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A COOLING FLOW IN A HIGH-REDSHIFT, X-RAY–SELECTED CLUSTER OF GALAXIES[1]

ROBERTO NESCI,[2] ISABELLA M. GIOIA,[3,4] TOMMASO MACCACARO,[3,4] SIMON L. MORRIS,[5] GIUSEPPE C. PEROLA,[2] RUDOLPH E. SCHILD,[3] AND ANNA WOLTER[3]
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ABSTRACT

The X-ray cluster of galaxies 1E 0839.9+2938 was serendipitously discovered with the *Einstein Observatory*. CCD imaging at *R* and *V* wavelengths show that the color of the dominant elliptical galaxy of this cluster is significantly bluer than the colors of the next brightest cluster galaxies. Strong emission lines, typical of cD galaxies with cooling flows, are present in the spectrum of the dominant galaxy, from which a redshift of 0.193 is derived. The emitting line region is spatially resolved with an extension of about 13 kpc. All the collected data suggest that this cluster is one of the most distant cooling flow clusters known to date.

Subject headings: galaxies: clustering — galaxies: intergalactic medium — galaxies: X-rays

I. INTRODUCTION

Rich, compact clusters of galaxies are known to be luminous (10^{43}–10^{45} ergs s^{-1}) X-ray sources, the emission coming from a hot ($\sim 10^8$ K) intracluster gas with a total mass comparable to the luminous mass in the galaxies of the cluster (see, e.g., Sarazin 1986 for a comprehensive review of this topic). In nearly one-third of the nearby clusters studied so far in X-rays, the cooling time of the intracluster gas in the central region of the cluster is a few billion years, substantially less than the Hubble time (Arnaud 1988). A cooling flow of gas is thus expected toward the cluster center, driven by the pressure of the surrounding hotter gas. According to Hu, Cowie, and Wang (1985), when the central particle gas density exceeds a critical value ($\sim 5.6 \times 10^{-3}$ cm^{-3}), strong optical emission lines arise: the emitting line region is rather extended (~ 10 kpc) and is not symmetric (Cowie *et al.* 1983).

Tracking the time evolution of the cooling flow phenomenon requires identification of a number of X-ray clusters in a wide redshift range. As already pointed out by Hu *et al.* (1985), if the intracluster gas were of relatively recent origin ($z \sim 1$), the frequency of such flows at redshifts about 0.2 should already be appreciably lower than at $z < 0.1$. This would not be the case, on the contrary, if the gas were coeval with the galaxies ($z > 5$). Clearly, a sufficiently wide and homogeneous sample of clusters, not yet available, is needed to perform such a test. So far, indeed, the detection of these cooling flows has been performed mainly by observing well-known (i.e., optically selected) clusters, most of them at relatively low redshifts ($z < 0.1$). The Extended Medium Sensitivity Survey (EMSS; Gioia *et al.* 1988*a*) contains a significant number of distant clusters with redshift up to about 0.5 (Gioia *et al.* 1988*b*). Such redshifts are generally out of reach for present Schmidt telescope surveys, upon which optical catalogs of clusters are mainly based. For example, the compilation of all published redshifts for Abell clusters by Struble and Rood (1987) contains only seven clusters with $z > 0.3$, out of 578.

In this paper we present X-ray, optical, and radio observations of one of the X-ray–selected EMSS clusters of galaxies, 1E 0839.9+2938, which shows the characteristic features of a cooling flow cluster. In § II, the X-ray, optical, and radio data are described. The results are discussed in § III and summarized in § IV.

Throughout the paper we adopt $H_0 = 50$ km s^{-1} Mpc^{-1} and $q_0 = 0$. This implies a linear scale of 4.3 kpc $arcsec^{-1}$ at the redshift of the cluster.

II. OBSERVATIONS

a) X-Ray Data

The cluster 1E 0839.9+2938 is one of the sources serendipitously discovered as part of the extension of the *Einstein Observatory* Medium Sensitivity Survey (Gioia *et al.* 1988*a*). The IPC observation (seq. number 3033), carried out on 1979 October 28, lasted 2080 s and was centered on 4C 29.31, a radio source in a high-redshift cluster of galaxies. In this frame 1E 0839.9+2938 is detected as a weak source (about 100 net counts) at $08^h39^m53^s.9$ + 29°38′48″ (1950), about 17′ from the center of the IPC image. At this distance from the center, the IPC Point Response Function is somewhat degraded from the on-axis value of about 170″ (FWHM).

The source appears to be slightly extended, but the limited number of detected photons did not allow us to perform a detailed analysis of the surface brightness and energy distributions. The X-ray isointensity contours are shown in Figure 1. Inspection of the Palomar Observatory Sky Survey prints reveals the presence of a faint cluster of galaxies at the position of the X-ray source. This cluster is classified in the Catalog of Galaxies and Clusters of Galaxies by Zwicky *et al.* (1968) as compact and extremely distant (Zw 0839.9+2937).

The 0.3–3.5 keV flux was computed assuming a Raymond-Smith thermal spectrum (Raymond and Smith 1977) with 6 keV temperature and with 50% solar abundances. This assumption is based on the observational evidence for heavy elements in the intracluster gas of many clusters, with abundances roughly one-half the solar value (see Sarazin 1986). After correction for Galactic absorption due to a hydrogen column density of 4.2×10^{20} cm^{-2} in the direction of 1E

[1] This paper uses data obtained at the Multiple Mirror Telescope Observatory (MMTO), which is operated jointly by the University of Arizona and the Smithsonian Institution.

[2] Instituto Astronomico dell'Universitá di Roma.
[3] Harvard-Smithsonian Center for Astrophysics.
[4] Istituto di Radioastronomia del CNR.
[5] Mount Wilson and Las Campanas Observatories.

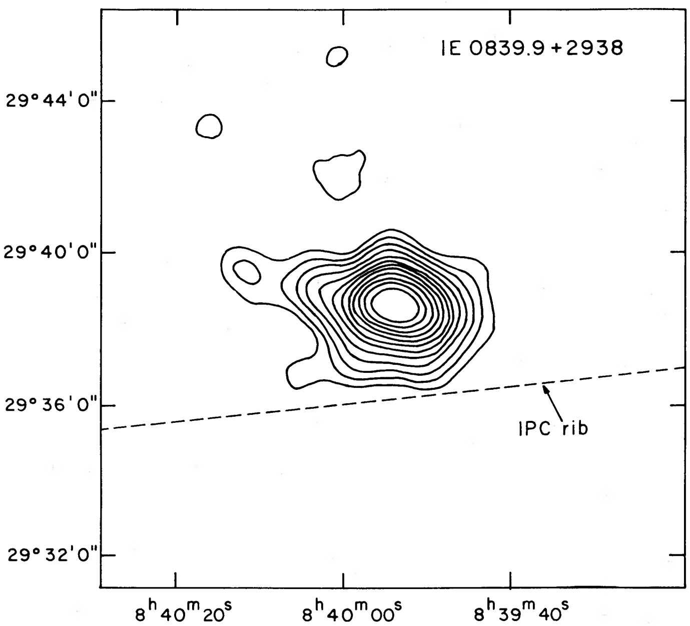

FIG. 1.—X-ray contours of 1E 0839.9+2938. The image has been background-subtracted (background level = 0.061 counts pixel^{-1}), smoothed with a Gaussian ($\sigma = 32''$), and vignetting corrected. The first contour corresponds to the 3 σ level. All other contours are in increments of 1 σ.

0839.9+2938, the flux is 2.23($\pm$0.24) $\times$ 10^{-12} ergs cm^{-2} s^{-1}. At a redshift of 0.193 (see § II*d*), this corresponds to an X-ray luminosity of 3.9 $\times$ 10^{44} ergs s^{-1}.

b) CCD Photometry

Photometry of the cluster was obtained with the RCA CCD camera (Geary and Kent 1981) at the Whipple Observatory 24" (61 cm) telescope. Exposures of 10 and 20 minutes were obtained with the *R* and *V* filters, respectively, on 1986 November 28. The photometry was standardized from observations of a field of M67 (Schild 1984). Figure 2 (Plate 1) is a 4' $\times$ 6' CCD frame of the cluster region. The brightest galaxy, labeled G1, is a giant elliptical (Hubble type E2), with a faint secondary nucleus 2" to the NE (P.A. = 75°).

A plot of the *V* surface brightness profile of G1 against $r^{1/4}$ is shown in Figure 3. Near the galaxy center, seeing smears the image and causes a brightness deficiency at the center and a brightness excess in the 3"–6" region. We show in the figure the best fitting de Vaucouleurs model with seeing effects included (*curved solid line*). It is apparent that, within our sensitivity limit (26.2 *V* mag arcsec^{-2}), there is no sign of departure from a pure de Vaucouleurs profile. Taking into account the *K*-correction (0.39 mag according to Schild and Oke 1971) and the $(1 + z)^4$ term, the sensitivity limit is $V = 25.0$ mag arcsec^{-2} in the galaxy rest frame. Inspection of surface brightness profiles in cD galaxies given by Thuan and Romanishin (1981) shows that in three out of eight objects, departures from a de Vaucouleurs profile occur beyond this limit: we cannot therefore exclude that galaxy G1 is a cD galaxy.

Integrating the de Vaucouleurs model fit up to the sensitivity limit given above (corresponding to 25" from the center) gives a total *V* magnitude of 16.24; at a redshift of 0.193 (see § II*d*), this corresponds to an absolute visual magnitude of -24.65 (including the *K*-correction quoted above). A comparison with the magnitudes of the brightest galaxies in nearby Abell clusters can be made using the data by Hoessel, Gunn, and Thuan (1980), who give magnitudes within 16 kpc radius for 107 first-rank ellipticals. Integrating our brightness profile up to 3".7 (16 kpc) gives $V = 17.9$, corresponding to $M_V = -23.0$. The average M_V for the brightest elliptical in a Bautz-Morgan class I cluster is -22.8 with a dispersion of 0.2 mag (Hoessel, Gunn, and Thuan 1980), so our finding is in agreement with the expected value.

Table 1 lists magnitudes and colors for 13 galaxies (including G1) within 80" around the dominant galaxy. Photometry was

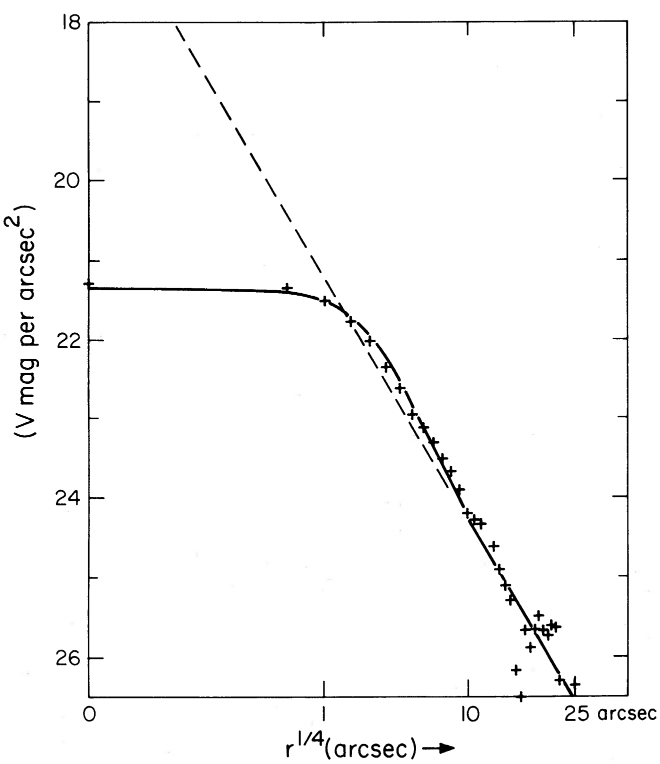

FIG. 3.—Plot of *V* surface brightness of galaxy G1 against $r^{1/4}$. The dashed line is a de Vaucouleurs profile; seeing effects are taken into account for the solid line.

TABLE 1
PHOTOMETRIC DATA AND REDSHIFTS

Galaxy	V	$V-R$	z
G1	17.53	0.82	0.193
G2	18.83	0.89	...
G3	18.87	0.80	...
G4	19.31	0.84	...
G6	18.50	0.85	...
G7	19.09	0.97	...
G9	19.24	0.90	0.194
G11	18.56	0.78	0.198
G17	18.33	0.91	0.200
G20	19.04	0.86	...
G25	19.78	0.56	...
G27	18.45	0.42	0.186
G30	19.00	0.92	...
G31	...	...	0.197

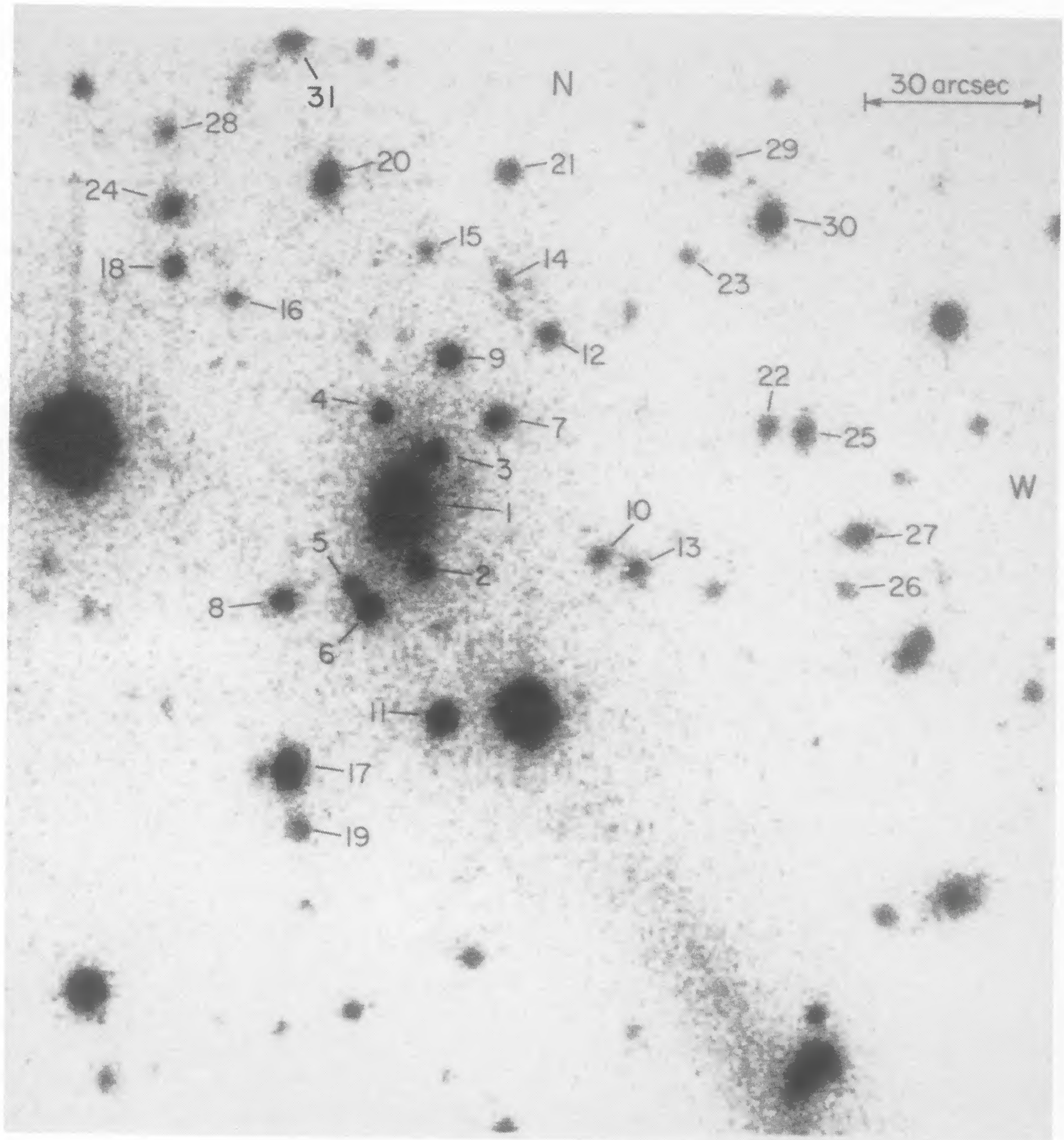

FIG. 2.—CCD finding chart of 1E 0839.9+2938

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performed by integrating over a circular area of 10″2 diameter (44 kpc) centered on each galaxy.

Quite remarkably, the color of the dominant galaxy, which is normally the reddest cluster galaxy, is 0.15 mag bluer than the expected value for a giant elliptical at $z = 0.193$ ($V-R = 0.97$; Schild and Oke 1971).

The average $V-R$ color for the five reddest cluster galaxies is 0.92, comparable, within the errors of photometry and cosmic scatter, to the normal value for bright cluster ellipticals. So it is unlikely that the blue color of galaxy G1 is due to an offset of our photometry and must rather be considered as real. No color gradient for the dominant galaxy is seen in our V and R images within 5″1 from the galaxy center. Because the question of a color gradient will come up in a later discussion of the existence of an AGN in the cluster giant galaxy, we have analyzed two 20 minute exposure CCD images taken in 1″5 seeing in the J (i.e., III*a*-J 4800 Å) and I bands. By forming a ratio image of the J to I image frames, we can say that there is no $(J-I)$ color gradient at the 10% error level.

c) Radio Data

The cluster was observed at 6 cm with the VLA in the "C" configuration on 1986 October 24. For a description of the VLA and its modes of operation, see Thompson *et al.* (1980) and Napier, Thompson, and Ekers (1983). Continuum observations were made simulataneously at 4835 and 4885 MHz with a bandwidth of 50 MHz. The synthesized beam is $\sim 5''$.

The cluster was observed for 32 minutes at the X-ray position. The data were reduced using the standard procedure. An unresolved source was detected at $08^h39^m53^s.3$ $+29°38'16''$ with a flux density $S = 5.6$ mJy. The radio position coincides with the optical position of the brightest galaxy in the cluster. The observed flux corresponds to a luminosity of 1.1×10^{24} W Hz^{-1} and is a typical value for compact radio sources in dominant galaxies at the center of cooling flow clusters (O'Dea and Baum 1986; Jones and Forman 1984).

Table 2 summarizes the X-ray, photometric, and radio data for the dominant cluster galaxy G1.

d) Optical Spectroscopy

Spectra of the dominant galaxy and of five other cluster members were obtained at the Multiple Mirror Telescope with the FOGS, in two observing runs. The scale along the slit was 0″42 pixel^{-1}, and the reciprocal dispersion was 3.5 Å pixel^{-1} and 4.7 Å pixel^{-1} for the blue and the red grating, respectively. Eight separately movable slits were available. Each slit had a width of 1″25. The spectral resolution (FWHM), derived from the night sky lines, was 3.0 pixels for both gratings, corresponding to 10 Å and 14 Å in the blue and in the red respectively. The detector was a TI 800 × 800 pixel CCD. Quartz-lamp exposures were used for flatfielding and a He-Ne-Ar lamp for the wavelength calibration. A journal of the observations is given in Table 3.

TABLE 2

RELEVANT DATA FOR GALAXY G1

Parameter	Value
Total V magnitude	16.24
$V-R$	0.82
de Vaucouleurs R_{eff}	10″4
Central V surface brightness	16.2 mag arcsec^{-2}
Angle of major axis (from north to east)	75°
Eccentricity	0.54
Hubble type	E2
Absolute V magnitude	−24.65
X-ray luminosity (0.3–3.5 keV)	3.9×10^{44} ergs s^{-1}
Radio luminosity (6 cm)	1.1×10^{24} W Hz^{-1}

The blue spectra were taken to measure the redshift of the X-ray source 1E 0839.9+2938 within the program of optical identification of the EMSS sources, thus, the exposure times were kept short. As strong emission lines were present, red spectra were taken later to determine the emission line intensities and to try to spatially resolve the emitting region, a feasible task with good seeing conditions if the region were of a size comparable to that of A1795. For this reason, care was taken to have at least one field star in one of the FOGS slits adjacent to the galaxy G1, in order to derive the instrumental point spread function along the slit. The two position angles used (68° and 158° from north to east) correspond to the major and minor axes of the galaxy, respectively. Spectra taken at P.A. 68° included the faint secondary nucleus quoted above. No standard star was observed during these observing runs, so our MMT spectra are not flux-calibrated.

Besides the typical absorption features of an elliptical galaxy, a number of emission lines are present (see Fig. 4). From these lines a redshift of 0.193 ± 0.001 was derived, giving a (luminosity) distance of 1270 Mpc. A consistent redshift was obtained from the Mg *b* and Na D absorption lines. These absorption lines were also used to derive redshifts for other galaxies with a sufficiently high signal-to-noise ratio level (see Table 1).

The equivalent widths derived from the red spectrograms for G1 at different position angles showed a good agreement (within 18%). The equivalent widths of Hβ and [O III] λ5007 derived from the blue and the red spectra agreed within 30%, a result compatible with the lower quality of our blue spectra. All the spectra taken with the red grating were therefore averaged to give a single spectrum of G1 which is shown in Figure 4. Figure 5 gives the average of the two blue spectra for G1.

The equivalent widths for the stronger emission lines, derived from the average spectra, are given in column (2) of Table 4. Corrections for the underlying stellar absorption at Hβ, [O III] λ5007, and Hα of 2.5, 2.5, and 1.6 Å, respectively, have been applied. These values were derived from the template spectrum of a normal elliptical without emission lines as given by Hu *et al.* (1985, their Fig. 8). Due to the galaxy redshift, the Hα + [N II] spectral region is contaminated by night sky emission.

Unfortunately, seeing conditions were not good during our MMT observations. In order to explore the spatial extension of the emitting region, further observations (see Table 3) were performed with the University of Hawaii 88″ (2.2 m) telescope on Mauna Kea using the Hawaii Wide Field Grism Spectrograph. The slit was 2″7 wide, with a dispersion of about 6.9 Å pixel^{-1} and scale along the slit of 0″58 pixel^{-1}. Spectral resolution (FWHM), derived from the night sky lines, was about 26 Å. Two slit orientations, P.A. 0° and 90°, which are about 20° different from the galaxy axes, avoiding the secondary nucleus, were used.

A spectrum of a field star was secured each night for determination of the instrumental profile. A standard star (BD + 26°2606) was observed with the same slit on the first night, to obtain the flux calibration. As only one observation of the standard was made, the standard extinction curve of Mauna Kea was used. Taking into account that the slit used

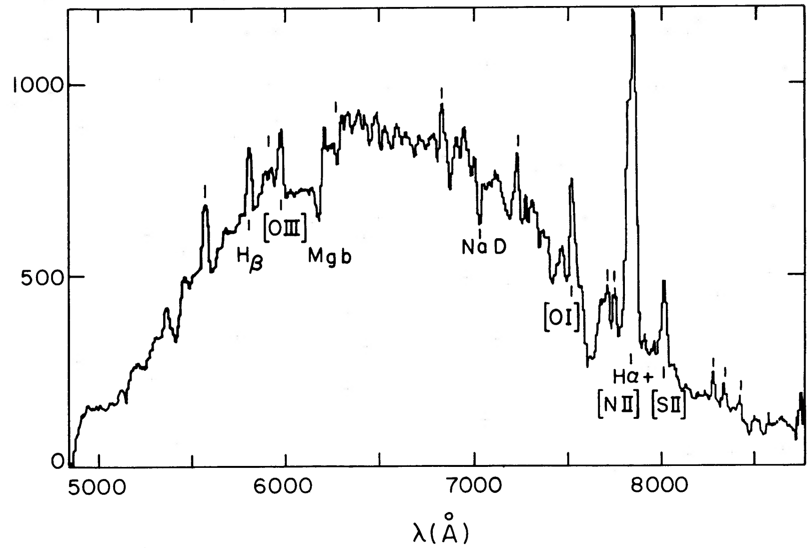

FIG. 4.—Net spectrum (red grating) of galaxy G1 from the MMT. Ordinate in arbitrary units; observed wavelengths in abscissa. Unlabeled vertical dashes indicate night-sky lines.

was not large (usual spectrophotometric work is done with a 5″ slit) and that the centering of the star in the slit was not very accurate, our calibration is uncertain by some tenths of a magnitude.

A flux calibrated spectrum 7 pixels wide (about 4″) centered on the galaxy nucleus with the slit along the N–S direction is given in Figure 6. Equivalent widths of the strongest emission lines are given in column (3) of Table 4, showing very good agreement with the MMT data. Due to the lower spectral resolution, disentangling the relative contributions of Hα and [N II] λ6584 was more uncertain than in the MMT spectra, so that only the total equivalent width of this blend is reported.

Column (4) of Table 4 gives the line flux ratios relative to Hα: the Hα/[N II] ratio was obtained from MMT spectra, for the reason given above. Column (5) gives the observed range of these ratios in seven cD galaxies in X-ray clusters studied by Hu *et al.* (1985, their Table 5). Values for [O II] λ3727/Hα (not measured by them) were derived from the data of Kent and Sargent (1978) and Johnstone, Fabian, and Nulsen (1987).

From Table 4 one notes that all the line flux ratios in G1 are consistent with the range of values observed in cD galaxies with "bona fide" cooling flows. Remarkably, the values in G1 are generally near the lower boundary of the range. Inspection of the line flux ratios of the galaxies in the sample of Hu *et al.* (1985) shows that these galaxies may be divided into two groups: one with high line flux ratios and low X-ray luminosity, the other with low line flux ratios and brighter in X-rays. The data for 1E 0839.9+2938 are consistent with those for clusters belonging to the second group.

Peak surface brightnesses of 7.3×10^{-16} for the [O II] line

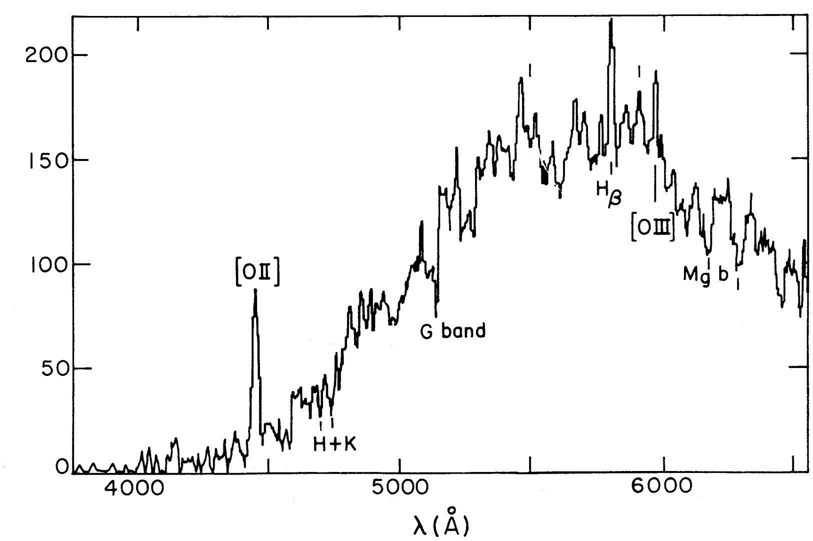

FIG. 5.—Net spectrum (blue grating) of galaxy G1 from the MMT. Ordinate in arbitrary units; observed wavelengths in abscissa. Unlabeled vertical dashes indicate night-sky lines.

TABLE 3

JOURNAL OF SPECTROSCOPIC OBSERVATIONS

Spectrum Number	Date	Grating	Exposure Time (minutes)	P.A.	Telescope[a]
1............	1985 Apr 22	blue	10	...	MMT
2............	1985 Apr 22	blue	10	...	MMT
3............	1986 Feb 2	red	20	158°	MMT
4............	1986 Feb 2	red	20	158	MMT
5............	1986 Feb 2	red	15	158	MMT
6............	1986 Feb 2	red	20	68	MMT
7............	1986 Feb 2	red	20	68	MMT
8............	1986 Feb 2	red	15	68	MMT
9............	1988 Apr 10	...	30	0	UH
10............	1988 Apr 10	...	30	0	UH
11............	1988 Apr 11	...	15	90	UH
12............	1988 Apr 11	...	30	90	UH

[a] MMT = Multiple Mirror Telescope; UH = University of Hawaii 88 inch (2.2 m) telescope.

and of 3.1×10^{-15} (ergs cm^{-2} s^{-1} arcsec^{-2}) for the blend of Hα + [N II] were derived from the two central rows of the galaxy spectrum. These values may be inaccurate by some 30% due to the calibration problems quoted above. For comparison we recall that the peak surface brightness in Hα + [N II] of A1795 is 3.2×10^{-15} in the same units (Hu *et al.* 1985).

To explore the spatial extension of the Hα + [N II] emission-line region, we derived the continuum galaxy profile along the slit at Hα by interpolation of the profiles at two continuum wavelengths shortward of [O I] λ6300 and longward of [S II] λλ6717/30. This profile was then subtracted from the observed galaxy profile at Hα, leaving the net emission profile due to the line. A similar procedure, with the proper choice for the continuum points, was performed also for the [O II] λ3727 line. These profiles are compared to the stellar image profile in Figure 7. Normalization has been made so that the areas of the emission line and stellar profiles are equal. It is evident that the emitting line region is well resolved in the

TABLE 4

EQUIVALENT WIDTHS AND LINE RATIOS RELATIVE TO Hα FOR G1 AND OBSERVED LINE RATIO RANGES FOR COOLING FLOWS

Emission Line (1)	E.W. (MMT) (Å) (2)	E.W. (UH) (Å) (3)	Line Flux Ratio (4)	Observed Range for Cooling Flows (5)
[O II] λλ3727/29	100. (±10)	93 (±9)	0.53 (±0.10)	0.5–2.5[a,b]
Hβ	9. (±2)	8. (±2)	0.18 (±0.03)	0.21–0.48[c]
[O III] λ5007	9. (±2)	7. (±2)	0.13 (±0.03)	0.12–0.41[c]
[O I] λ6300	15. (±3)	10. (±2)	0.24 (±0.05)	0.2–0.6[c]
Hα	46. (±5)	...	1.00	1.00
[N II] λ6583	71. (±7)	114. (±11)[d]	1.54 (±0.15)	0.9–2.0[c]
[S II] λλ6717/30	24. (±5)	20. (±4)	0.47 (±0.09)	0.6–2.2[c]

[a] Kent and Sargent 1979.
[b] Johnstone *et al.* 1987.
[c] Hu *et al.* 1985.
[d] Hα + [N II].

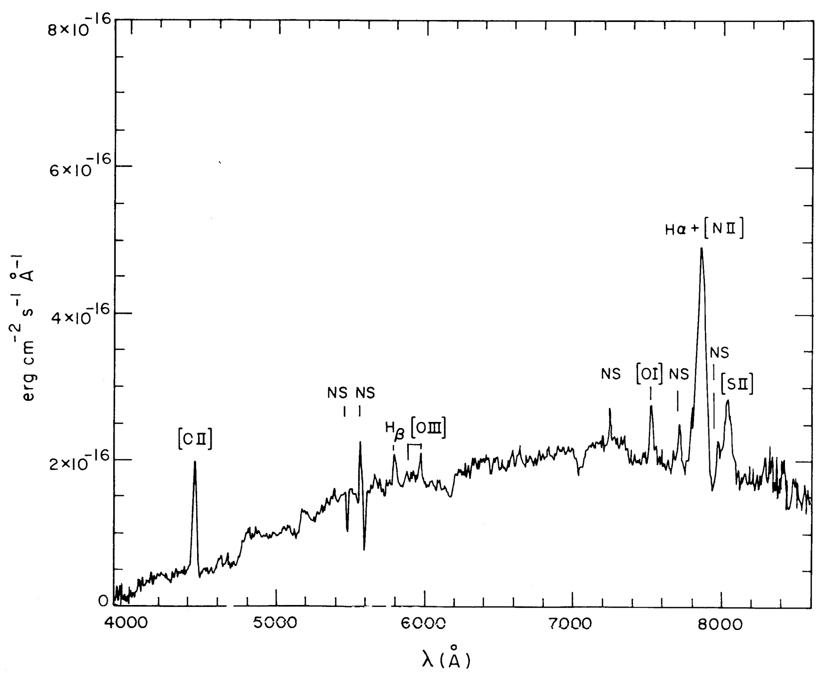

FIG. 6.—Flux-calibrated spectrum of galaxy G1 from the UH telescope, P.A. = 0°, integrated over 7 pixels. Observed wavelengths in abscissa. NS are night-sky lines.

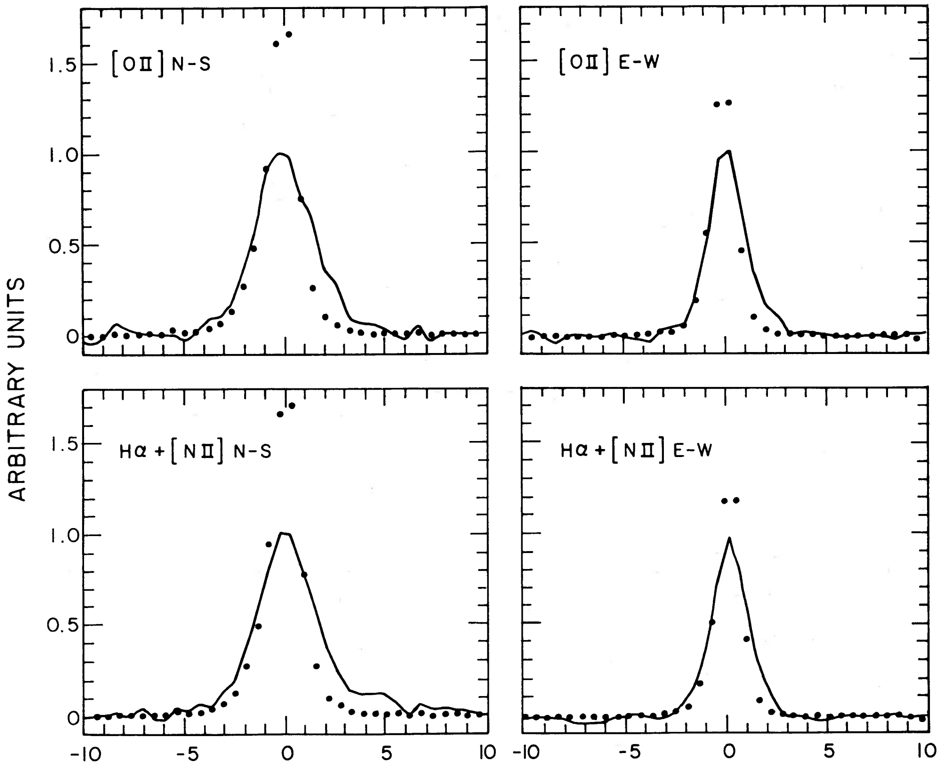

FIG. 7.—Spatial profiles (along the slit) of the Hα + [N II] emission and [O II] emission compared with the stellar (i.e., instrumental) profile. Left panels for P.A. = 0°, right panels for P.A. = 90°. Abscissa in arcsec from the peak emission; ordinate in arbitrary units.

N–S direction (close to the major axis), while extended emission is less evident in the E–W direction. A formal Gaussian fit to the stellar and Hα profiles gives the FWHM values reported in column (2) of Table 5. The intrinsic line profiles listed in column (4) of this table are obtained by subtracting in quadrature the FWHM values of the stellar profiles from the observed line profiles. One derives from Table 5 that the core of the emitting region is 13 kpc along the N–S direction, and about half this value along the E–W direction.

A lower limit to the total flux in Hα + [N II] may be derived integrating the line profile along the N–S direction (shown in Fig. 7), which is the more extended. Over an area of 2″.7 × 11″.6 we measured a flux of 3.3×10^{-14} ergs cm^{-2} s^{-1}, corresponding to 6.0×10^{42} ergs s^{-1}, comparable to the luminosity of A1795 (1.6×10^{42} ergs s^{-1}; Cowie *et al.* 1983).

III. DISCUSSION AND CONCLUSIONS

The cluster of galaxies 1E 0839.9+2938 is a luminous (3.9×10^{44} ergs s^{-1}) X-ray source, quite comparable to one of the most studied bona fide cooling flow clusters, A1795 ($L_x = 5.1 \times 10^{44}$ ergs s^{-1} in 0.5–3.0 keV within 0.5 Mpc radius; Jones and Forman 1984). The peak of the X-ray emission is consistent with the position of the brightest cluster galaxy, a giant elliptical with a secondary nucleus. The presence of such a dominant galaxy is typical of cooling flow clusters. Because of the short exposure time of the X-ray observation and the moderate angular resolution of the IPC, an accurate spatial analysis of the X-ray brightness distribution cannot be made.

TABLE 5

SPATIAL FWHM OF THE Hα + [N II] EMISSION

Slit Position (1)	Observed Hα (2)	Stellar Profile (3)	Deconvolved Hα (4)
N–S	3″.4 (±0.3)	1″.9 (±0.1)	3″.0 (±0.3)
E–W	2.1 (±0.2)	1.5 (±0.1)	1.5 (±0.2)

The optical spectrum of the dominant galaxy shows strong emission lines, with equivalent widths and line ratios similar to those of cooling flow clusters. The ratio between the Hα + [N II] surface brightness and the X-ray luminosity fits very well the empirical relation for cooling flow clusters given by Hu *et al.* (1985). Furthermore, the emitting line region is spatially extended (FWHM of 13 kpc in a direction close to the major axis of the galaxy) and asymmetric. Additional circumstantial evidence comes from the radio flux at 6 cm from the dominant galaxy, which has a value typical for sources in central galaxies of cooling flow clusters. We stress that, at a redshift of 0.193, this is the second most distant cooling flow cluster known to date, after the candidate 3C 295 ($z = 0.461$; Henry and Henriksen 1986).

Given the redshift of this cluster, a detailed study of the spatial extent of the optically emitting region, comparable to that available for nearby clusters, will be feasible only with the Hubble Space Telescope. A determination of the X-ray brightness distribution, and thus of the central cooling time, will require future X-ray telescopes such as the forthcoming ROSAT or AXAF.

Two points are worth noting about this cluster. The first one is the $V-R$ color of the dominant galaxy. A comparison with the synthetic $V-R$ color by Bruzual (1983*a*, *b*) shows that even the most delayed star formation rate considered in his model of elliptical galaxies ($\mu = 0.5$) has a color definitely redder ($V-R = 1.0$) than that of G1. Only a model with $\mu = 0.3$ fits the data, implying that a substantial rate of star formation including massive (hot) stars may still be present. Alternatively, one might propose that a nuclear nonthermal source could produce the bluer colors, but it should also give rise to a central peak in the radial brightness profile and a detectable color gradient on a scale of 5″. Neither is seen in the present observations.

The second point is the presence of two "blue" galaxies out of 13, namely galaxies G25 and G27 (see Table 1). Blue galaxies in the core of nearby rich clusters are extremely rare (1% frequency), while the probability of finding blue galaxies seems to be substantially higher ($\approx 20\%$) in more distant clusters (Butcher and Oemler 1984; see also MacLaren, Ellis, and Couch 1988), an occurrence commonly referred to as the Butcher-Oemler effect. The spectrum of galaxy G25 is too faint to allow a redshift measure, so that we cannot be sure of its cluster membership, while the spectrum of galaxy G27 shows the same emission lines as the dominant galaxy but with nearly double equivalent widths, as well as a strong emission at the position of He II λ4686. To estimate the probability of this galaxy to be a cluster member, we computed the mean redshift and velocity dispersion in the cluster using our data and four additional cluster galaxy redshifts (D. G. Fabricant, private communication). We found the redshift of G27 resulted to be different from the mean cluster value by only twice the cluster velocity dispersion, suggesting its membership. We tentatively classify this galaxy as an AGN. The presence of such active galaxies has also been noted in other clusters showing the Butcher-Oemler effect (Dressler and Gunn 1982, 1983). We feel, however, that a single blue galaxy is not enough to claim for the presence of the Butcher-Oemler effect in 1E 0839.9+2938, and a larger number of galaxies should be observed before a definite conclusion may be derived.

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ISABELLA M. GIOIA, TOMMASO MACCACARO, RUDOLPH E. SCHILD, and ANNA WOLTER: Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA 02138

SIMON L. MORRIS: Mount Wilson and Las Campanas Observatories, 813 Santa Barbara Street, Pasadena, CA 91101

ROBERTO NESCI and GIUSEPPE CESARE PEROLA: Istituto Astronomico, Universitá di Roma, via Lancisi 29, 00161 Roma, Italy