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Mass Distribution in Compact Groups

J. Perea, A. del Olmo, L. Verdes-Montenegro

Instituto de Astrofísica de Andalucía (CSIC), Granada, Spain

M. S. Yun

National Radio Astronomy Observatory,[1]*, Socorro, NM, USA*

W.K. Huchtmeier

Max-Planck-Institut für Radioastronomie, Bonn, D-53121, Germany

B. A. Williams

University of Delaware, Newark, Delaware, USA

Abstract. New redshift surveys of galaxies in the field of compact groups have discovered a population of faint galaxies which act as satellites orbiting in the potential well of the bright group. Here we analyze the mass distribution of the groups by comparing the mass derived from the bright members and the mass obtained from the satellite galaxies. Our analysis indicates the presence of a dark halo around the main group with a mass roughly four times that measured for the dominant galaxies of the compact group.

We found that heavier halos are ruled out by the observations when comparing the distribution of positions and redshifts of the satellite galaxies with the distribution of satellites of isolated spiral galaxies. The results agree with a picture where compact groups may form a stable system with galaxies moving in a common dark halo.

1. Introduction

As it is known, the existence of compact groups poses an interesting dynamical problem. Early simulations such as those done by Barnes (1989) suggested that the time scale for merging was very short. This result has lead to some authors to question the reality of the groups or to describe them as transient configurations in larger systems (Mamon, 1986; Hernsquist et al. 1995; Diaferio et al. 1994). However recent simulations showed that there exist stable enough systems with a common dark halo around all the galaxies (Athanassoula et al. 1997)

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New observations indicate the existence of fainter galaxies at the same redshift of the group but at larger distances (e.g. de Carvalho et al. 1997, Barton et al., 1998, Zabludoff & Mulchaey, 1998). In this work we assume that the small galaxies are orbiting as test particles in the potential well of the bright group. For such configuration we can obtain two mass estimations, one from the galaxies forming the compact group and the other from the positions and velocities of the satellites.We expect the last being larger, if a dark halo exists, since we are sampling a larger scale.

2. The Sample

We analyze 13 compact groups from the Hickson's catalog (1982). Redshifts and positions for satellites were obtained for groups HCG 16, 23, 42, 62, 63, 67, 86, 87, 90, and 97 from the work by De Carvalho et al (1997). In addition we included HCG 96, 92 and 37, where the redshifts were obtained from our VLA HI data (HCG 96 and 92) and from the optical using Alfosc[1] at the Nordic Optical Telescope (HCG 37 and 96). We also included the objects detected by Peterson & Shostak (1980) in HCG 92.

3. Mass estimation and dark halos

To measure the mass of each group we evaluated the two versions of the projected and virial mass estimators. For the compact group the self graviting estimators of the virial ($M_v(CG)$) and projected ($M_p(CG)$) mass were calculated after Heisler et al. (1985) and Perea et al. (1990). For the satellites we applied the mass estimators ($M_v(Orb)$ and $M_p(Orb)$) for test particles around a point mass as described by Bahcall & Tremaine (1981).

In Fig. 1 we compare the virial and projected mass estimators. In the left panel we show the results for the compact groups (CG) and in the right one the estimations from the satellite galaxies (Orb), the mass is expressed in units of $10^{12}\mathrm{M}_\odot$ with $\mathrm{H}_0 = 50$ km $\mathrm{s}^{-1}\mathrm{Mpc}^{-1}$. As can be seen, both estimators are equivalent for CGs but there is a discrepancy for the orbiting satellite galaxies where we obtain $M_p(Orb) \approx 1.37 \times M_v(Orb)$.

The orbital mass is a linear function of the central mass as it is expected when the compact group dominates the dynamics. As can be seen from Fig. 2, the results are consistent with an almost constant fraction $M(Orb)/M(CG)$. Observationally we found the following linear fit,

$$M_v(Orb) \approx (4.1 \pm 0.7) \times M_v(CG)^{0.92\pm0.07}$$

with a Student's t=4.0 (probability > 99%) for the correlation. This result indicates the existence of a dark halo with a larger extension, concentrated on the position of the compact group, and with a mass about four times the one obtained from the dominant galaxies of the compact group.

[1]The data presented here have been taken using ALFOSC, which is owned by the Instituto de Astrofísica de Andalucia (IAA) and operated at the Nordic Optical Telescope under agreement between IAA and the NBIfA of the Astronomical Observatory of Copenhagen.

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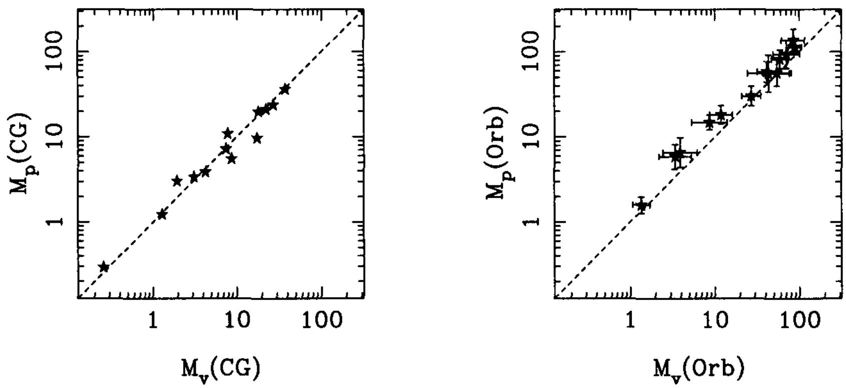

Figure 1. Comparison between the Virial and Projected Mass. The error bars were obtained by bootstrap.

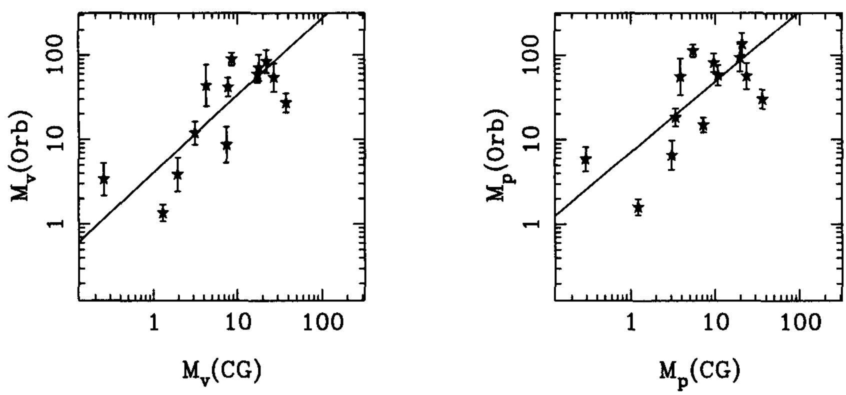

Figure 2. Comparison between the orbital and CG masses

3.1. The extent of the halos

It is possible to know more about the extent of the dark halo if we combine all the information provided by the satellites. For doing so we followed the formalism derived by Van Moorsel (1982) for binary galaxies and by Erickson et al. (1999, EGH) for satellites of spiral galaxies. We analyze the distribution of orbital masses as defined by $M_\chi = v_z^2 r_p/G$ using the satellites in each compact group v_z is the radial velocity of the satellite with respect to the central group and r_p is the projected separation. The orbital mass should be corrected by a factor χ, accounting for all the projections, to obtain the real mass of each group (see EGH, for details) . For that we use the observational quantity $\chi_{obs} = v_z^2 r_p/M_g$, related to χ through $\chi_{obs} = (M_\chi/M_g)\chi$, where M_g is the mass of the central system ($M_v(CG)$ or $M_p(CG)$). In this way the analysis of the mass distribution is reduced to the study the distribution of χ_{obs} for all the satellite galaxies in all

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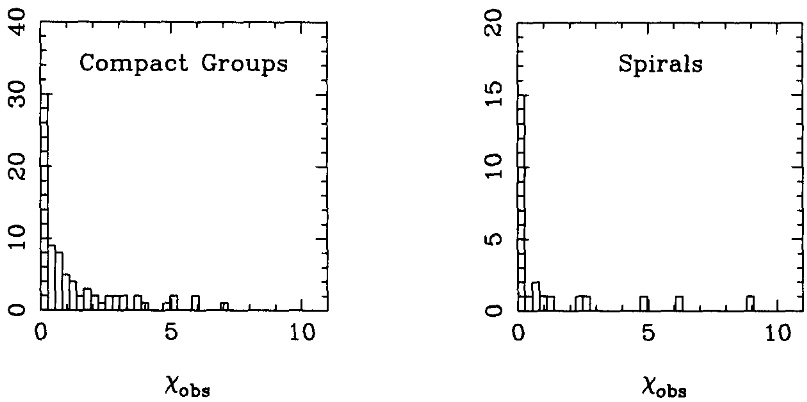

Figure 3. χ_{obs} for Compact Groups and Spirals

groups (see left panel of Fig. 3). The quantity χ_{obs} measures the extension of the dark halo.

The χ_{obs} distribution for the satellite galaxies in CGs are similar to those observed for the satellites of isolated spirals by EGH (right panel in Fig. 3) and in particular their models 5 & 6 apply here and indicate that the values of χ_{obs} can be explained only if no heavy halos are present.

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