DYNAMICS AND SUBSTRUCTURES IN CLUSTERS OF GALAXIES

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RESUMEN. Se dan estimaciones preliminares de las dispersiones de velocidad, las velocidades medias y las masas viriales para Sersic40/6, A496, SC0625-536, SC0624-547 y A1750, con base a nuevas observaciones y datos publicados. La mayor parte de los objetos están asociados con fuentes de rayos X (tres de ellos son fuentes muy intensas). Se discuten brevemente las principales estructuras ópticas y de rayos X junto con las distribuciones del campo de velocidad de algunos de estos cúmulos.

ABSTRACT. Preliminary estimates of velocity dispersions, mean velocities and virial masses are given for Sersic40/6, A496, SC0625-536, SC0624-547 and A1750, based on new observations and published data. Most of them are associated with X-ray sources (three are very strong sources). The main optical and X-ray structures together with the velocity field distributions of some of these clusters are briefly discussed.

Key words: **CLUSTER-GALAXIES – GALAXIES-REDSHIFTS**

I. INTRODUCTION

The information that X-ray data provide on cluster structures is essential to understand the evolution of clusters. However this information must be complemented with optically determined parameters concerning, in particular, the dynamics of the clusters, such as velocity dispersions and virial masses, galaxy distributions and populations. We have studied five clusters having one or two sharply peaked X-ray centroides. Two of them, A1750 and SC0624-547, show clear bimodal structures (Forman *et al.*, 1981). We report here spectroscopic observations and preliminary parameters for these clusters, where full results will be published elsewhere.

II. OBSERVATIONS AND DATA REDUCTION

The observations included in these results were made between 1982 and 1985 at the 100" Du-Pont telescope at Las Campanas Observatory using the Boller & Chivens spectrograph with a 600 lines/mm grating giving a useful range from 3500[Å] to 7000[Å] with a resolution of 2 [Å] (2 pixels) on the Shectograph detector. The basic information of the clusters is given in Table 1. The data reduction was performed with the IRAF image processing system on the VAX8600 of the Universidad Católica. The He-Ar comparison spectra were calibrated with 5 or 6 order polynomials using 16 to 20 spectral lines, giving a rms fit smaller than 0.3 [Å]. The accuracy was checked with the sky lines, where normally a deviation smaller than 0.4 [Å] was found. Agreement with velocities of standard objets (stars and bright galaxies) showed that no zero-point correction in velocity was needed for this instrument. Redshifts were computed using a quadratic minimization of velocities residuals of line measures of each spectrum (using a gaussian fit). The typical rms error of mean radial velocities of galaxies range from 30-40 (km/s), from the measurement of 5 to 12 spectral lines, typically: H, K, Ca 4226 [Å], Gband, H γ, Fe 4384 [Å], H β, Mg triplet, Na and occasionally emission in [OII] 3727 [Å], [OIII] 4959 and 5007 [Å] and H α lines.

III. RESULTS AND CONCLUSIONS

We have calculated the mean cluster redshifts and dispersions following the precepts of Danese *et al.* (1980) and the mass estimators for self-gravitating systems of equal mass bodies of Heisler *et al.* (1985) . The results are summarized in Tables 2 and 3.

We have added a significant number of galaxy velocities to those already published for clusters Sersic40/6, A496 and SC0624-547, while for A1750 and SC0625-536 the results reported here are first estimates. The values of the masses obtained are consistent between the different estimators, except for A1750. The clear bimodal substructure of A1750 is an important criterion in the correct applicability of such estimators, where each subcluster should be treated as a dynamical unit.

A summary of X-ray emmision, velocity and galaxy density structure in each cluster is the following:

Sersic40/6 – This cluster presents no significant substructures. Its centre is associated with a dumb-bell galaxy as given by the X-ray, velocity and density data (Quintana and Ramírez, 1989a).

A496 – A symmetric cluster which is centered in a cD galaxy with a north-west group which is probably not bound to the cluster (Quintana and Ramírez, 1989a).

SC0626-547– The velocity field shows a gaussian distribution. Its optical image does not present the bimodal substructure that is detected in the X-ray emmision (Quintana and Ramírez, 1989b).

Table 1. Characteristics of the Clusters Studied.

Cluster (1)	X-ray source (2)	R.A. (3)	Dec. (4)	R (5)	BM (6)
Sersic40/6	1H0429-616 2A0430-615 4U0427-61	04 30 33	-61 33 34	2	I
A496	1H0430-133 2A0431-136 4U0431-12	04 31 19	-13 21 58	1	I
SC0625-536	S0625-536	06 25 17	-53 39 43	-	I-II
Group		06 25 00	-53 39 56	-	-
SC0626-54	1H0623-539 2A0626-541 4U0627-54	06 26 29	-54 25 24	2	I-II
A1750		13 28 17	-01 35 32	0	II-III

Notes to table: (1) Cluster name; (2) X-ray sources – 4U: Fourth Uhuru catalog, 2A: 2nd Ariel V catalog, 1H: HEAO A-1 source catalog and S: survey of X-ray clusters by Kowalski *et al.* 1984; (3) R.A. (1950); (4) Dec. (1950); (5) Richness; (6) Bautz-Morgan type.

Table 2. Mean Velocities and Velocity Dispersions.

Cluster (1)	z (2)	$<v>$ (3)	σ (4)	error (5)	N (6)	Ref. (7)
Sersic40/6	0.0588	17359 ± 167	1440	(+126,-110)	84	
			1517	(+252,-167)	29	MQ81
A496	0.0319	9652 ± 77	614	(+60, -47)	71	
		9661 ± 125	657	(+104, -72)	32	QMIT85
SC0625-536	0.053	15669 ± 288	1372	(+242,-158)	26	
Group	0.050	15011 ± 615	1427	(+683,-278)	7	
			1588	±502	6	MCTH82
SC0626-54	0.0508	15109 ± 135	1098	(+103, -80)	74	
		15617 ± 221	939	±161	28	HM85
A1750	0.0849	24486 ± 150	1021	(+114, -85)	55	
A1750 North		23921 ± 215	978	(+177,-155)	25	
A1750 South		24957 ± 161	800	(+129, -87)	30	

Notes to table: (1) Cluster name; (2) Redshift; (3) Mean relativistic velocity in km s^{-1}; (4) Velocity dispersion in km s^{-1}; (5) Error with 68% confidence limits in km s^{-1}; (6) Number of galaxies; (7) Reference of previous results – QMIT85; Quintana *et al.* 1985, MCTH82: Materne *et al.* 1982, MQ81: Melnick and Quintana 1981, HM85; Hopp and Materne 1985.

SC0625-536 – This cluster lies in a confused X-ray region with extended emission, having a weak flux upper limit at the source S0625-536 (Kowalski *et al.*, 1984). A centrally located giant dumbbell dominates the opical cluster where a symmetric central region shows a high galaxy density. This cluster is near SC0626-547 in position and in velocity space (there are only 560 ± 159 km/s difference between clusters). These two clusters form a supercluster which includes a middle group of galaxies: called Group in Tables 1 and 2. (See figure 1). It is necessary to analyze more velocities to obtain a conclusion about its dynamical structure (Quintana and Ramírez, 1989b).

Table 3. Estimated Masses.

Cluster (1)	N (2)	MV (3)	MP (4)	MA (5)	MM (6)
Sersic40/6	84	3.3 ± 0.6	4.8 ± 0.9	3.8 ± 0.7	2.9 ± 0.7
A496	64	0.5 ± 0.1	0.7 ± 0.1	0.5 ± 0.1	0.5 ± 0.04
SC0625-536	26	1.3 ± 0.4	1.5 ± 0.5	1.3 ± 0.4	1.4 ± 0.6
SC0626-547	74	2.3 ± 0.4	3.2 ± 0.6	2.5 ± 0.4	2.1 ± 0.5
A1750	54	2.0 ± 0.4	3.3 ± 0.7	2.6 ± 0.5	1.0 ± 0.3
A1750 North	25	1.3 ± 0.4	3.4 ± 1.0	2.3 ± 0.7	2.2 ± 1.1
A1750 South	29	0.7 ± 0.2	1.2 ± 0.4	1.1 ± 0.3	0.5 ± 0.2

Notes to table: (1) Cluster name; (2) Number of galaxies; (3),(4),(5),(6): Virial mass, Projected mass, Average mass and Median mass estimators in units of 10^{15} M$_\odot$.
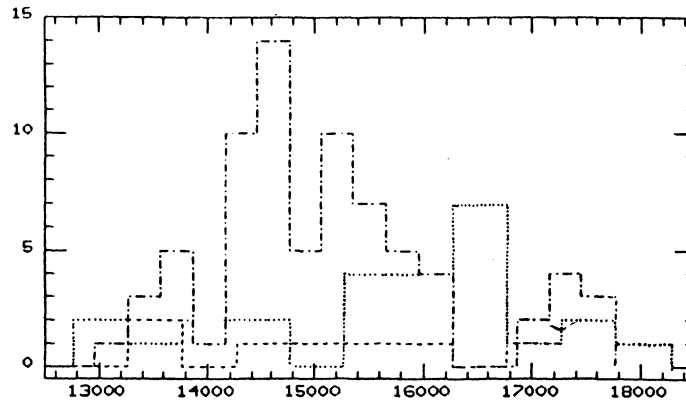

Figure 1: Histograms of velocities for SC0626-547 ($- \cdot - \cdot - \cdot -$) , SC0625-536 ($\cdots\cdots$) and Group ($- - --$). Velocities in (km/s) and frequencies in (counts of galaxies).

A1750 – This is an X-ray, density and velocity double structure cluster. There is a difference in velocity of 1036 ± 269 (km/s) between both substructures. They are probably bound and contitute a good example to apply a simple dynamical model as done for A98 by Beers *et al.* (1982).

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