Books

Cosmic Radio Waves. By I. S. Shklovsky. Translated from Russian by Richard B. Rodman and Carlos M. Varsavsky. 444 pp. Harvard U. Press, Cambridge, Mass., 1960. $12.50. *Reviewed by Otto Struve, National Radio Astronomy Observatory.*

THE first radio map of the sky published by Grote Reber in the November, 1944, issue of the *Astrophysical Journal* showed a distribution of meter-wavelength radiation resembling the optical brightness distribution of the Milky Way. Superposed over this broad band of radio radiation he found three distinct regions of greater than average intensity: in the constellations Sagittarius, Cassiopeia, and Cygnus. These intense sources of radio emission had no immediately identifiable counterparts in the optical appearance of the Milky Way. All three are now known to be the brightest discrete sources of radio emission: the first is Sagittarius *A*—the central nucleus of the Milky Way—which is obscured from direct view by intervening cosmic clouds of dust; the second, Cassiopeia *A*, is the remnant of a supernova which exploded in the Milky Way about 256 years ago, at a distance of about 10 000 light years from us. Intervening dust clouds conceal most of the optical emission of this expanding shell of gas, but Baade and Minkowski succeeded in photographing tiny wisps of the shell with the 200-inch Hale telescope and in measuring its velocities of expansion and internal turbulence. The third, Cygnus *A*, is associated with a pair of colliding and, otherwise, fairly normal galaxies at a distance of about one billion light years.

Each of the two optical galaxies may be about 100 000 light years in diameter; they are apparently colliding face on, with a relative velocity of about 3000 km/sec, and their optical spectra show strong emission lines which are usually faint or absent in single galaxies.

The associated radio source consists of two "blobs" separated by about 300 000 light years, and located symmetrically on both sides of the optical pair. The distance between the outer edges of the blobs is of the order of half a million light years. Shklovsky suggests that "the radio power generated by this process is fantastically great: the flux of radio waves from Cygnus *A*, observed at the earth, rivals that from the sun." But the distance of the sun is only a few light minutes, while that of Cygnus *A* may be one billion light years.

The radio emission of the blobs is probably caused by the synchrotron mechanism of a large number of relativistic electrons in a magnetic field of about 10^{-4} gauss.

Each galaxy must have been embedded in a "corona" of very tenuous and very hot gas. With a density of 10^{-25} gr/cm^3 and a relative velocity of 3×10^8 cm/sec, the kinetic energy of the colliding gas masses would be 5×10^{59} ergs. The radio luminosity of the two blobs is 1.6×10^{44} ergs/sec (or about 10 times the optical luminosity of the two galaxies). Over an interval of 10^7 years or 3×10^{14} sec (the duration of the collision) the energy emitted to date is 5×10^{58} ergs, or 10 percent of the available kinetic energy.

Shklovsky's book discusses these and many other types of radio sources. It can be used as a textbook, but it is really much more than that, viz., a fascinating and interest-gripping scientific detective story, in which the author is the detective and the mysterious radio waves his tools. The original Russian edition was published in 1956. The English translation has been brought up to date (to April, 1960) by the author and the two translators. It is dedicated "to the memory of Grigory Abramovich Shajn", whose brilliant astrophysical work must have had a decisive influence on Mr. Shklovsky's life.

When I was a member of the faculty of the University of Chicago, I heard a great deal about R. M. Hutchins' project of the "Great Books of the Western World". But while this project was concerned with all fields of knowledge throughout history, I have often thought about the great books of my own time and in my own field of science. Among these are H. Poincaré's *Leçons sur les Hypothèses cosmogoniques* (1913); R. Emden's *Gaskugeln* (1907); W. W. Campbell's *Stellar Motions* (1913); A. S. Eddington's *The Internal Constitution of the Stars* (1926); J. H. Jeans' *Astronomy and Cosmogony* (1928); A. Unsöld's *Physik der Sternatmosphären* (1955), etc. Shklovsky's book belongs to this list. Not all of its conclusions will stand the test of time; and in a very few cases I have been unable to follow the reasoning. But astronomers and physicists will agree with Bok that Shklovsky's "name will always be associated in our minds with one of the most fruitful suggestions of the past decade—that of the importance of the synchrotron process of relativistically accelerated electrons moving in interstellar magnetic fields".

It should perhaps be noted that the book is almost entirely concerned with the interpretation of radio observations made outside the Soviet Union, and it is gratifying that the author acknowledges that "at the present time the American radio astronomers occupy a leading position in the continuing development of this field". It is equally gratifying to record that Russia is making rapid strides in developing its own radio astronomical observatories. Thus, an entire issue of 186 pages in the *Izvestia* of the Pulkovo Observatory (Volume 21, Part 5, 1960) is devoted to observational radio astronomy; and even more impressive installations are now in existence, or are believed to be in the process of erection, at the Serpukhov and Crimean radio-astronomical stations of the Lebedev Institute in Moscow.