhagavantam's and Nye's books there are numerous parallel sections on the physical properties such as stress, strain, elasticity, thermal expansion, electrical, magnetic and optical properties and transport phenomena. However, the overlap is not as extensive as might appear, for several reasons. Bhagavantam's book is only about two thirds the length of Nye's. In addition there are a number of topics like group theory and its applications as already mentioned, that are not covered in Nye's book, as well as others like magnetoelectric polarizability, piezomagnetism and third-order elasticity. Those sections that do overlap are treated comparatively very briefly in Bhagavantam's book.

As in Nye's book, the necessary background mathematics and geometrical crystallography has been includ-

ed and kept relatively simple. The book has been aimed primarily at students of solid-state physics but with the hope that it would also prove useful to the experimenter interested in studying the properties of single crystals. The dearth of references in the text is rather disappointing. There are only about 30 in all, and nowhere is any mention of Nye's book, to say the least! This shortcoming is excused by the author on the grounds that his book is largely based on work carried out by himself alone or in conjunction with collaborators. For this reason also no attempt was made to append a complete bibliography. There is a fairly good subject index, but, as would be anticipated, no author index. The book contains about a dozen diagrams and numerous useful tables. Problems at the ends of the chapters are dispensed with, and examples are kept to a minimum.

The author is listed as Scientific Adviser to the Minister of Defense, New