NEWS AND VIEWS

Interacting Radio Galaxies or Radio Trails?

MOST sources listed by radio astronomers are thought to be extragalactic. Of the brighter ones which have been studied in detail, about one third are associated with galaxies, one third with blue stellar objects (quasars) and one third cannot be identified with any optical objects, probably because these last are galaxies beyond the present reach of the largest optical telescopes.

High resolution observations with aperture synthesis telescopes have revealed a wide diversity in the radio structures of these sources. The most powerful, with radio luminosities more than a million times that of our own galaxy, are double and consist of two emitting regions which may be separated by distances as small as 30 and as great as 3×10^5 light years on either side of the related optical object. The most compact sources, which can only be studied by transcontinental baseline interferometers, are often associated with quasars, but the most extensive may, like Cygnus A, be associated with a galaxy, although in other wide doubles the central object is a quasar. There seems to be no way of distinguishing between quasars and radio galaxies by radio means and indeed it is becoming doubtful whether any such distinction should be made. In the case of several extensive double sources, even though no central star-like image can be seen optically, a compact central radio component is found.

One of the fundamental problems is the origin of the vast quantities of energy necessary in such sources (up to 10^{53}–10^{54} J). In view of the frequent occurrence of compact radio and optical features at the centre of extended double sources, it seems likely that energy is released more or less continuously throughout the lifetime of these sources which must be at least 10^6 years. Gravitational energy seems to provide the only satisfactory supply, and many hypotheses have been made concerning the way in which it is made available; these vary from known processes such as supernova explosions which result in the formation of neutron stars to exotic mechanisms involving collapsed galactic nuclei.

The other problem is how this energy reaches the main radio emitting regions and what prevents the rapid expansion of the components. The energy may be transmitted from the nucleus in the form of (a) relativistic particles, (b) a fast moving plasma or (c) low frequency electromagnetic waves (0.1–1 kHz) associated with the magnetic dipole radiation of neutron stars. All aspects of these problems seem to require the existence of an intergalactic gas.

Radio sources of intermediate power (about 10^8 times that of normal galaxies) often have a more complex structure than the most powerful ones. In 1968 a particularly interesting class of such objects was recognized from studies with the one mile radio telescope at Cambridge in which two galaxies in the Perseus cluster (NGC 1265 and IC 310) were found to have an associated source in the form of an extensive tail in a direction away from that of the active Seyfert galaxy (NGC 1275) near the centre of the cluster. Subsequent observations showed a similar source in the Coma cluster and one in an unnamed cluster (the radio source 3C 129). The radio tails are of very great extent, that associated with 3C 129 probably being more than 6×10^5 light years in length. It is difficult to understand the very marked curvature of these tails without supposing that there is a significant amount of gas and magnetic field within the cluster. Further evidence for the presence of such gas comes from a study of the physical sizes of double sources inside and outside clusters. De Young has recently shown that those in clusters are of smaller extent suggesting that the gas density may be greater inside clusters than in the general intergalactic medium.

In all known cases these sources are close to a more compact source of comparable radio luminosity associated with an active galaxy in the same cluster. These observations suggested that the companion galaxies were being excited in some way by the emission of relativistic particles, plasma or possibly low frequency electromagnetic radiation originating in the active galaxy. Another possibility is that the motion of the galaxy at high velocity through the intergalactic gas may itself be sufficient to convert kinetic energy into the relativistic particles responsible for the radio emission.

Miley, Perola, van der Kruit and van der Laan on page 269 of this issue of *Nature* present observations of some of these sources with the Westerbork synthesis radio telescope. The authors suggest as an alternative explanation that each galaxy itself contains a source of energy and ejects clouds of plasma containing relativistic particles as in the case of powerful double sources. It is then proposed that if the galaxies have a high velocity through the intergalactic medium, as is observed in the case of NGC 1265, the ejected clouds are stopped, leaving trails of emitting material behind the galaxy. This mechanism avoids the necessity for any association with the other active galaxy in each cluster.

Whatever the ultimate explanation for this strange class of object, there seems little doubt of its importance. First, these sources provide a way of investigating the intergalactic gas in the cluster. Second, the mechanisms involved in containing particles within a relatively narrow tail of very great linear extent are clearly closely related to those occurring in powerful radio galaxies. Third, an understanding of the problems of energy transport and supply in these complex sources should illuminate the much more severe problems associated with the most powerful sources. Fourth, it may be that these objects provide evidence for the conversion of kinetic energy into relativistic particle energy, a process which has often been the subject of conjecture in the past. Fifth, these studies are related to the general question of the dynamical stability of clusters of galaxies.

These sources are thus related to a very wide range of astrophysical problems. From the radio astronomical end of the spectrum, further observations at Cambridge have provided maps of 6″ arc resolution at 5 GHz and similar observations are planned with the Westerbork instrument. The new data from these instruments and from the new Cambridge 5 km radio telescope, which should shortly provide a resolution of $\sim 2''$ arc, are likely to prove of great importance.—From a Correspondent.