THE DWARF LOW SURFACE BRIGHTNESS POPULATION IN DIFFERENT ENVIRONMENTS

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ABSTRACT

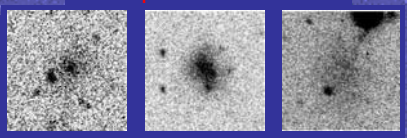
The **nature of the dwarf galaxy** population as a function of location in the cluster and **within environments of increasing density** is investigated. The sample of dwarf galaxies is obtained from **uniform data sets** and **uniform data analisys,** reaching extremely faint total magnitude (B~ -10 at the Virgo Cluster distance of 16 Mpc) and surface brightness values (μ_B~26B mag/arcsec^2). *How well do these observations fit in with our current picture of galaxy formation and evolution?* The aim of this search is to investigate how the environment affects galaxy evolution and discriminate among different physical processes (tidal interactions, morphological transformations, SN winds, pressure confinement, photoionization).

The Field

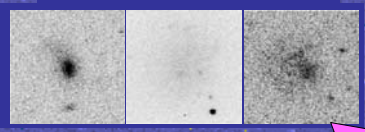
The data for the field covers 30 deg^2 from the Millennium Galaxy Survey (MGS). Even in the faint magnitude range that we explore, in the main dwarfs in the field are very different from those in the cluster: their morphology is rather irregular, their B-I colour bluer and the rate of detections in HI higher.

The number density is about 4 gal/deg^2.

Examples of field dwarfs



Examples of Uma dwarfs



The Ursa Major Cluster

The Ursa Major Cluster (Uma) is approximately at the same distance of the Virgo Cluster, however it is a lower density environment, dominated by late-type galaxies. The cluster has a lower velocity dispersion and a higher crossing time ⟶ interactions within the cluster potential and/or harassment processes should be minimal.

Our results for the search for dwarfs in UMa is consistent with observations of the general field, showing no enhancement of dwarf galaxy numbers.

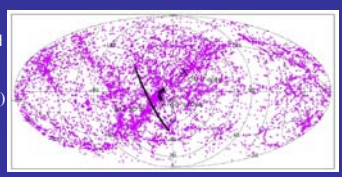
The environments and the galaxy selection

The **data is unique** in that it is observed and reduced in exactly the same way. Moreover, galaxy detection over the whole set of data is performed using the *same* automated detection algorithm and selection criteria ⟶ this enables a proper comparison of the data in different regions, minimising the impact of observational biases.

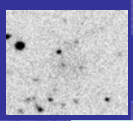
The search on our data set resulted in a catalogue of **624 dwarfs** (part of them previously unkown) searched over a total area of **~70 deg^2** of the Local Universe, down to extremly faint magnitudes (**-14≤M_B≤-10**) and surface brightness values (**23 ≤μ_{0B} ≤ 26 Bmag/arcsec^2**)

The survey covers **environments of increasing density** and it is arranged in this way:

The field - 30 deg^2
M101 – isolated Spiral – 15 deg^2
The Ursa Major Group – 1.7 deg^2
The Virgo Cluster – 25 deg^2



Example of M101 companion

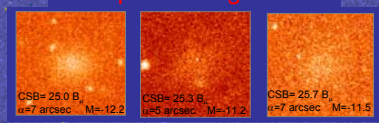


M101

M101 is a large face-on spiral of magnitude M_B~-21.5, situated at a distance of ~ 6.6 Mpc. It is part of a very low density group. The search for dwarfs was made on an area within 350 Kpc from the galaxy.

As for UMa, there is no evidence for an excess of dwarf galaxies in this region above that expected from any random piece of sky.

Examples of Virgo dwarfs



The Virgo Cluster

The Virgo cluster (VC) is a complex structure, assembling itself out of at least 5 different components. Our data consist of two perpendicular strips sampling regions with different properties (E-Ws, N-Ss).

Comparing to the EWs, the dwarfs in the NSs are on average fainter, although with the same surface brightness distribution → this supports the idea of them being part of infalling clouds.

In both strips there is a cluster dwarf population: dwarfs are not just companions of the brighter galaxies.

On the whole, the VC is dwarf rich if compared to all other environments (number density ~20 gal/deg^2).

Discussion

Observations did not confirm the predicted ΛCDM large number of dwarfs in the lower density environments, whereas in higher density environments, such as Virgo, larger numbers have been found. A comparison of the dwarf galaxy content in the different environments (by means of the dwarf-to-giant ratio, DGR) is given in the table 1.

There are two possibilities:
- ΛCDM predictions are incorrect – therefore the dwarfs observed in clusters are not the predicted primordial ones;
- ΛCDM predictions are correct, but the formation of dwarf galaxies in the lower density environments is suppressed in some way,
- compared to higher density environments.

Different mechanisms affecting galaxy evolution can be investigated to complete this picture

CREATING DWARFS:

-Galaxy harassment ⟶ our dwarfs are too small no tidal streams were found

-Tidal Interations ⟶ rate is too low for accounting the Virgo numbers.

SUPPRESSING DWARFS:

- SN winds ⟶ only for M < 10^8 solar masses and low M/L values

-Photoionization ⟶ reionization could be too early ($z_{re\text{-}ion}$ ~20) needs further investigation, see downsizing

Survey/simulation	*DGR*
MGS field	< 6
M101	1
Virgo cluster N-S strip	22
Virgo cluster E-W strip	14
LF ($\alpha = -0.6$)	0.24
LF ($\alpha = -0.8$)	1
LF ($\alpha = -1.0$)	4
LF ($\alpha = -1.2$)	18
LF ($\alpha = -1.4$)	80
LF ($\alpha = -1.6$)	367
LF ($\alpha = -1.8$)	1735
LF ($\alpha = -2.0$)	8371

Tab 1: Comparison of all the environments

CONCLUSIONS

We compared observations of a N-S strip with that of the E-W strip of the Virgo Cluster and with other environments. We find clear differences in the two regions, reflecting properties of brighter galaxies and following the composition of the cluster → although we are sampling a parameters space previously unexplored, the properties of these extremely faint galaxies still agree with the picture of the Virgo Cluster forming out of discrete units.

The population of dwarf galaxies in the Virgo Cluster is far larger than that of lower density environments (Uma, M101, the field).

Different processes affecting galaxy evolution and related to the environment have been investigated. Our interpretation is that **there should be many very LSB or totally dark galaxies in the Universe that have not yet been discovered**. **In the cluster environment many of these have been 'lit-up' by enhanced star formation due to being pulled and pushed around within the cluster**. In support of this we found that:

- The galaxies we detect in Virgo are too small to be the result of harassment
- There are too few tidal interactions in Virgo for them to be created tidally
- There is a clear lack of dwarf galaxies in the dynamically young Ursa Major cluster and in lower density environments
- If the dwarfs have high mass-to-light ratios they will not be subject to gas lose by Sn driven winds
- The dE galaxies in Virgo are bluer than the giant ellipticals (→ their SF was delayed until the cluster was formed
- Down-sizing implies low efficiency SF in the lowest mass objects (but more rapid in clusters?)

References: Roberts et al, 2007, MNRAS, in press; Sabatini et al, 2005, MNRAS, 357, 819; Davies et al, 2005, MNRAS, 356, 794; Roberts et al, 2004, MNRAS, 352, 478; Sabatini et al, 2003, MNRAS, 341, 981