Small Galaxy Groups
ASP Conference Series, Vol. 209, 2000
M. Valtonen and C. Flynn, eds.

Las Campanas Compact Groups: Star formation properties

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Abstract. Using the equivalent width (EW) of [O II] λ3727, I analyse the star formation properties of Las Campanas Redshift Survey galaxies in different environments. The star formation activity in compact groups is found to be depressed relative to that in loose groups and the field.

1. Introduction

Allam & Tucker (1998) produced a catalogue of compact groups (CGs) — with physical characteristics similar to those of the Hickson Compact Groups (1982; HCG) — from the Las Campanas Redshift Survey (LCRS; Shectman et al. 1996). We applied a standard friends-of-friends algorithm (Ramella et al. 1989) to extract a sample of CGs systems in the LCRS (hereafter LCRS CGs). Our definition was the following:

- members: ≥ 3 galaxies,
- Compact: projected inter-galaxy separation of $D_L \leq 50h^{-1}$kpc ~ 1 galaxy diameter, (where $h \equiv H_0/100$ km s^{-1} Mpc^{-1}), and
- isolated: inter-galaxy velocity difference $V_L \leq 1000$ km s^{-1}

With these criteria a total of 76 CGs was found, each having 3 or more members. The total number of galaxies in LCRS CGs is 253. The average projected separation of LCRS CG members is $\sim 48h^{-1}$ kpc. The median redshift is $\sim$ 0.08, twice that of the HCG catalogue. LCRS CGs represent some of densest concentrations of galaxies known, and may provide ideal laboratories for studying the effect of strong interactions on the morphology and stellar content of galaxies.

It is well known that tidal shocks induced by galaxy-galaxy interaction are expected to trigger rapid bursts of star formation (SF) (e.g. Bushouse 1987); so, if interactions in CGs are as common as expected, a global enhancement in the SF rate of the galaxies should be detected.

2. The Star Formation in LCRS galaxies

One powerful sign of SF activity is the ionization lines emitted by heated gas surrounding regions of SF. The equivalent width of the [O II] λ3727 emission line, EW(O II), can be used as quantitative and spatial tracer of SF in distant galaxies (Kennicutt 1992).

https://doi.org/10.1017/S0252921100055287 Published online by Cambridge University Press

The primary data are: a sample of 253 LCRS CG galaxies, a sample of 7621 LCRS loose group (LG) galaxies, and a sample of 13452 LCRS field galaxies (see Allam et al. 1999). I used the measured rest-frame EW(O II) for the LCRS galaxies, where the mean error of EW(O II) is 2.2 Å. The distribution of EW(O II) for the LCRS galaxies in CGs, in LGs, and in the field is shown in Fig.(1). The emission line strength is classified as follows:

- NEM (no emission), EW < 5 Å, which indicates non-star-forming galaxies;
- WEM (weak emission), 5 Å $\leq$ EW < 20 Å, which indicates normal galaxies where the SF is governed by internal factors such as gas content and disk kinematics; and
- SEM (strong emission), EW $\geq$ 20 Å, which indicates mainly starburst galaxies, where SF is due to interaction.

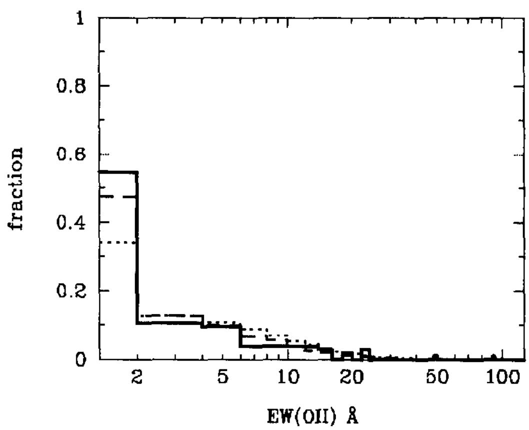

Figure 1. The distribution of the equivalent widths (EW) of [O II] λ3727 for LCRS galaxies in CGs (solid line), in LGs (dashed line), and in the field (dotted line). A χ^2 – test indicates that the distribution for CGs differs from LGs at the 99.99965% confidence level, and from the distribution for the field galaxies at the 99.99951% confidence level.

In Table (1) the frequency of EW(O II) for galaxies in different environments is shown. For high density environments, the fraction of CG galaxies showing normal galaxy SF (WEM) is only two-thirds that for the field galaxies, while the fraction of CG galaxies which are starbursting is only half that of the field. Interestingly, for intermediate environments, the fraction of LG galaxies showing a normal SF is only three-fourths that for the field, and the fraction of LG galaxies showing starburst (SEM) activity is only two-thirds that in the field. The results of the above comparison demonstrates that the SF rates are generally higher in the field than in denser environments.

Table 1. EW(O II) for LCRS Galaxies in Different Environments

Galaxies		EW(O II)					
Environment	Total No.	NEM EW<5 Å		WEM 5 Å≤ EW <20 Å		SEM EW ≥ 20 Å	
Compact Group	104	72	(69%)	27	(26 %)	5	(4.8%)
Loose Group	6612	4312	(65.2%)	1892	(28.6 %)	408	(6.2%)
Field	12915	6804	(52.7%)	4905	(38 %)	1206	(9.3%)

3. The Morphologies of LCRS Galaxies

The C index, measured from the second order moments of a galaxy's light distribution, is used as a substitute for the Hubble type, where late/irregular type galaxies have smaller C values (see Allam et al. 1999, and references therein). The total number of galaxies in the sample having a measured C index is 12901. The mean and median C index is given for each of the different galaxy environments in Table 2.

Table 2. The Concentration Index C of LCRS Galaxies.

Galaxy Environment	Total No.	mean	median
Compact Group	86	0.324 ± 0.009	0.302
Loose Group	4528	0.303 ± 0.001	0.298
Field	8287	0.287 ± 0.008	0.28

Figure 2 shows the dependence of the mean EW(O II), <EW(O II)>, on the mean C index, <C>, for galaxies in CGs, LGs, and the field. In LGs and the field, <EW(O II)> increases smoothly as <C> decreases, which parallels the relation between the EW(O II) and Hubble type (Kennicutt 1992). The <EW(O II)> for LCRS CG galaxies, however, appears deficient toward late types (small C).

4. Conclusion

I compared the amount of star formation (SF) based on the strength of the [O II] λ3727 emission line (NEM for no SF, WEM for normal SF, and SEM for starbursts) for compact group (CG), loose group (LG), and field galaxies. The starburst activity for CG galaxies is found to be roughly half of that for the field, whereas for LG galaxies it is roughly two-thirds of that for the field. Also, normal galaxy SF occurs for CG galaxies at roughly two–thirds the rate for the field; for LG galaxies, three-fourths that for the field. This means that the SF in the field is generally enhanced with respect to high density environments. Also the SF vs. C index relation is compared for CG, LG, and field galaxies, and it is found that the SF for LCRS CGs appears to be deficient for late morphological type (small C index). Much of the depressed star formation for CGs relative to LGs and the field can be ascribed to the higher fraction of early-type galaxies in CGs. In addition, the SF rate in CGs late type galaxies is particularly deficient — only one-half to one-third of that in field spirals.

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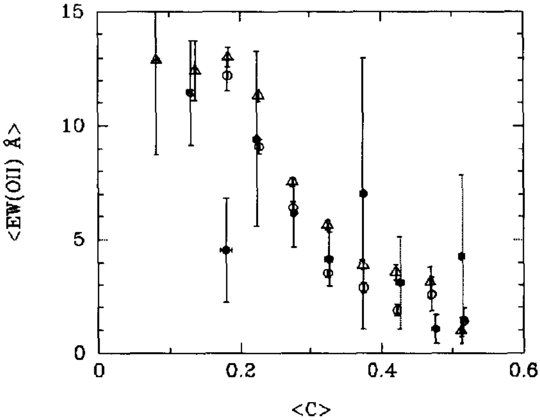

Figure 2. The relation between the mean concentration index <C>, and the mean O II equivalent width, <EW(O II)>, for galaxies in CGs (filled circles), LGs (open circles), and the field (open triangles).

Therefore, although there exist obvious signs of interaction in LCRS CGs in the form of tidal tails, bridges, etc. (Allam & Tucker 1998), these indicate limited efficiency (there is no merging) and limited SF triggering (one-half to one-third of that in field spirals). One interpretation could be that the main consequence of frequent and repeated close tidal interactions on time-scales shorter than the usual dynamical friction time ($\sim$ 1 Gyr) is to strip galaxies of their gas, which is then heated to the virial temperature of the group system. The gas, which is extended and diffuse and hot enough to emit X-rays (Voges et al. 1999), does not participate in the dissipation and braking of the galaxies nor in the star formation in individual galaxies. Comparative studies of the H I content of CGs, LGs, and field galaxies will help to resolve this issue.

Acknowledgments. This work was supported by the U.S. Department of Energy under contract No. DE-AC02-76CH03000 while I was a visiting scientist at Fermilab.

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