recently several industrial applications have been gaining a hold. The presence of different phases can be recognized by the superimposition of spectra; for example, in supposedly aluminium doped yttrium iron garnet (YIG) the presence of a precipitate of pure YIG can be recognized from the Mössbauer spectrum. The determination of the ferrous to ferric ratio in sintered iron ore mixtures is being used to estimate the optimum conditions for operating blast furnaces, and at the Atomic Energy Research Establishment at Harwell Mössbauer spectroscopy has proved a valuable tool in the production of a series of aluminium garnets.

EXTRA-OPTICAL ASTRONOMY

X-ray and Microwave Progress

from our Cosmology Correspondent

REASONABLY accurate measures of the positions of X-ray sources are in most cases essential before any identification of the object with an optical or radio source can be attempted. It is therefore particularly welcome that W. Mayer, H. V. Bradt and S. Rappaport have determined fairly good positions for twelve X-ray sources, all lying in the intensity range 1.5–8 keV, and all observed on the same rocket flight on July 26, 1968.

By making a rapid sequence of still stellar photographs, the orientation of the rocket was recorded at any time in the flight, and the accuracy of the alignment is confirmed by the detection of the well known source Sco X-1 with a position error of less than $2'5$ (*Astrophys. J. Lett.*, **159**, L115; 1970). For each of these twelve objects, the positions given by Mayer *et al.* are better than those previously known, in some cases considerably so. But none of the sources seem to exhibit the irregular variation seen in some of the more closely studied sources, such as Sco X-1, because the observed intensities on this flight are roughly comparable with those seen several years before.

In the same issue of *Astrophys. J. Lett.* (**159**, L123; 1970) comes news of improved information about the other important class of new objects recently detected as a result of the expansion of astronomy either side of the optical range. P. R. Schwartz and A. M. Barrett have surveyed 134 infrared sources in a search for microwave H_2O emission, and have found this in three new sources, NML Cygni, V Herculis and W Hydrae. Two of these three stars are long period variables, as is becoming almost standard in such cases, but there are considerable differences between their other properties, both at microwave and infrared wavelengths. VY Canis Majoris and R Aquilae, previously known H_2O sources, were also studied. Like V Herculis (a Mira variable) and W Hydrae (a semi-regular variable) R Aquilae varies in intensity, although in detail its spectrum is unlike those of each of the other variables. Perhaps the most important similarity is that in each case the radial velocities of the radio H_2O lines lie between the radial velocities of the H_2O emission and absorption lines at visual wavelengths, although closer to that of the visual absorption line. Although this offers a hint as to the details of the maser action producing these lines, no entirely satisfactory model of these sources is likely to emerge until more intensive studies of the stars have been carried out.

CARBON FIBRES

Fine Structures in Ribbons

from our Materials Science Correspondent

THE results of an intensive programme of research into the detailed structure of high strength carbon fibres, in progress for the past three years in the laboratories of Union Carbide Research Associates in Brussels, have been summarized recently by Fourdeux, Hérinckx, Perret and Ruland (*CR Acad. Sci.*, **269**, 1597; 1969). Most of their work was done with 'Thornel' fibres, made from cellulose by Union Carbide, but studies carried out elsewhere on fibres made by the British process from polyacrylonitrile (PAN) have shown that both types of fibre have very similar structures. Techniques used included X-ray and electron diffraction, small-angle X-ray scattering, electron microscopy and potassium intercalation.

The conclusion is that high strength carbon fibres consist of two dimensional ribbons of trigonally bonded carbon sheets, highly oriented but somewhat twisted, with long, narrow, lens-shaped cavities making up between 5 and 30 per cent of the total volume, and entirely isolated from each other. The carbon ribbons form very shallow parallel stacks between 30 Å and 100 Å thick. This, however, does not imply that even within these slender stacks the individual layers are put together in a graphitic stacking sequence: the structure is parallel but in arbitrary azimuth, properly described as turbostatic. The fact that the fibres are able to form a complete sequence of potassium intercalation compounds in spite of the highly irregular structure is taken by Fourdeux *et al.* as evidence that there are essentially no cross-links between adjacent layers and specifically that no sp^3 carbon atoms are present. Presumably, because parallel stacks do form, they must be held together by weak van der Waals bonds.

The conclusion that cross-links are absent is parallel to the view taken by Halpin and Jenkins (*Proc. Roy. Soc., A*, **313**, 421; 1969) with respect to vitreous carbon, which is made in the same way as fibres by pyrolysis of polymers. Halpin and Jenkins reached their conclusion on the basis of the ready formation of potassium intercalation compounds. Fibres and vitreous carbon thus differ only in the presence or absence of preferred orientation of the *c* axis, and (possibly) in the presence of cavities in fibres. Nothing seems to be known about the presence or absence of cavities in vitreous carbon. Fourdeux and her colleagues point out that carbon fibres are wholly non-graphitic (as is vitreous carbon) and that the references in the literature to "graphitizing temperatures" should be taken as metaphorical.

Another approach to the problem, using the time-of-flight neutron diffraction technique, has been taken by Sinclair, Wedgwood, Harris and Egelstaff (UKAEA Report, AERE-R 6052, HMSO, 1969). Using Harwell (PAN) fibres, they, too, found a stack thickness of 100 Å down to less than 50 Å, depending on the mode of manufacture, with alignment as good as 3° – 4° (again in agreement with the best Union Carbide results). Attempts to detect cavities by small-angle neutron scattering have so far been vitiated by parasitic scattering from other sources. Sinclair *et al.* regard the technique as sufficiently promising to warrant further experiments.