The X-ray Emission from the Hercules Supercluster

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Summary

X-ray observations with the Ariel V S.S.I. of the Hercules supercluster (A 2147, A 2151, A 2152) are described. A source (A 1600+16) is found with intensity 0.7 ± 0.1 Ariel c s⁻¹, consistent with the intensity of 3U 1551+15. Its identification with A 2147 is proposed on the basis of the improved positional accuracy. An upper limit (0.16±0.13 c s⁻¹) is given for the signal from A 2151 (the classical Hercules Cluster). The difference in X-ray luminosity of these two members of the supercluster is briefly discussed in the light of their optical and radio properties.

Key words: Supercluster of galaxies - X-rays - Intracluster gas

I. Introduction

The cluster n. 7 in field 108 of Zwicky's catalogue (Zwicky and Herzog, 1963) is a large complex of galaxies extending about 7° N-S and 3° E-W. It contains three subcondensations which were classified by Abell (1958) as separate rich clusters: A2151 (the Hercules Cluster), A2152 and A2147. On the basis of an extensive spectroscopic analysis, Tarenghi et al. (1977) (see also Burbidge and Burbidge, 1959 and Bautz, 1972) confirm that the Zwicky cluster n° 7 can be considered a "supercluster" with a mean recession velocity of 10,800 Km sec⁻¹, and an extension of about 25 Mpc (H₀=50 Km sec⁻¹ Mpc⁻¹ is used in this paper). The 3U Catalogue of X-ray sources (Giacconi et al. 1974) contains a weak source, 3U1551+15 with a very large error box containing all the three Abell clusters mentioned above. In order to reduce the positional uncertainty of the X-ray source this region was scanned with the Sky Survey Instrument (S.S.I.) on board of Ariel V. The observations are described in Sect.II and a brief discussion of the results follows in Sect. III.

II. The Observations

The Ariel V S.S.I., its observing modes and related data analysis are described elsewhere (e.g. Villa et al. 1976). Several long observations

Fig.1. The 90% error box of the source A1600+16 is superimposed to a smoothed galaxy distribution (number of galaxies per square degree, taken from Shane, 1976). The nominal (Abell, 1958) centres of A2151 (+), A2152 (X) and A2147 (☆) are indicated. The centre of A2147 coincides with the position of the cD galaxy. The black dot and triangle indicate the position of the tailed radio galaxies NGC 6034 and 6061 respectively. The white triangle indicates the position of the extended radio source 1600+15 W2.

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signal greater than 3\sigma above background was
found from this region. Five out of the eleven
detections were subsequently rejected because of
the presence of the source A1518+08 in the field
of view of the collimator. The other six
detections are consistent with the presence of a
single source, A1600+16, with a steady level of
intensity of 0.7 ± 0.1 Ariel counts sec^{-1}. This
value is consistent with the intensity of
301520+15, 2.1 ± 0.5 Uhuru counts sec^{-1}, when the
conversion factor of 3 (which applies for a Coma-
like spectrum) is used. The counts, converted to
energy units as for a Coma-like spectrum, give
$F_{\gamma}(2-10 \text{ KeV}) = (3.5 \pm 0.5) \times 10^{-11} \text{ erg cm}^{-2}\text{s}^{-1}$. The
single detections were combined to produce
probability contours for the position of the source.
The coordinates of the maximum probability
density are: R.A. = 16h 06m 21s, Dec. = 16\degree 52' 52" (1950.0) and
the area of the 90% probability contour is
0.25 deg^2. The 90% error box is reproduced in
Fig. 1, superimposed on a smoothed galaxy distri-
bution (Shane, 1976), to help the identification of the
three clusters. A2151, A2152 and A2147, indicated
(from Abell, 1958). A2151 is definitely outside the
error box. The other two clusters, as can be
seen from the figure, are spatially not well
defined but the nominal centre of 2152 is outside
the 90% probability contour (it actually lies
outside the 99.7% probability contour) while that
of A2147 is on the edge of the 90% probability
contour. Therefore, on positional grounds, the
identification of A1600+16 with A2147 is proposed.

As the method has been checked for a fainter X-ray emission by using the Point
Summation Technique (P.S.T.), in which we sum all the
available data, irrespective of the scan
direction, for each point in an array centred on
a given position. With this technique an intensity of
0.16±0.13 Ariel counts sec^{-1} at the position
of A2151 was found, but this value must be
considered as an upper limit. The P.S.T. technique
could not be applied to A2152 because of its
proximity to A1600+16, in the following discussion
we shall concentrate on the properties of A2151
and 2147 for which both radio and optical data are
available.

III. Discussion

According to Tarenghi et al. (1977) the
Hubble distance to the Hercules supercluster is
D = 216 Mpc. Therefore the luminosity of A1600+16
is $L_{\gamma} = 8 \times 10^{44}$ erg sec^{-1}. The X-ray luminosity of
A2151 is lower than this by at least a factor of 2-3. In view of the correlational studies (Bahcall,
1974, 1977) between the X-ray and the optical-
radio properties of Abell clusters, a brief
comparative description of these two clusters is now
given (see also Fig.1).

i) Presence of a cD galaxy. A2147 contains three
giant ellipticals. Two of these are members of a
short chain of E galaxies, A2199 (Oemler, 1976) with
the same limiting radius and is brighter by only 0.46
mag. This galaxy can therefore be rightly
considered a cD galaxy. A2151 also contains very
bright ellipticals, but none with such an
outstanding size of the envelope. The two clusters are
classified correspondingly as Bautz-Morgan
class II (A2147) and class III (A2151) (Sandage
and Hardy, 1973).

ii) Richness. Abell (1958) assigns A2147 to the
Richness Class I and A2151 to the Richness Class
2. The number of galaxies with linear size > 15" on
the Red Palomar Sky Survey Prints within
radius of 3 Mpc is 138 in A2147 and 159 in A2151
(Thompson, 1974), that is A2151 is only slightly
richer than A2147.

iii) Galaxy content. Tarenghi et al. (1977) find
that the content of spiral and irregular galaxies is at least 60% in A2151, and less than 40% in
A2147. The difference is even more marked when
the very bright galaxies are considered: very
bright spirals are rather numerous in A2151, but
absent in the other. Following Oemler (1974),
A2147 can be classified as "spiral poor", A2151 as "spiral rich".

iv) Compactness. There are no determinations of the
core radius of the two clusters in the litera-
ture. However it can be judged from Fig.1 that
A2147 is less compact than A2151. This property is
rather unusual for a cluster containing a cD
galaxy.

Altogether, with the exception of the low
degree of concentration of A2147, the two clusters
have the optical properties characterizing the
intermediate type (A2147) and the irregular (late-
type (A2151) clusters, according to a modified

The fact that A2147 is more powerful in X-rays
than A2151 seems to conform to the correlation
found between X-ray luminosity and optical properties of clusters by Bahcall (1974). Moreover,
several authors (see Bahcall, 1977 for a review)
have proposed that $L_{\gamma}$ is proportional to a large
(from 2 to 4) power of $v_{\Phi}$, the three-dimensional
velocity dispersion. Since $\Delta v$ (A2151) = 1087 km
sec^{-1} (Burbridge and Burbridge, 1959) and $\Delta v$(A2147) = 1869 km sec^{-1} (Bautz, 1972), $L_{\gamma}$(A2151) is expected on this basis to be from 3 to 9 times less than
$L_{\gamma}$(A2147).

v) Radio properties. The information quoted in
this section comes from a study with the
Westerbork telescope at 1415 MHz (Jaffe and Pero-
la, 1975) and at 610 MHz (Valentijn and Perola,
in progress). A2151 contains four relatively
strong radiogalaxies, the strongest being a wide-
angle tail associated with NGC 6034 ($F_{1415}=1.2\times
10^{28}$ WHz^{-1}). The source associated with NGC 6061 ($F_{1415}=1.5\times10^{28}$ WHz^{-1}) is also a wide-angle tail.
In A2147 the strongest source is a double (50 Kpc in size) with $F_{1415}=1.7 \times 10^{23}$ WHz^{-1} only, identifi-
ed with the cD galaxy. In the area of A2147 there are
two sources with relatively strong flux
(1559+15W1, $S_{1415}=560$ mJy; 1600+15 W2, $S_{1415}=887$
mJy, as compared with 33 mJy from the cD). The
first has no optical counterpart brighter than
21^m, the second is tentatively identified with a
18m5 galaxy and has an amorphous extended
structure of about 3'. They are probably back-
groud sources, and the second one (a distant
cluster?) could be an interesting alternative
candidate for identification with the X-ray source.
However they lie both outside the present 99.7% error box.

There is evidence of low brightness polarized emission at 610 MHz from A2147, which is probably due to a galactic contribution (the North Polar Spur). Because of this contamination it is difficult to separate a low brightness emission from the cluster itself, of the type detected with a similar study in the Coma Cluster (Jaffe, Perola, Valentijn, 1976). For this reason, the inverse Compton origin of the X-rays cannot be concretely discussed in the moment.

We cannot exclude, until higher resolution X-ray observations are performed, that the emission comes from a hot gaseous halo around either the cD galaxy or one of the other two giant ellipticals in A2147, as in the case of M87. This sounds rather unlikely, however, because the X-ray source is about 10 times more powerful than M87, while the mass of the cD galaxy is only 2.3 times larger than that of M87, if the mass scales as the optical luminosity. Moreover, M87 is a very active radiogalaxy, while none of the three giants in A2147 is a powerful radioemitter.

It seems more likely to us that the X-rays come from a hot intracluster gas. The presence of the two wide-angle radio tails in the northern and southern extensions of A2151 indirectly proves that gas with a density of order $10^{-4}$ cm$^{-3}$ (Valentijn and Perola, in preparation) is present also in those regions, and probably pervades the whole supercluster. From this point of view, it is noteworthy that the peak in the X-ray emission does not coincide with the region where the galaxy concentration is highest (A2151). This anticorrelation between the X-ray brightness and the projected galaxy density within the supercluster seems a feature that, when studied in detail both spatially and spectroscopically, should give valuable information on the evolution of the intracluster gas and on its interaction with the galaxies in superclusters of this type, which optically appear to be in an "early" phase of their dynamical evolution (cfr. White, 1976). With regard to this, we note that if A2147 is brighter in X-rays because its intracluster gas is currently denser than in A2151, this could provide a reasonable explanation for the different content of spirals in the two clusters. Indeed, the larger density combined with the higher value of $\Delta T$ would lead to a greater efficiency in A2147 of the "ram pressure" stripping of the gas from the spirals, a mechanism suggested by Gunn and Gott (1972) for the conversion of spirals into SO galaxies in clusters.

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