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 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 background 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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HYPOTHETICAL INTERSTELLER 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.***)

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 solution 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 included 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.

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JANES, G.S., LEVY, R.H., BETHE, H.A., AND FELD, B.T.

ON A NEW TYPE OF ACCELERATOR FOR HEAVY IONS. December, 1965.

Contract AF 49(638)-1553.

Published in Phys. Rev. 145:925 (May 1966).

A new device (called HIPAC - Heavy Ion Plasma Accelerator) which may be capable of accelerating ions of any atomic number to energies sufficient to overcome the nuclear Coulomb barrier is described. A closed potential well is created by filling a toroidal vacuum chamber with electrons; the electrons are contained by a magnetic field whose intensity is so low that its effect on the ions can be neglected. Ions are both accelerated and trapped in the well; the trapping effect allows sufficient time for the ions to become highly stripped by electron impact. The very large ion energies that can be achieved in this way would allow a wide variety of nuclear reactions to be studied, including inverse fission. The present primitive state of development of the HIPAC is described, and the future prospects assessed.

WEISS, R.

THE NEAR WAKE OF A WEDGE. December, 1964. Contracts DA-30-069-ORD-1955 and AF 04(694)-414. AFBSD-TDR-64-150. N65-15716. AD 609577.

Published in AIAA J. 4:1557-1559 (September 1966).

An analytical model of the two-dimensional laminar near wake is described. All relevant physical features of the flow, including the boundary layer expansion at the shoulder, free shear layers, recirculation regions and recompression region are included. A tractable problem is formulated by matching approximate solutions for each of these regions along mutual boundaries. A set of coupled algebraic equations is derived, and numerical results obtained for the conditions of a wind tunnel wedge experiment. Satisfactory agreement is obtained between the measured and theoretical variation of base pressure with Reynolds number. Additional computations are carried out for a series of wedges of different length, apex angle, and wall temperature. The variation of base pressure, wake angle and neck enthalpy ratio with altitude is obtained for these bodies. It is shown that the near wake dimensions scale approximately with body size, and that the neck enthalpy ratio has a significant variation with body size, wall temperature and altitude. The effect of free-stream velocity on the neck enthalpy ratio is seen to be relatively unimportant, however. A number of extensions of the first-order model are suggested.

Delhi, India, and apart from his publications in the scientific journals has also to his credit another book with T. Venkatarayuda, *Theory of Groups and Its Application to Physical Problems* (Andhra University, Waltair, 1962, 3rd ed.) with which this reviewer is not familiar. In summary, I would say that Bhagavantam's new book will be most useful, especially in conjunction with Nye's book; furthermore, it is very readable and well organized.

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Electron beams and electromagnetic waves

NON-LINEAR ELECTRON-WAVE INTERACTION PHENOMENA. By Joseph E. Rowe. 591 pp. Academic Press, New York 1965. $18.00

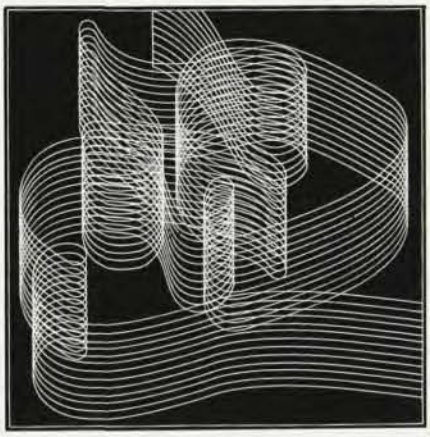
by H. J. Hagger

There are very few systematic treatments of electron-wave interactions; we find, however, discussions of this topic in books on specific types of microwave tubes. In almost all these cases a linear, small-signal theory is developed. Rowe based the book on his own research and the work done by his research students, and has succeeded in treating the large-signal and nonlinear behavior of all types of microwave tubes. The topics are developed essentially from one single base that makes the difficult subject quite easy to follow.

The first four chapters provide the general framework for more detailed applications to specific interaction configurations. After a general introduction two approaches to the problem are treated, the consideration of the electron beam as a whole and the particle-wise development of the theory. The latter may be applied both to normal and crossed-field devices. In chapter 3 there follows a quite general introduction into rf equivalent circuits, both for metallic transmission lines and for surface-wave propagation of a plasma beam. Multidimensional and backward-wave structures are considered. The next chapter is devoted to space-charge field configurations.

In chapter 5 we find a one- and two-dimensional klystron analysis together with radial and angular as well as relativistic effects. Chapter 6 is similar in its systematic construction for travelling-wave tubes without crossed fields. The next chapter deals with O-type backward-wave oscillators. In chapter 8 drift-space interaction phenomena in crossed fields are considered, serving as a basis for the next two chapters on forward-wave crossed-field amplifiers and M-type backward-wave oscillators. For tubes with an emitting sole, e.g. the travelling-magnetron oscillator and amplifier, we find just the remark that they can be treated in a similar way. The remainder of the book is then devoted to special problems in microwave electron-beam tubes.

In chapter 12 the author discusses multibeam and beam-plasma interactions. In general the crossed-field devices show higher efficiencies than linear beam tubes because with the potential energy conversion process in the former tubes the electron bunch stays in synchronism with the rf wave. In chapter 13 Rowe investigates some phase-focusing means, e.g. velocity tapering or a dc gradient in the beam flow, which improve the percentage of energy extracted from the beam. This investigation applies both to amplifiers and oscillators. In the next chapter the influence of pre-bunching the beam before it enters the interaction space is considered and the power required to bunch an electron beam is calculated. In order to increase the efficiency even further the collector-depression technique is investigated.



The last chapter is devoted to low- and high-frequency modulation processes. In three appendices rf structure impedance variations and Kompfner dip conditions for normal and crossed-field tubes are considered. We find a selected list of references to each chapter and—unfortunately—quite a small subject index. The reviewer might add that there are captions to the figures that often lack the information required to understand the figures and the conclusions to be drawn from them. This very minor criticism has been mentioned just to improve a next edition of the book.

As a whole we have here an excellent book on the large-signal behavior of electron-beam tubes, the theory of which is based on the same basic relations for all microwave electron-beam tubes. The approach derived by Rowe will certainly find other applications to field-plasma interactions. The book will serve as an outstanding book on nonlinear analysis of interactions. The research scientist interested in this field will be pleased to have this book.

The reviewer doubts, however, that it will find much use as a textbook for a graduate course. Parts of it will serve excellently as a source and root for an advanced course and it must be left to the lecturer to select the problems to be treated. The book requires that the reader be familiar with the basic theories of electron-beam tubes found in well known standard books and famous papers. In any case Rowe's book can be highly recommended for research studies in nonlinear interaction theory. The book will be an excellent guide through the field and it will occupy its well deserved place as a standard work on this special field for a very long time.

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Quanta and large things

WAVE MECHANICS AND MOLECULAR BIOLOGY. Louis de Broglie, ed. 186 pp. Addison-Wesley, Reading, Mass., 1966. $8.75

by R. Bruce Lindsay

In the past 20 years application of quantum chemistry to structure and behavior of large organic molecules has made great strides. This has par-