Book Reviews

Magnetic Fields in the Cosmos

The Magnetic and Related Stars. Proceedings of a symposium, Greenbelt, Md., Nov. 1965, and the Helen B. Warner Prize Lecture of the American Astronomical Society, Berkeley, Calif., Dec. 1965. ROBERT C. CAMERON, Ed. Mono Book Corporation, Baltimore, 1967. xii + 596 pp., illus. $25.

This is an excellent symposium volume. In general, books with many contributors may confuse rather than illuminate a subject. This book covers well an extremely complicated field of astrophysical research, in which some major mysteries have been revealed, and most are left unexplained. The book has the advantage of containing excellent broad reviews of observational data and proposed theoretical explanations. Although some of the detailed papers are of value mainly for the specialist, it is nevertheless true that the non-astronomer can obtain an excellent introduction to a very difficult and complicated subject.

Magnetic fields were found first in the sunspots, were next suspected as a general field in the sun, and finally were discovered to be present in interstellar space and in the stars. The stars that show large, general, somewhat simply arranged magnetic fields are limited in type; most of them have surface temperatures near 10,000° to 15,000°K and belong to the young population of our galaxy. They tend to rotate somewhat more slowly than the average star of this type, and they show spectra which range from relatively simple to unbelievably complex. The absorption lines in some of these stars are almost unrecognizable to the trained spectroscopist, often being extremely crowded, ionized rare earths.

In addition to the spectral peculiarity, the field of such a star varies, sometimes in quite short periods, possibly connected with the rotation of the star. The elements are concentrated in different patches, with different fields, and these periodic variations of line intensity, elements present, and sign and size of the magnetic field are a very interesting observational phenomenon. The changes in color and light are minor. The elements present are often such as to arouse disbelief, rather than enthusiasm. The observed fields reach up to 34,000 gauss. Variation periods run from one to a few hundred days. A few late-type, highly evolved red giants have smaller magnetic fields.

The two theories advanced to explain the observed variability are that of the "magnetic oscillator" and that of the "oblique rotator." Rapid rotation changes the temperature distribution over the surface of the star, and very large magnetic fields may also have the property of providing a source of nonuniformity. In a magnetic oscillator, since ionized stellar plasma cannot move across lines of force, a star attempting to pulsate will, in fact, undergo a complex surface deformation which will result in small radial velocity changes, brightness and color changes, and presumably, therefore, in spectral changes. The oblique-rotator model imagines that a magnetic dipole is present whose axis is not parallel to the axis of rotation. Alternate magnetic poles are carried past the observer during the rotation. In the oblique-rotator model, giant areas of the star, like sunspots but not necessarily darker than the mean surface, contain the peculiar elements and move onto the disk and off after half a period.

Distinction between these models is not simple, nor is it clear whether the oblique rotator can eliminate the need for some magnetohydrodynamic oscillations. The depth to which the magnetic field reaches in the star is not known. In the range of surface temperatures in which these stars lie it is possible that convection occurs only at some depth below the surface and that the peculiarities of field and composition observed are confined to the surface layers.

The contributions outlining the background of the subject include a reprint of the Helen B. Warner prize lecture of the American Astronomical Society by George W. Preston, which provides an excellent review of the data, and an outline by Ian W. Roxburgh of the theory of rotation and magnetism and their effect on stellar structure and evolution. There is an exposition by Paul Ledoux of the complex oscillations that would occur in the coupling of wave motion and magnetic fields. One of the major controversies at the symposium concerned the possibility that the magnetic stars are the exposed cores of highly evolved red giants which have lost their surface layers and their extensive low-density envelopes. Observations of the locations of these stars in the luminosity-temperature diagram seem to reduce the plausibility of such a model. Extensive discussions of the nuclear reactions required to produce the peculiar composition lead to the possibility that the stars have suffered high-energy particle bombardment at the surface, at least sufficient to produce spallation, and subsequent neutron capture to produce some of the elemental peculiarities. The general fact that the abundance of very heavy elements is greatly increased makes nucleosynthetic processes involving neutron capture attractive. Whether this capture has occurred as a consequence of neutron release in the red-giant stage in the core or because of particle acceleration in the magnetic fields near or above the surface is not yet clear. The spectroscopic analyses of the composition of such stars provide a bewildering variety of information. In brief, excess abundances of middle-heavy elements by a factor of a thousand are quite common, and even sometimes absolutely inexplicable anomalies such as the presence of He^3 in one such star or of enormous quantities of holmium in another still provide inexplicable, fascinating problems.

The book is best suited for those with interests in astrophysics or nucleosynthesis, and as a background reading for advanced courses in stellar spectroscopy and evolution. For the general reader several of the resumé articles provide an excellent introduction.

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