RADIO OBSERVATIONS OF CLUSTERS OF GALAXIES: THE TAIL SOURCES

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The "head-tail" class of radio galaxies (e.g. Ryle and Windram, 1968 and Miley et al., 1972) are of particular interest in the context of this symposium since they provide some of the clearest evidence for a diffuse medium.

Models to explain the morphology of these radio galaxies (e.g. Jaffe and Perola 1973, Pacholczyk and Scott 1976, Cowie and McKee 1975) generally involve some or all of the following three concepts:

i) a dynamic pressure $\propto \rho_{IG} V_G^2$ to bend the tail back away from the galaxy,

ii) a static pressure $\propto \rho_{IG} T_{IG}$ to confine the back part of the tail, and

ii) a Mach number $\propto T_{IG}^{\frac{1}{2}}$ to give the desired geometry. The minimum pressure in the radio emitting region can be determined rather reliably from equipartition agreements and the velocity of the galaxy, V_G, from measurements of galaxy redshifts. Hence we can then use the arguments (i) - (iii) to determine the density, ρ_{IG}, and temperature, T_{IG}, of the intergalactic medium.

I do not intend to dwell on details of these models here but to discuss two new observational results concerning the velocities and environment of the head-tail radio galaxies.

At first it was thought that radio galaxies with tails had exceptional high velocities with respect to the intergalactic medium, e.g. NGC 1265 has a radial velocity component of +2 200 km/sec with respect to the mean velocity of the Perseus Cluster. However, in a recent analysis of 14 head-tail radio galaxies Ulrich (preprint) has shown that the distribution of velocities is in fact consistent with that expected if the galaxies were selected at random from their clusters. This result has important implications for the deduced density of the intercluster medium since by relation i) we need a higher value of ρ_{IC} to compensate for a lower average value of V_G, and when combining relations ii) and iii) we need a lower temperature to keep the galaxy supersonic and hence again a higher value of ρ_{IC} to still have static confinement.

M. S. Longair and J. Einasto (eds.), The Large Scale Structure of the Universe, 149-151. All Rights Reserved.

https://doi.org/10.1017/S0074180900144468 Published online by Cambridge University Press

It has also been generally assumed that the head-tail phenomenon is confined to rich clusters of galaxies and that the relatively high intergalactic densities required only pertained in these regions of space. If we take a sample of 21 head-tail sources now known, most of these are in fact in Abell clusters. However, in many cases these tail sources have only been found because of the observations of Abell clusters. If we form an unbiased sample using radio catalogues we then have only 8 objects of which 2 are in Abell clusters, 3 are in the much poorer Zwicky clusters and the others are obscured or are in the southern hemisphere, and we have inadequate information for a quantitative classification.

Hence it may still be the case that the head-tail sources are always found in some type of clusters but they are certainly not confined to the rich clusters. One interesting example of a head-tail source in a poor cluster is B2 1615+35 (Ekers, Fanti, Lari and Ulrich, preprint). This is a long tail (700 kpc) in a "medium compact" Zwicky cluster with a line-of-sight velocity dispersion of 584 km sec^{-1}. Model calculations suggest a number density of about 10^{-3} cm^{-3} for the intergalactic medium, similar to the value found for rich clusters. Since clusters of this type are 100 times more numerous than the rich Abell clusters it is clear that their contribution to the density of the Universe can be much greater ($\Omega \sim 0.2$).

Finally, there is another interesting result in the region of B2 1615+35. This Zwicky cluster, together with the Abell clusters 2197, 2198 and 2162 and another Zwicky cluster 1611.6+3717 all have the same average redshift and form a clear supercluster complex 30 Mpc in extent. If we assume that the intergalactic density we find in the region of the tail source pertains to the entire supercluster then the volume involved is much greater and such an intergalactic medium in the superclusters could make a dominant contribution ($\Omega \sim 0.2$) to the density of the Universe.

References

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DISCUSSION

de Vaucouleurs: I refer to the last two lines of your last slide showing both superclusters and groups, each contributing $\Omega = 0.2$. This seems to be redundant because small groups are the components (the subunits) of superclusters.

Ekers: Yes, if all groups are in superclusters.

https://doi.org/10.1017/S0074180900144468 Published online by Cambridge University Press

Chernin: The mean velocities of galaxies within a cluster are close to the sound velocity of the gas which is smoothly distributed and is in virial equilibrium. So the strongly supersonic motion you refer to is hardly the case. Perhaps, you mean with respect to low temperature clouds?

Ekers: I included the supersonic velocity case because this is required for some tail radio source models. However, especially since we now have evidence that the tail sources have the same velocity distribution as the rest of the cluster galaxies, I agree that the supersonic case is less likely. Low temperature clouds do not seem very likely because of the smooth form of many of the tail sources.