RADIO-OPTICAL STUDIES OF A COMPLETE SAMPLE OF ABELL CLUSTERS

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Study of the properties of radio galaxies in clusters is beset with problems of selection and identification. To reduce these problems we have selected a complete sample of Abell clusters and are using optical spectra of identified galaxies to determine their cluster membership. The sample is in a volume of space defined by the limits of coverage and sensitivity of the two Sydney University radiotelescopes and the Anglo-Australian Telescope; it comprises the 42 clusters with $\delta \leq -8°$ and distance class 4 or closer. Radio maps have been prepared using archive 408 MHz data from the Molonglo Cross. Possible optical identifications have been selected from the Palomar Sky Survey and low-dispersion optical spectra have been taken of these and sometimes other galaxies or stellar objects within the cluster area. When needed, maps of the cluster areas have been produced at 1415 MHz using the Fleurs Synthesis Telescope. Some details of our early results have been published (Mills et al. 1978, 1979) and here a brief summary of the overall statistics is presented. Observations on five clusters remain to be completed but should not greatly affect the present conclusions.

The 408 MHz maps cover areas ranging from 0.25 to 4 square degrees, depending on the cluster distance. Mostly the coverage extends to the Abell radius or beyond. Results currently available for 37 clusters are as follows:

Total number of radio sources	263
Optical spectra obtained	84
Number of radio galaxies in clusters	48 (54)

The number in parenthesis includes six possible identifications with cluster galaxies which are at present uncertain. Confining attention to the more certain identifications, the distribution of radio galaxies among the clusters is as follows:

Number of radio galaxies/cluster	0	1	2	3	4	5
Number of clusters	13	11	5	6	1	1

This result is not significantly different from a Poisson distribution with a mean of 1.3 radio galaxies per cluster.

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In order to examine the relationship between cluster properties and the occurence of radio galaxies, the clusters have been allocated to three distinct groups, those containing no radio galaxies (13), those containing one radio galaxy (11) and those rich radio clusters containing three or more radio galaxies (8). For these clusters we have calculated the mean richness R as defined by Abell, the mean redshift z, and the mean Bautz-Morgan classification:

Radio galaxies in cluster	0	1	≥3
<R>	0.69 ± .21	0.73 ± .27	0.75 ± .16
<z>	0.071 ± .006	0.067 ± .005	0.052 ± .004
<BM class>	2.75 ± .16	1.94 ± .13	2.08 ± .42

Although the richest radio clusters are also the richest optically, the correlation is weak and not statistically significant. The significant negative correlation between radio richness and z is to be expected because lower luminosity radio galaxies can be detected at closer distances. The correlation with the BM classification arises because all BM types I or I-II in the sample contain at least one radio galaxy (not always the cD).

An important result is the very weak correlation between radio and optical richness, a result which has appeared in various guises in other investigations. The expected number of radio galaxies in a cluster is pN where p is the probability of a galaxy becoming a radio galaxy and N is the number of galaxies. If p is constant, a strong correlation between radio and optical richness would be expected. In the present sample N covers a range of about 6:1. The most natural explanation of the poor correlation here and elsewhere is that p independently varies over a greater range. There is some indirect evidence for variations of p in the present sample. Each of the seven clusters classified as BM types I or I-II contains at least one radio galaxy and the average is 2.3, more than twice the average of the remaining clusters. Additionally, it appears that the presence of strong X-ray emission is associated with a high value of p. Six of these clusters have been recorded as X-ray sources in published surveys. Five possess three or more radio galaxies each and the sixth, A1060, which has no clear-cut example, was detected as an X-ray source only because of its proximity (z = .010). Radio emission from three 'normal' galaxies in A1060 was detected for the same reason. Another obvious cluster property which may be related to p is the proportion of elliptical galaxies; this property is currently under examination.

To summarise, the majority of clusters in our sample contains at least one radio galaxy; radio galaxies are the rule rather than the exception in Abell clusters. They occur preferentially in clusters with above-average amounts of gas as shown by the BM and X-ray correlations.

REFERENCES

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