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Mass Distribution in Hickson Compact Groups of Galaxies

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Acknowledgement

- HP thanks the Brazilian Cnpq for its financial support to attend this conference and the LAM for its financial support during the visit of HP at the LAM in Marseille in Feb 2007 to prepare this work.

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Introduction

- For the past ten years a few studies have been carried out on Compact Groups o galaxies to see the influence of dense environment on galaxy's dynamics and kinematics (Nishiura et al. 2000, Rubin, Hunter & Ford 1991).
- Since 1995, we launched an observational program in order to obtain rotation curves from 2D velocity fields observed using a scanning Perot Fabry. After studying particular cases such as HCG16 or HCG92 we began to consider our whole sample (Amram et al 2003, Plana et al. 2003).
- Mendes de Oliveira et al. (2003) showed the Tully Fisher relation for 23 rotation curves of late type galaxies from the total of 100 observed galaxies. The study shows that HCGs follow the TF relation with some galaxies being brighter than expected from the relation in relation of their low mass. Some RCs are showing strong asymetry due to interaction.
- The next step is to investigate the distribution of the dark halo for these galaxies.

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The data and Samples

- We have fit 19 rotations curves from the sample of Mendes de Oliveira et al. 2003. Six galaxies did not have satisfactory J photometry.
- In order to determine the dark halo shape, we allied both the stellar light contribution coming from the photometry and the dark halo contribution from the RCs.
- We used the model developped by Carignan & Freeman (1985) and modified by Blais-Ouellette (2000) to fit the RCs. The surface brightness profile is transformed into a mass distribution for the stellar disk and the stellar bulge assuming a variable but radially constant M/L ratios for both the stellar disk and the Bulge.
- The main interest of this study is to be compared with similar studies in different environment. We compared the shape of the dark halo with Barnes et al. (2004) and the GHASP survey (Epinat et al 2007 in preparation - Garrido et al. 2005).

Photometry and profile decomposition

- Surface brightness profiles have been built using the J band from the 2MASS survey because it probes better the mass dominant stellar component.
- We have fitted ellipses to the isophotes of the J band images using ELLIPSE task of the SDSDAS package with IRAF. We only fixed the center of the ellipse in the fitting parameters and we usually used a 0.2 arcsec space between two ellipses.
- In order to use the mass model, we perform a decomposition of the surface brightness profile in the classical two components:

  an exponential disk $\mu = \mu_0 + 1.0857\ r/r_0$

  an $r^{1/4}$ bulge profile $\mu = \mu_e + 8.3268\ [(r/r_e)^{1/4} + (r/r_t)^4]$

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- To perform the decomposition we used an home made program based on a minimized square routine from the MINUIT package. The program first fits the disk using a visual estimate on the profile. It then substracts the fitted disk and adjusts the bulge. The operation is repeated by interaction in order to minimize the χ^2 of each disk and bulge parameters.
- We then have five parameters, two for the disk

  μ_0 : the central surface brightness,

  r_0 : the disk scale parameter

and three for the bulge

  μ_e: the central surface brightness

  r_e and r_t :scales factors

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Mass Model

- We fit the rotation curve of each galaxy using the model desenvolved by Carignan & Freeman (1985) and revised by Blais-Ouellette (2000). This model calculates the contribution of each velocity component (bulge, disk and halo) using the photometric profile decomposition for the luminous contribution (bulge and disk) and a predetermined density profile for the halo. The result of the quadratic sum of each velocity component is fitted to the observational rotation curve by minimizing the χ^2 in the four dimensions space: $(M/L)_{disk,}$ $(M/L)_{bulge}$, ρ_0 and R_0.
- For this study we used a spherical distribution that represents the dark halo, the so called isothermal sphere (ISO model) with a density profile given by:

$$\rho(r) = \rho_o / [1 + (r/R_o)^2]$$

and the Navarro, Frenk and White (1996) (NFW) density profile:

$$\rho(r) = \rho_c / [(r/ R_c) (1 + r/R_c)]$$

We also fit the RCs using the Maximum Disk Model (MDM), by finding the highest contribuition of the disk in the RC.

Table 1

Photometric and Mass Model parameters

	Photometric Parameters						Mass Model Parameters				
HCG[1]	μ_0[2]	r_0[3]	μ_e[4]	r_e[5]	r_t[6]	M/L_{disk}[7]	M/L_{bulge}[8]	R_0[9]	ρ_0[10]	χ^2
07c	19.12	7.21	14.70	9.02	2.81	0.05	0.55	6.00	0.050	4.29
10d	17.8	2.47	0.00	0.00	0.00	1.60	1.00	1.80	0.175	0.39
16a	17.64	3.98	9.91	3.16	3.12	0.40	0.20	1.60	0.500	7.61
16c	16.6	1.44	12.35	9.92	2.86	0.03	0.11	6.00	0.130	3.00
19a	0.00	0.00	9.95	1.88	25.06	0.10	0.00	9.00	0.024	39.53
19b	18.75	3.12	11.90	0.84	2.71	0.05	0.14	8.00	0.012	3.13
87a	17.62	6.78	12.80	10.58	5.32	0.05	0.00	8.60	0.009	1.01
87c	18.26	2.85	0.00	0.00	0.00	0.10	0.10	3.50	0.126	2.07
88a	17.21	4.56	13.01	11.02	2.65	1.75	1.05	21.00	0.016	0.90
88b	18.13	4.56	9.10	1.12	4.27	1.50	0.20	45.00	0.013	3.64
88c	17.95	2.09	19.72	3882	3.54	0.45	0.30	19.50	0.007	5.89
88d	17.94	2.85	0.00	0.00	0.00	0.97	0.10	14.50	0.010	1.2
89a	19.62	12.48	13.30	6.81	5.31	0.80	1.20	18.00	0.013	1.28
89b	18.17	4.24	0.00	0.00	0.00	0.70	1.00	2.00	0.189	1.28
89c	18.51	2.12	0.00	0.00	0.00	1.10	1.00	6.00	0.052	0.28
91a	18.13	7.42	13.15	20.69	8.44	0.10	1.00	2.00	0.350	33.14
91c	18.76	5.08	14.80	12.78	4.26	0.70	0.00	3.00	0.010	1.66
96c	16.30	1.29	12.43	3.83	2.50	0.16	0.05	18.00	0.005	0.81
100d	18.11	1.68	0.00	0.00	0.00	0.10	0.10	3.00	0.019	91.76

[1] Hickson Group; [2] Disk central surface brightness; [3] Scale lenght in kpc; [4] Bulge central surface brightness; [5] Caracterist radius in kpc; [6] Generalized caracteristic radius kpc; [7] Mass / Luminosity ratio for the disk in $M_\odot/L_\odot$; [8] Mass / Luminosity ratio for the bulge in $M_\odot/L_\odot$; [9] Caracteristic radius for the Dark Halo in kpc; [10] Central density for the dark halo in $M_\odot\ pc^{-3}$

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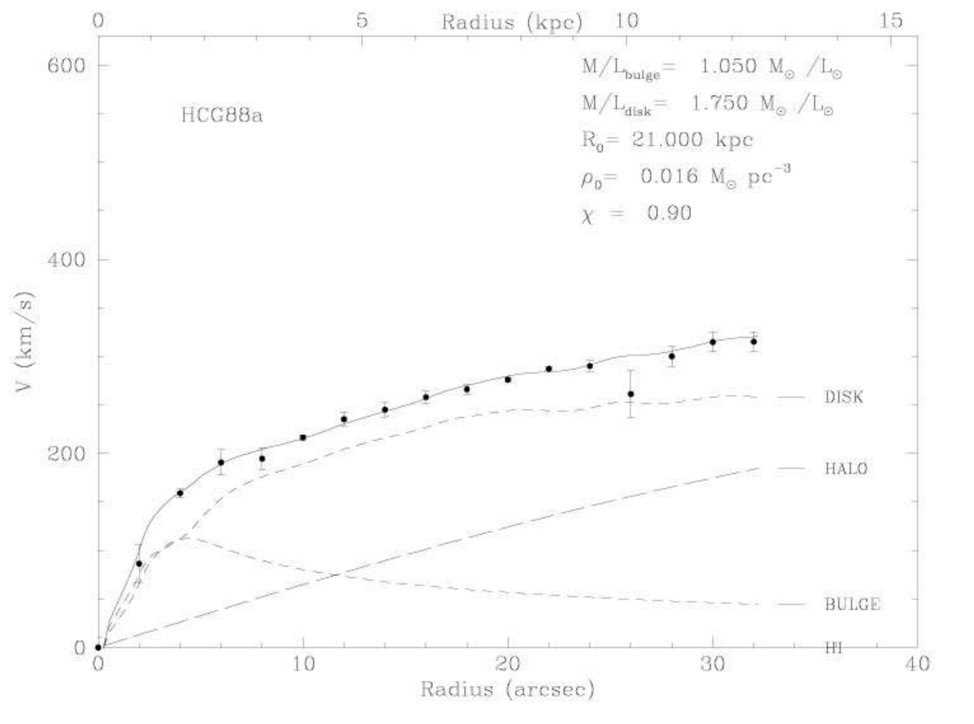

Fig. 1 Rotation Curve of HCG88a with the Disk, Bulge and Halo components.

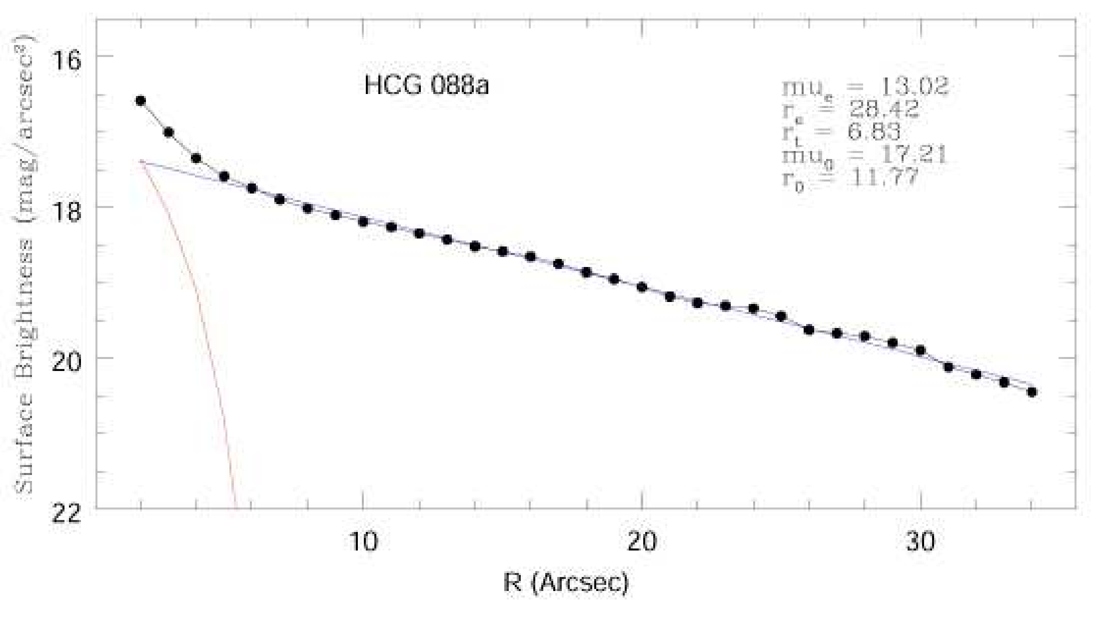

Fig. 2 SBA galaxy HCG 88a. J surface brightness profile with the bulge + disk decomposition.

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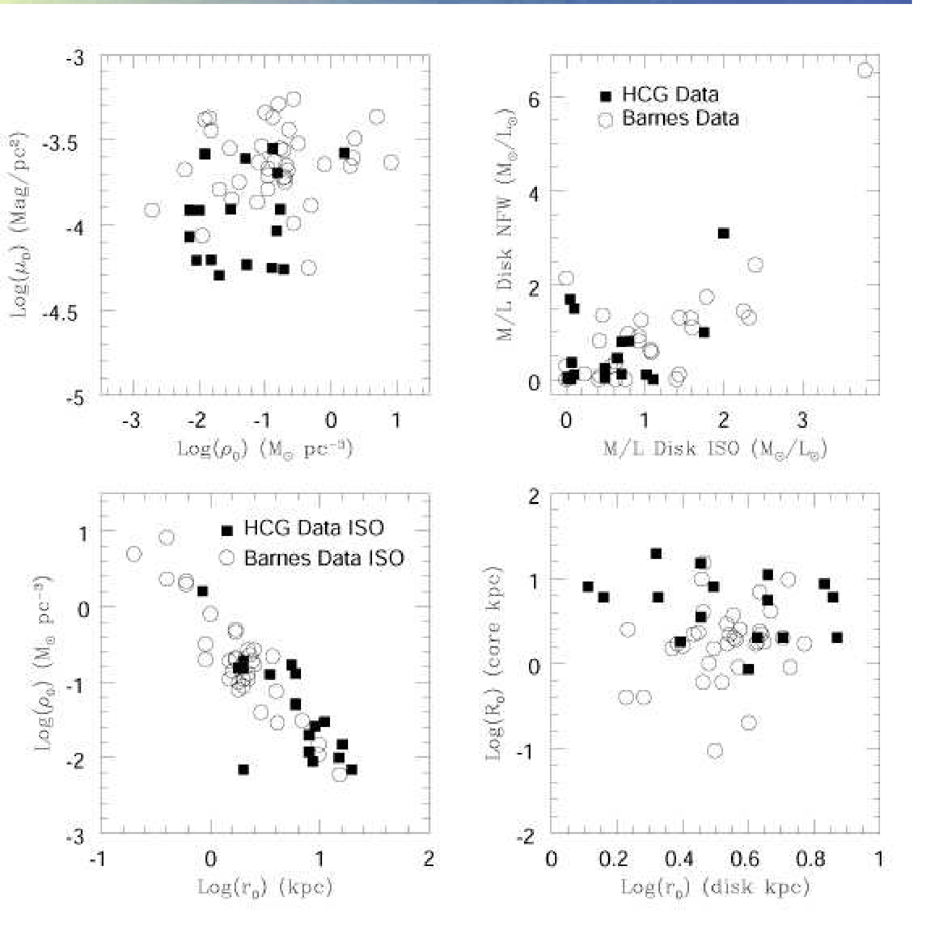
Figure 3 - Correlations between the 3 models - ISO - NFW - MDM



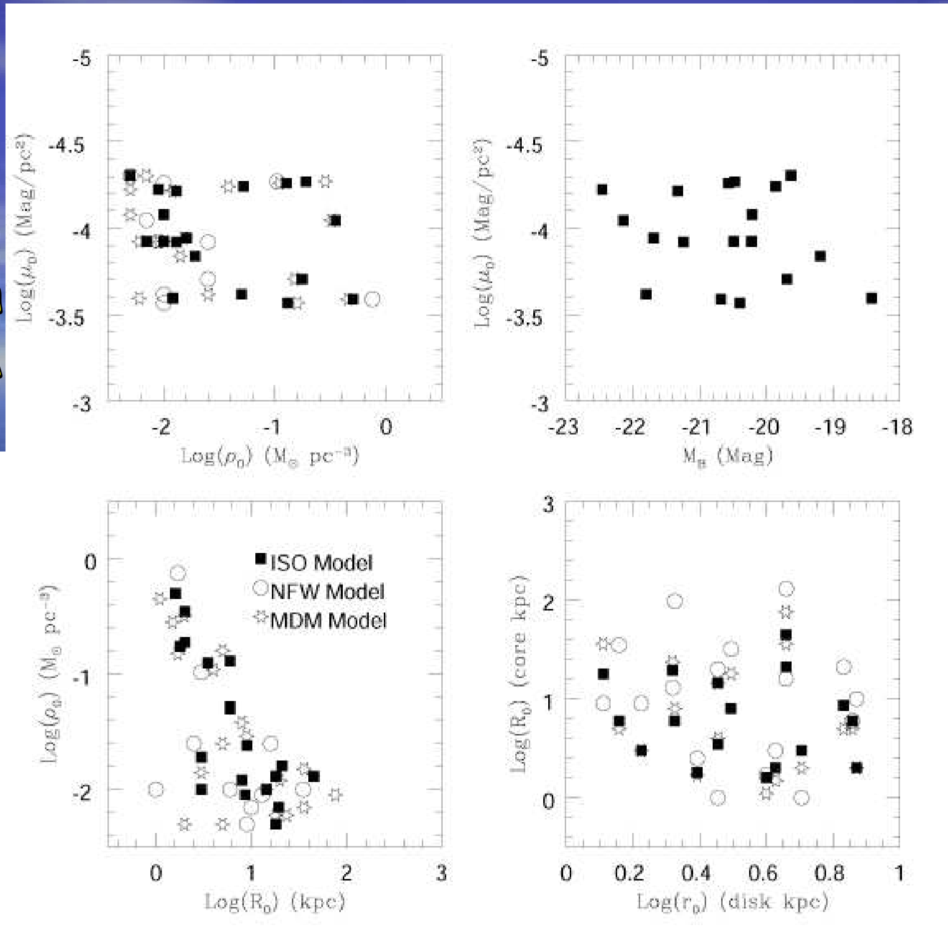


Figure 4 - Correlations compared with the Barnes sample for the ISO model

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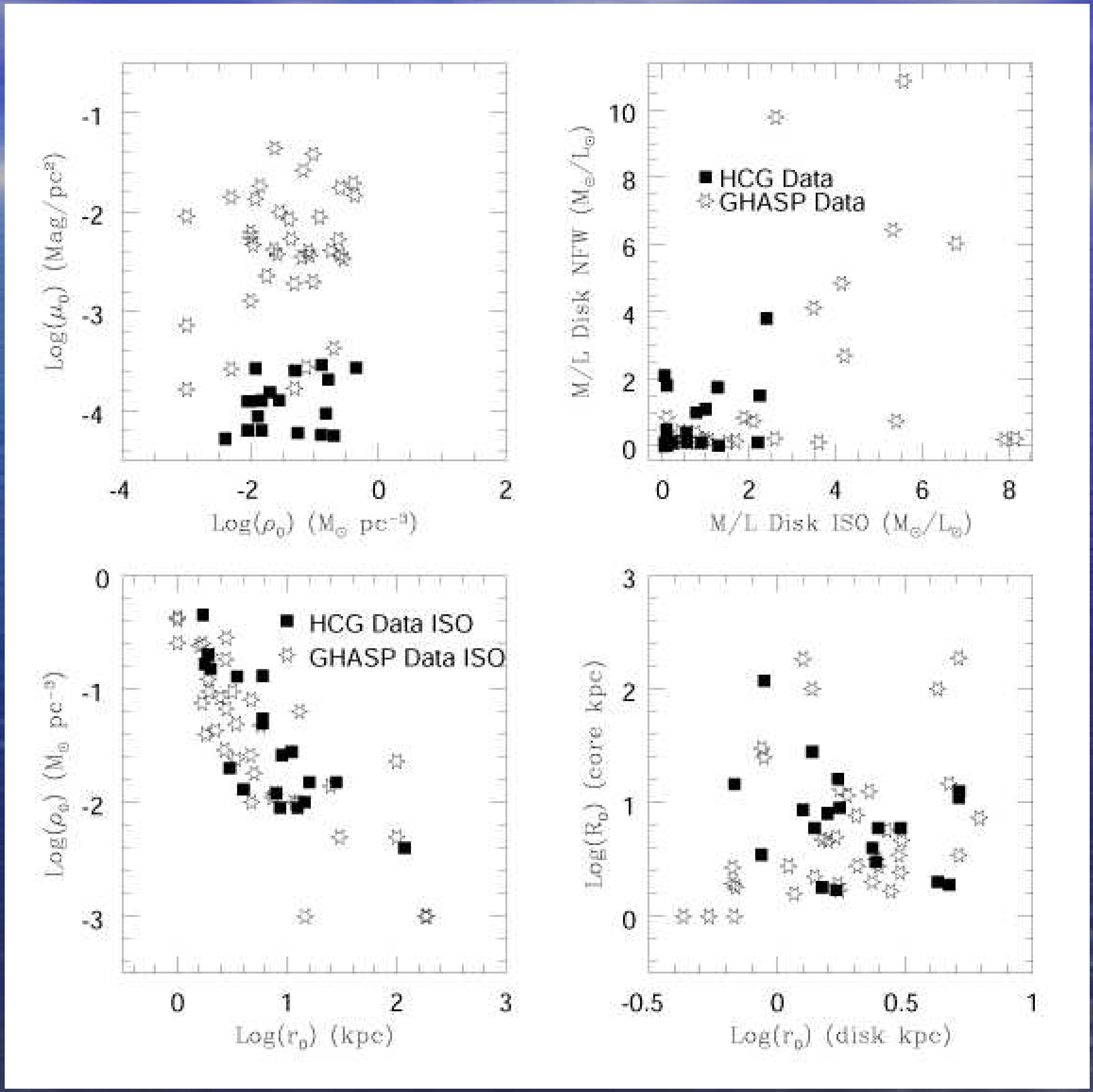
Figure 5 - Correlations with the GHAPS sample for the ISO model



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Results - Conclusions

- We fit 19 RCs of Galaxies in dense environement with different mass models.
- Central dark halo density and the core radius show a very tied correlation, using the three models: isothermal, NFW and maximum disk. The scale length, also seems to be related with the core radius, but the relation is weaker (Figure 4). Donato et al. (2004) show a much stronger relation.
- Scale length vs Core Radius seems to show different correlation for our HCG sample and the sample from Barnes (2004). Barnes (2004) sample is formed by late type galaxies but in different environement (clusters galaxies, field galaxies).
- Comparison with the GHASP survey of isolated galaxies confirmed the correlation between dark halo central density and the core radius. On the other hand nothing can be said for the relation between Scale length vs Core Radius.
- The M/L for the disk seems to show a more scatered range of values for the Barnes and GHASP sample than for the HCG.