problems of diffraction and geometrical accuracy and stability which beset interferometry. The potential accuracy is therefore greater, but the apparatus at present is much larger and more complicated than that of Bay *et al.*, and not yet able to reach visible frequencies.—D. K.

SUPERNOVAE

Insight into Type I

by our Cosmology Correspondent

ALTHOUGH the spectra of type II supernovae are not too dissimilar to those of novae—more common but less violent eruptions of normal stars—and have thus been open to at least a degree of interpretation, type I supernovae have until recently proved a much tougher nut to crack. Now, a combination of theoretical and observational studies carried out by Charlotte Gordon, of Yeshiva University, New York, is at last yielding results which seem to be laying the empirical base for a better understanding of these objects (*Astron, Astrophys.*, **20**, 79 and 87; 1972).

The principal reason for the differences between the two types of supernovae is that type I occur among population II stars, and type II among population I—an unfortunate choice of nomenclature left over from an earlier age of astronomy—and that population II stars are deficient in heavy elements. Population II stars form the halo population of our own Galaxy, and predominate in elliptical galaxies, whereas population I stars, generally regarded as "second generation" products produced from matter already processed through a nuclear burning cycle (perhaps in population II stars which have exploded), occur chiefly in the spiral arms of galaxies.

It is not surprising, therefore, that population II stars, on the rare occasions that they explode into supernovae, produce supernovae with spectral features quite different with those of type II supernovae. Generally, spectra of type I supernovae consist of wide emission bands, and it is only in the past few years that any of the features have been identified with known lines of oxygen (O I) and helium (He II and He I). The problem is complicated both by the need to study supernovae in galaxies other than our own—for they are far too rare for astronomers using telescopes yet to have caught a glimpse of a "native" supernova—and by the complex and rapidly varying Doppler effects on the spectral features produced by the explosive expansion of a turbulent gas cloud. Gordon has studied the physical conditions in such an expanding shell and the formation of emission and absorption lines under those conditions. Density, temperature, chemical composition and other effects must all be included in these theoretical calculations before the models can be compared with observed spectra and adjusted until some sort of agreement is reached.

Much of the dynamics in Gordon's models comes from the work of Colgate and his colleagues (*Astrophys. J.*, **157**, 623 ; 1969 ; and **143**, 626 ; 1966). With a dispersion of velocities of up to 2×10^9 cm s^{-1} within the shell, it is no wonder that the spectra seen are complicated. The chemistry of the shell also poses problems. Hydrogen lines are conspicuous by their absence from these spectra, whereas usually they are the one feature which can be found in spectra of any astronomical object, and Gordon's models suggest that helium is the chief component of the shell, with its ions outnumbering those of hydrogen by ten to one. A further complication is provided by the possible existence of a young neutron star remnant at the supernova site, emitting hard radiation which will be stopped by the expanding shell.

In spite of these difficulties, Gordon has now tentatively identified many lines of helium, oxygen, carbon, iron, and other metals in three supernova spectra—those of the events that took place in 1937 in IC 4128 and NGC 1003, and that of the event of 1960 in NGC 4496. The rapid evolution of the spectra points to a rapid decrease in the degree of ionization in the inner layers of the expanding supernova shell ; after 30 day, Gordon predicts a number density of free electrons of 3×10^{10} cm^{-3}, which falls to 10^9 cm^{-3} after 89 day and to 3.5×10^7 cm^{-3} after 285 day. For the 1960 supernova in NGC 4496, Gordon finds that the degree of ionization and effective temperature in the shell required to explain her identifications of the lines point to two possible models. In the first, ionization occurs by the absorption of bremsstrahlung and ultraviolet lines formed in the inner layers of the shell; in the second, ionization is powered by the synchrotron radiation from the newly formed neutron star.

There seems to be no continuum in the spectrum of the NGC 4496 supernova, which consists of a system of emission lines truncated by an overlaying absorption, according to Gordon, and these features can be explained if the outward moving shell is ionized by an intense flux of X-rays.

The first model corresponds to the production of these X-rays in the innermost layer of the shell, which is heated by fast particles from the underlying neutron star, and the second model corresponds to the direct generation of X-rays by the neutron star.

These empirical results are far from complete, and leave many questions unanswered. But they provide a reasonable picture of the sequence of events in type I supernovae which agrees with generally held views about such objects.

Magnetic Field Structure of 3C 273A

MANY broad issues have yet to be resolved before the nature of the extragalactic radio sources associated with radio galaxies and quasars can be fully understood. One problem is how the radio sources are confined so that they do not expand adiabatically and quickly fade, and another is how a supply of energy from the optical object can be so directed to reach the radio component. In the past few years several containment models have been suggested, chiefly using the ram pressure of the intergalactic medium to confine the radio sources. A common feature of these models has been a hairpin magnetic field structure in which the magnetic field lines loop from the optical object to the radio component and back. In the next issue of *Nature Physical Science* (September 11) R. G. Conway and D. Stannard have found, in 3C 273, the first observational evidence of such a magnetic field structure.

The radio source 3C 273 is a quasar with an optical jet. Its radio structure comprises a very compact component, 3C 273B, coincident with the optical position of the quasar, and a second component, shaped like a cigar, 3C 273A, which is 20 arc s away and lies along a continuation of the jet. Using measurements made with an interferometer at 11 cm at the National Radio Astronomy Observatory, Greenbank, and at 73 cm at Jodrell Bank, Conway and Stannard have been able to find the one-dimensional distributions of total flux, linear polarization and position angle across the source. They find that the magnetic field at the end of 3C 273A nearest to the quasar is parallel to the direction of the jet, while the field at the other end of this radio jet is perpendicular to the jet. In short they have found the first example of the hairpin magnetic field structure predicted by the containment models.

So at last measurements have revealed a magnetic field structure that is in agreement with the theories. It has, however, not been found where it might have been expected, namely in a large powerful radio source such as Cygnus A, but in quite a small source that is only 2×10 arc s.