NEWS AND VIEWS

Switch Back to Radio Galaxies

During recent months, the attention of astronomers has concentrated on curious phenomena in our own galaxy, notably at the high and low ends of the spectrum which can now be studied, and sources ranging from X-ray stars and pulsars to cool clouds emitting microwave radiation have kept cosmology and the study of events outside our galaxy away from the centre of attention. But radio galaxies and other distant objects have remained enigmatic in many ways, and it now seems that some of the knowledge gained from the recent intensive study of high energy sources inside our galaxy can help to explain the behaviour of extragalactic sources. If so, these sources seem certain to become once more the subject of concentrated study by many more astronomers, and another clue to the nature of the universe might be uncovered.

On page 388 of this issue of *Nature*, M. Rowan-Robinson, of Queen Mary College, London, presents the results of a study which shows conclusively that evolutionary effects are significantly large in radio galaxies. This work is more a filling in of detail than a major step forward, because it is already accepted that such radio sources are subject to evolution, and the associated problem has seemed to be to explain how and why this evolution occurs. It is clearly a very important result, because we know from studies of our own and other radio quiet galaxies that evolution simply does not occur for the stellar population at anything like the rate required by the observed evolutionary effects in radio galaxies (that is, on a time scale of 10^9 years). Either radio galaxies as a whole age faster than "normal" galaxies, or the radio component itself ages rapidly compared with the ageing of the stars in the same galaxy.

Rowan-Robinson has studied the sources of the third Cambridge survey. Other surveys, notably the Parkes at high energies but including several studies of weaker radio galaxies, have all pointed to the same conclusion; the best suggestion that the theorists have been able to offer has been that the radio sources are ejected from the nucleii of radio galaxies, and then evolve separately from their parents. Although this idea explains, in an arm waving way, why so many radio sources are double, often with one centre of intensity on each side of the associated optical galaxy, nobody has been able to explain quantitatively the way in which plasma could be ejected from the galactic nucleus and interact with the intergalactic medium to produce the sort of radio source which we see. In particular, even out to a distance of 10^6 light years, ejected matter should be more strongly influenced by the gravitational attraction of the parent galaxy than by the evolution of the expanding universe.

But last week a completely new model for radio galaxies and quasars, which can account for their evolution and explains the origin of their energy without running into the problems involved in the ejected plasma model, was put forward by M. J. Rees, of the Institute of Theoretical Astronomy in Cambridge (*Nature*, **229**, 312; 1971). Rees proposed that the energy in these sources derives fundamentally from the collapse of pulsar-like or other sources, because gravitational energy seems the only source large enough to fill the observational requirements. Unlike other models, however, the latest proposal removes this energy from the nucleus of a galaxy or quasar in the form of low frequency electromagnetic radiation, and not as matter or as high energy radiation.

Rees's model derives directly from work which has been carried out on pulsars, from which it has become apparent that as much as 40 per cent of the rest energy of a collapsing star can be removed by rotation in the form of low frequency electromagnetic waves. Such radiation, having a frequency lower than the plasma frequency of interstellar, and even intergalactic, plasma will expand to produce a cavity containing radiation and relativistic particles, but no plasma. The radiation which we observe could then originate from the interaction of the relativistic particles with this low frequency radiation, producing a hybrid which Rees terms "synchro-Compton emission". It is clear that Rees's model is not only plausible, but produces some remarkable coincidences with the observations.

The energy which goes into the electrons trapped in the cavity gives a spectrum strikingly like that of a typical non-thermal source, even including the break at around 1 BeV which usually requires a very complicated interpretation. Furthermore, under certain conditions the low frequency radiation can be beamed by a self-collimating effect, the external plasma acting as a curved wave guide. This could not only produce the symmetry seen in many sources, but can be extreme enough to produce the jets seen in a few more unusual objects. To be sure, some of this agreement with the observations is so far known only to be possible, and is not a unique requirement of the basic postulates of the model. But the agreement is striking enough to encourage redoubled efforts by observers and theoreticians along the lines indicated by Rees.

As this idea stems from the re-thinking which astronomers have had forced on them by the discovery of pulsars, it is pleasing that these objects could be the sources of the low frequency radiation. Moreover, the short term variability of many sources is temptingly like the behaviour we would expect as new pulsars are formed explosively in the nucleii of radio galaxies and quasars. But even a much more extreme object, such as the massive rotating disk which Lynden-Bell has proposed as the energy source for a galactic nucleus (*Nature*, **223**, 690; 1969), could be the progenitor of the required low frequency electromagnetic waves. It is indeed fortunate that just when the evidence implying rapid evolution of radio sources has become overwhelmingly clear (unless we are prepared to dismiss all the widely held theories of cosmology), a model which can explain this evolution has appeared.