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OPTICAL AND X-RAY PROPERTIES OF GALAXY CLUSTERS AT INTERMEDIATE RESHIFTS

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RESUMEN

Analizamos las propiedades de los cúmulos e investigamos la población de galaxias de una muestra de cúmulos de galaxias de baja luminosidad en rayos X, con corrimientos al rojo intermedios ($z = 0.2-0.5$). El estudio está basado en observaciones de imágenes profundas y espectroscopía, y en datos en rayos X de archivo. Para uno de los cúmulos, localizado a $z = 0.485$, discutimos en detalle las propiedades globales y el contenido de galaxias del cúmulo basados en el análisis de la distribución de velocidades, la distribución proyectada de galaxias, el diagrama color-magnitud del cúmulo y el estudio de la distribución de la masa, basado en el efecto de lente gravitacional débil y la emisión de rayos X.

ABSTRACT

We analyze the cluster properties and investigate the galaxy population of a sample of low-luminosity X-ray galaxy clusters at intermediate redshifts ($z = 0.2-0.5$). The study is based on deep imaging and spectroscopic observations and X-ray archival data. We discuss in detail the global cluster properties and galaxy content based on the analysis of the velocity distribution, the galaxy projected distribution, the cluster color-magnitude diagram, and the study of the mass distribution, based on weak lensing and X-ray emission, for one of the cluster located at $z = 0.485$.

Key Words: cosmology: dark matter — cosmology: observations — galaxies: clusters — galaxies: evolution

1. INTRODUCTION

Cluster of galaxies are the largest gravitationally bound systems in the Universe. They are excellent laboratories for studying the large-scale structure formation, structure mass assembly and galaxy evolution. Clusters are complex systems, including a variety of interacting components such as galaxies, X-ray emitting gas and dark matter. Optical and X-ray studies show that a large fraction of clusters contains sub-structures, revealing that clusters are indeed dynamically active structures, accreting galaxies and groups of galaxies from their neighborhoods(e.g., Lima Neto et al. 2003). Even though it is thought that rich clusters form at redshift 0.8–1.2, there are numerous evidences (optical, X-ray) that clusters are still accreting sub-structures at intermediate and low redshifts (e.g., Gonzalez et al. 2005). We may witness the assembly of rich clusters by observing large groups or poor clusters which, in turn, would be the future core of rich clusters. The details of this process will depend in part on how these large groups/poor clusters relate to more nearby structures. Most galaxies in the Universe are concentrated in low-density environments (groups and poor clusters). For intermediate redshifts, $z \sim 0.3-0.5$, while massive clusters of galaxies have been widely studied, the intermediate-mass systems, those between loose groups and rich clusters of galaxies, have received comparatively little attention. A few poor clusters or groups at intermediate redshifts have been studied, either in X-ray and/or in the optical (e.g., Balogh et al. 2002; Mulchaey et al. 2006; Carrasco et al. 2007).

In this article we analyze the properties of a sample of low-luminosity X-ray clusters of galaxies at intermediate redshifts, based on optical and X-ray data.

2. THE SAMPLE AND OBSERVATIONS

The clusters were selected from the 160 Square Degree ROSAT Cluster Survey (Vikhlinin et al. 1998). Clusters with $L_X < 10^{44}$ erg s^{-1} and with redshift between 0.2 and 0.5 were observed with the Gemini Multi-Object Spectrograph (GMOS; Hook et al. 2004) at the Gemini telescopes (North and

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TABLE 1

CLUSTER PROPERTIES

Cluster	$N_{\rm gal}$	Z	σ_V km s^{-1}	L_X ($\times 10^{43}$ erg s^{-1})
RX J1117.4+0743	23	0.4822	592	4.6
	9	0.4919	391	
RX J1124.0-1700	22	0.4100	750	8.1
RX J1252.0-2902	13	0.1853	618	3.4
RX J0206.3+1511	30	0.2480	404	3.6

South). In addition, three other clusters at $z \sim 0.2$ were imaged with the Mosaic II camera at CTIO. All GMOS observations (imaging and spectroscopy) were processed with the Gemini IRAF package. The SExtractor package (Bertin & Arnouts 1996) was used to detect objects in the images and to obtain their relevant photometric parameters. One of the clusters, RX J1117.4+0743, was observed by XMM-*Newton*. The XMM-*Newton* data were downloaded from the archive and processed to derive the temperature, metallicity and the unabsorved X-ray flux and luminosity of the cluster.

3. RESULTS

Table 1 summarizes the main parameters of the clusters observed with GMOS.

Two of the cluster (RX J1252.0-2902 and RX J0206.3+1511) are dominated by passive (red) galaxies and lie at the so-called cluster red sequence. In addition, both clusters have a Giant Elliptical galaxy in their centers, coincident with the peak of the X-ray emission. The difference of more than two magnitudes between the brightest cluster galaxy and the second ranked galaxy in RX J1252.0-2902, the absence of other bright galaxies in a radius of < 0.5 Mpc and the moderate X-ray luminosity make this cluster a good candidate for a Fossil Cluster. The two clusters above $z = 0.4$ (RX J1117.4+0743 and RX J1124.0-1700) show a more complex morphology. The cluster RX J1117.4+0743 ([VMF98] 097) is composed by at least two structures (S1 and S2) along the line-of-sight as is inferred from the analysis of the velocity distribution. The two structures also differ in the galaxy populations content. Galaxies in S1 are redder (inside the red sequence for passive galaxies) while S2 is dominated by a population of blue, star-forming galaxies. Figure 1 shows the projected galaxy density, the X-ray emission and the weak-lensing projected mass distribution. All figures present the same overall features: the cluster core and two other structures (E and NE), indicating the complexity of the cluster morphology.

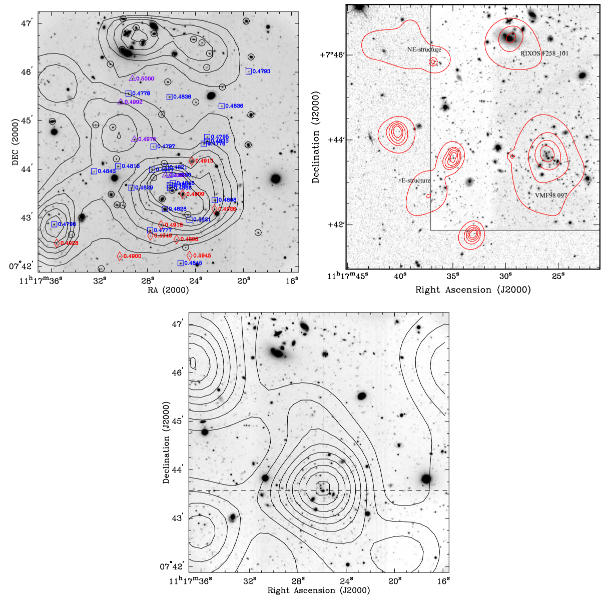

Fig. 1. Upper left: The projected galaxy density map of 272 galaxies brighter than $r' = 23$ mag. Upper right: adaptively smoothed X-ray emission plotted over the GMOS r' plus SDSS r' composite image. The inner rectangle shows part of the region covered by the GMOS field. Bottom: Weak-lensing reconstructed projected mass distributions.

The mass determination inferred from weak-lensing is in average 3 to 4.8 times higher (depending on the model assumed) than the X-ray mass. This discrepancy is usually interpreted as evidence of dynamical activity. Additional evidences of dynamical activity in this cluster are presented in Carrasco et al. (2007).

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