

Masssive Star Formation in different environments

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The Luminosity Function of Galaxies in the Hercules Cluster (Abell 2151)

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Summary

- Luminosity Function: meaning and applications
- The cluster: Abell 2151
- Methodology
- Hercules' LF and its Schechter parameters
- Conclusions
- Future Work

The LF of cluster galaxies

- Galaxy populations in clusters differ from that of the field → strong dependence with environment → clusters of galaxies.
- The Luminosity Function (LF) is a key tool when studying statistical properties of galaxies at different wavelenghts.
- Its meaning: the relative number of galaxies of a certain magnitude that exists in a determined population. Thus it is an OBSERVABLE quantity.
- Usually it is parametrically described by a Schechter function (Schechter 1976).
- Values for Schechter's α parameter (dwarf/giant galaxies fraction) vary significantly between the different cluster and field environment.

The LF of cluster galaxies

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$$\phi(m) = \phi^* \times \left[1\, 0^{0.4(m^* - m)} \right]^{\alpha+1} e^{-1\, 0^{0.4(m^* - m)}}$$

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Abell 2151

- A2151 (z~0.036), together with A2147 and A2152, form the Hercules Supercluster, this being one of the most massive structures in the nearby Universe (Freudling 1995). It is the richest (richness class III) and densest cluster within the supercluster.
- There are strong evidences of environmental effects in galaxies evolution in the Supercluster (X-rays luminosities (Huang & Sarazin 1996), HI content (Giovanelli et al. 1981)).

Cluster Properties

$\sigma_v \sim 705$ km s^{-1} (~0.7)

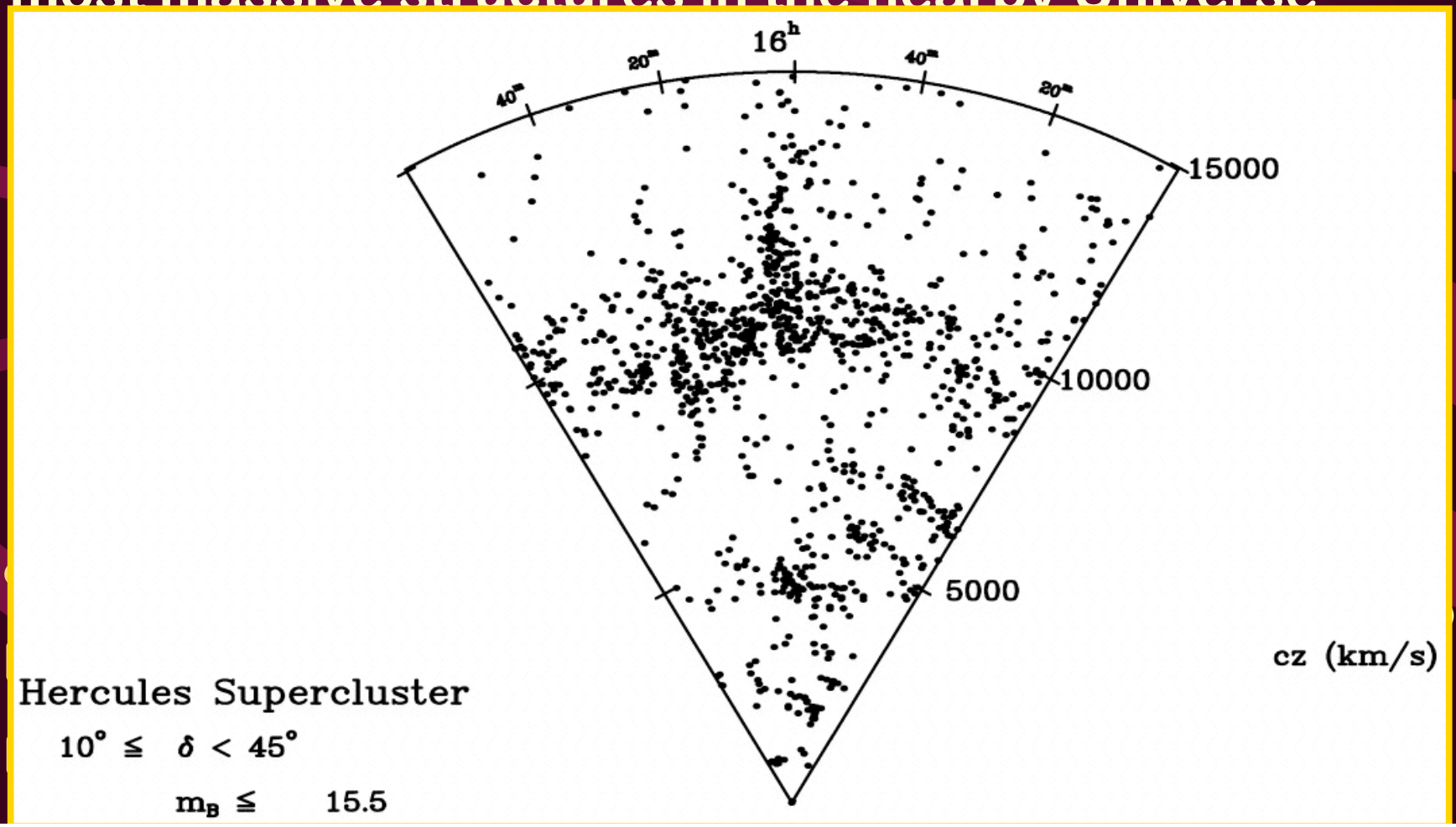
$M \sim 8 \times 10^{14}\ h^{-1} M_{\odot}$ (~0.57)

$L_X \sim 1 \times 10^{44}$ erg s^{-1} (0.17)

The X-rays data suggest that A2151 may not be relaxed (Bird et al. 1993). This is also supported by the normal HI content of its galaxies.

Abell 2151

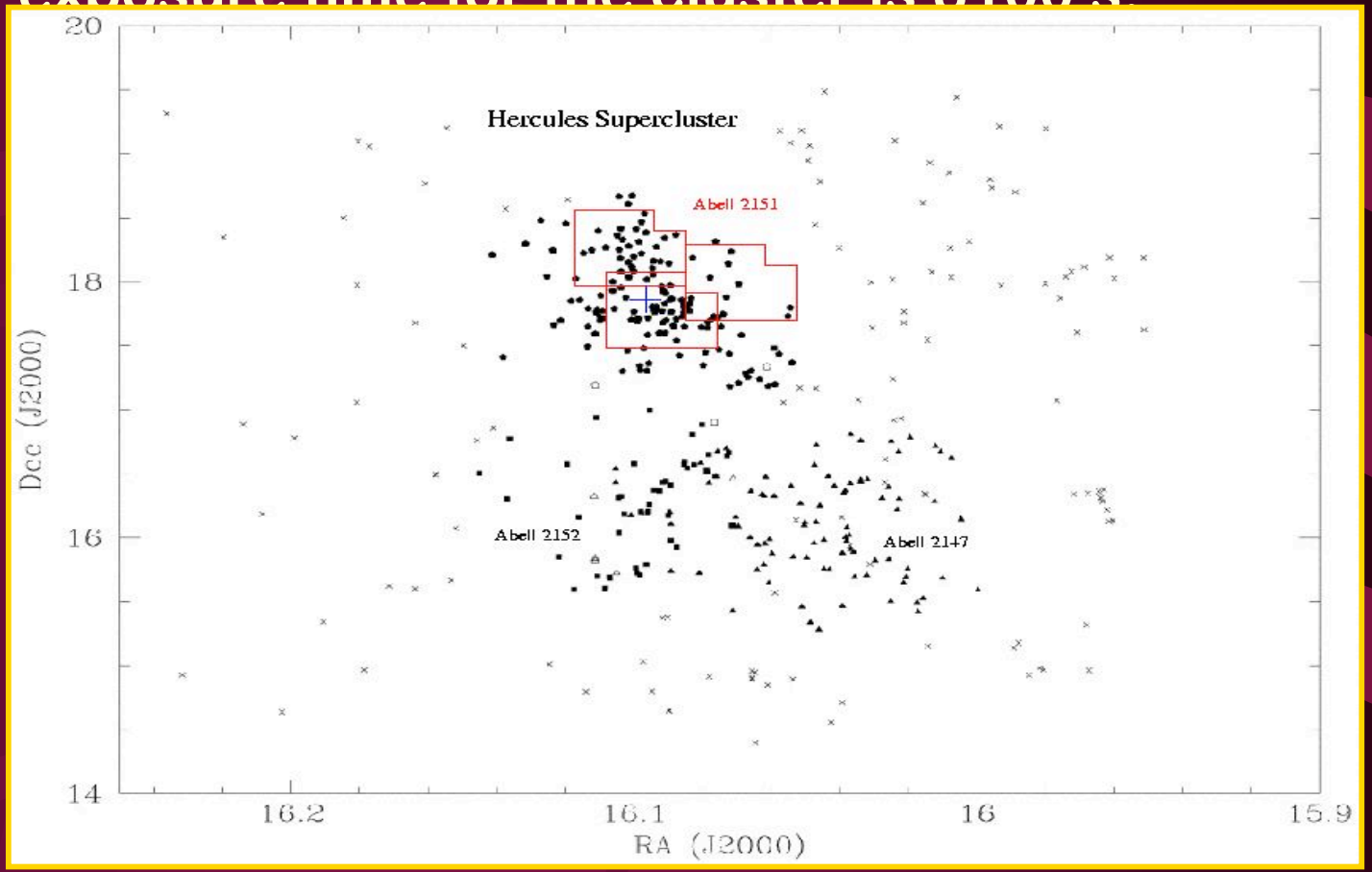
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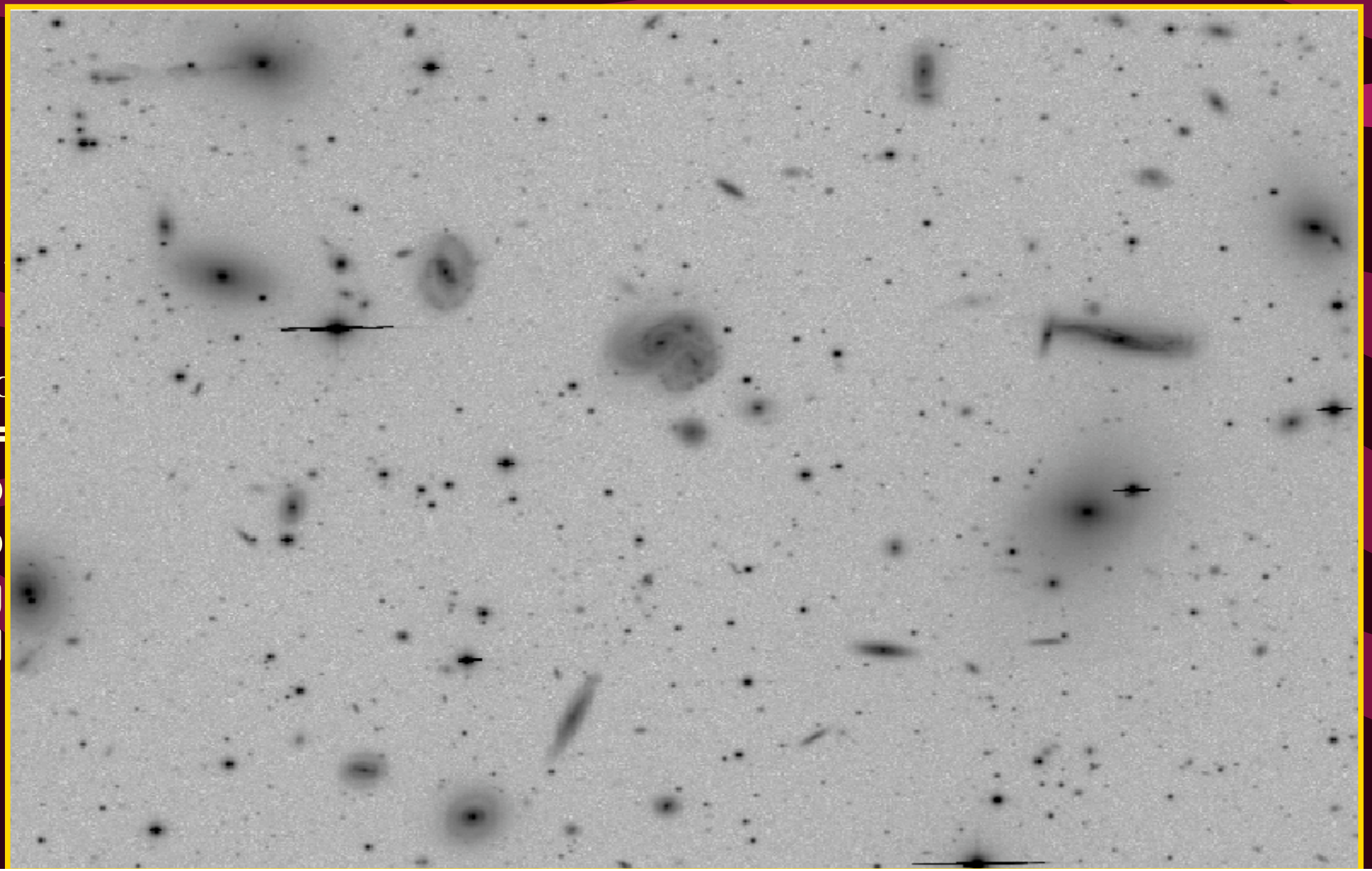
- We have imaged 3 different fields in the surroundings of A2151's CM. The optical (V-Harris) images were taken with the WFC mounted on the prime focus of the INT on night service mode. The total exposure time for the cluster is 8100 s.

- The standard field SA107 (α=15^{h}39^{m}14^s, δ=-00^{o}13'01") will be used for background galaxy counts decontamination.



Abell 2151

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d



Methodology

- Obtention of galaxy counts (number deg^{-2} mag^{-1}) in the cluster direction.
- Source extraction using SExtractor (Bertin & Arnouts 1996). Optimal settings:

  - Minimum area of 36 pixels (~ FWHM of the seeing disc)
  - 2σ detection threshold
  - DEBLEND_MINCONT = 10^{-4}
  - Background weighted

Methodology

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Still have to decontaminate from



Stars



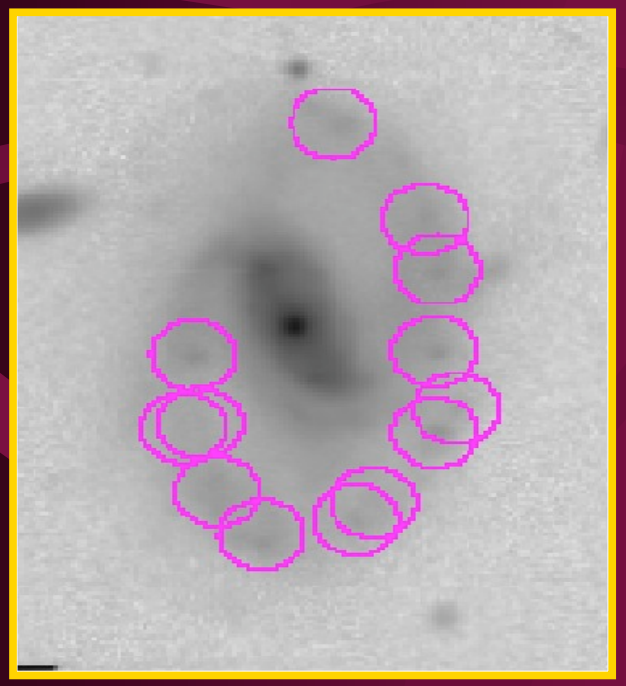
S/G classifier

(0 ≡ galaxy; 1 ≡ star)

Methodology

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Still have to decontaminate from



Few spurious detections, HII regions

Visual inspection (IMEXAM task)

Simulations

WHY?

1. Estimation of the code´s detection limit and limiting magnitude.
2. Reliable S/G classification.

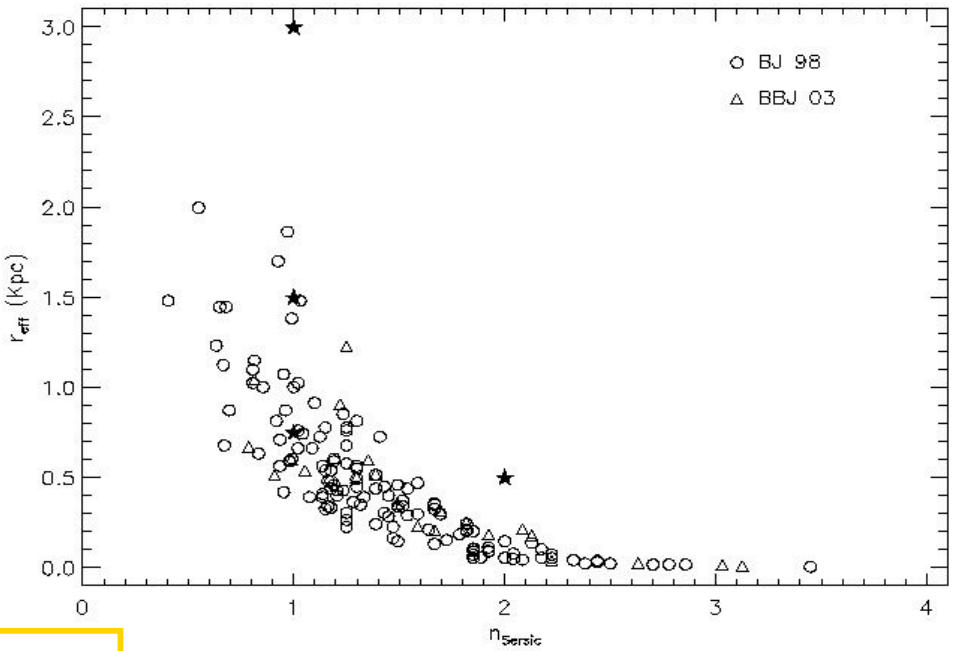
- We need to generate artificial images of faint cluster galaxies (MKOBJECTS).

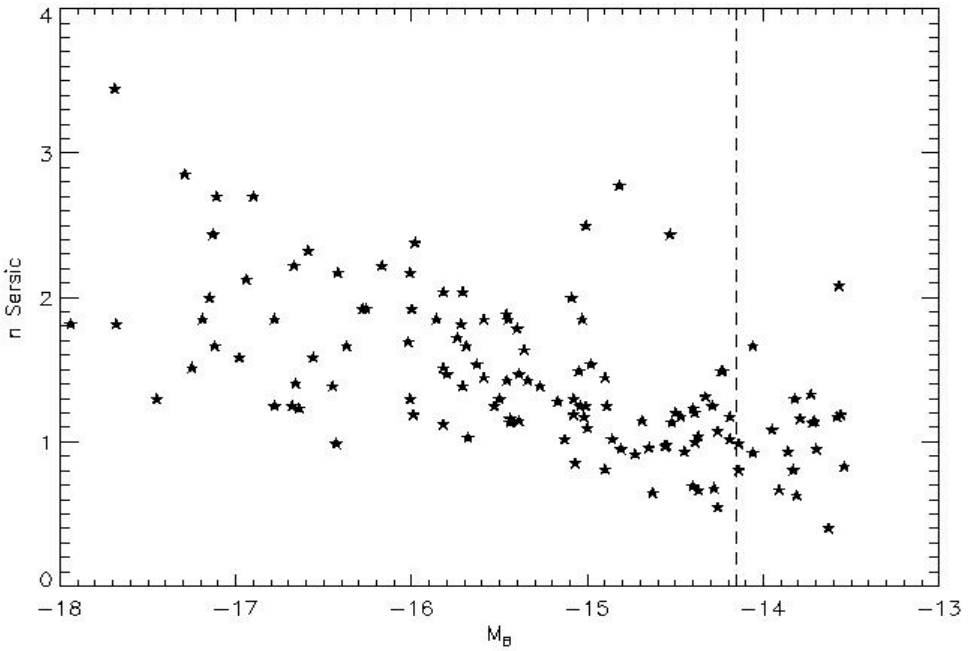
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dE and dSph data from Binggeli & Jerjen (1998) and Barazza, Binggeli & Jerjen (2003)

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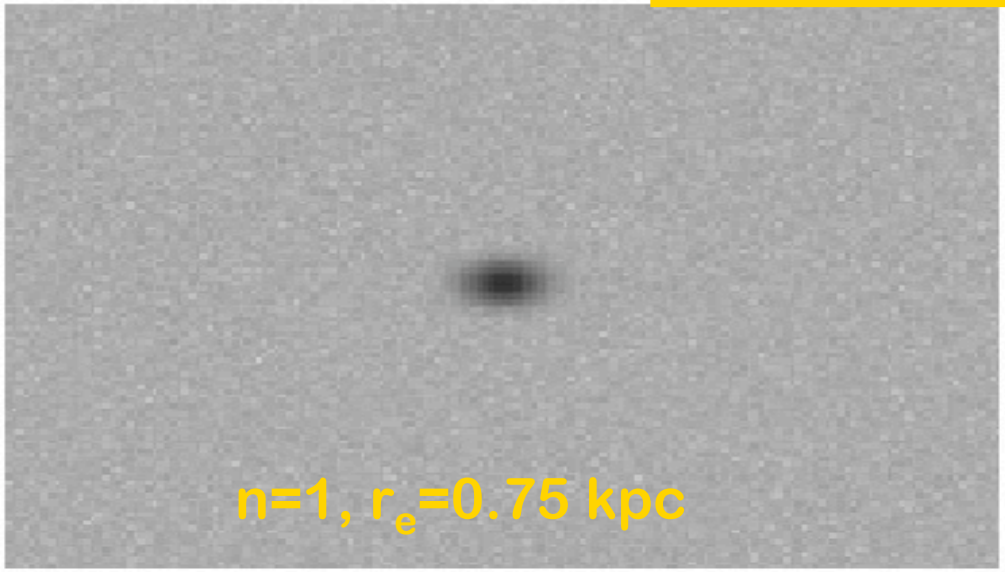
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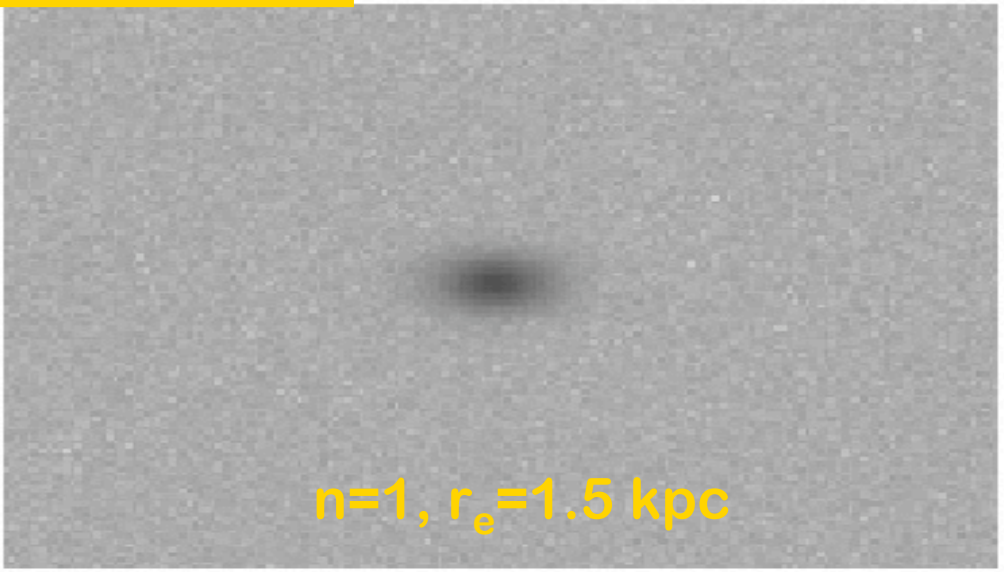
Simulations of isolated galaxies for each morphological type

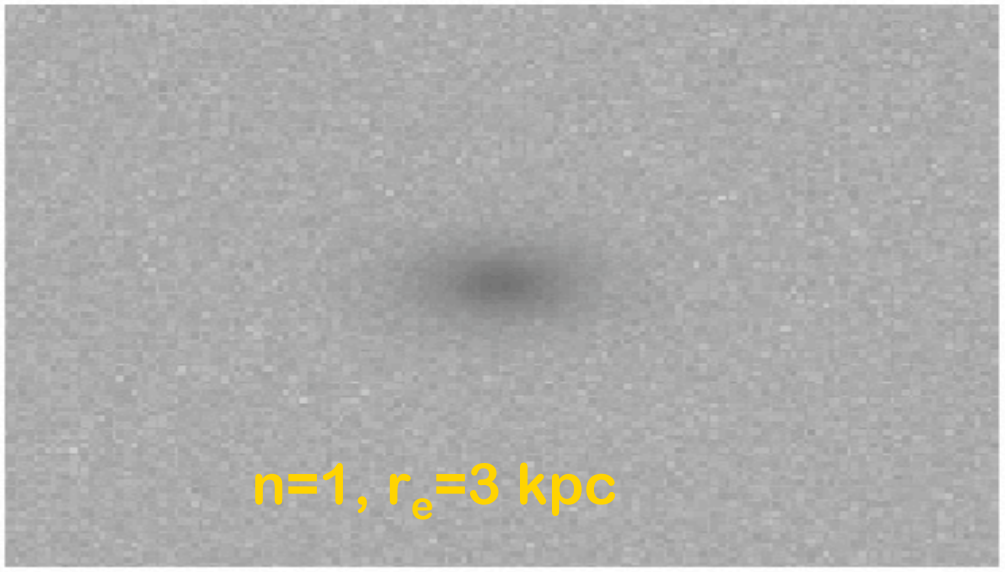
- 17-23 magnitude range (0.25 mag step)
- 3 different ellipticities (ε=0.3,0.6,0.9)

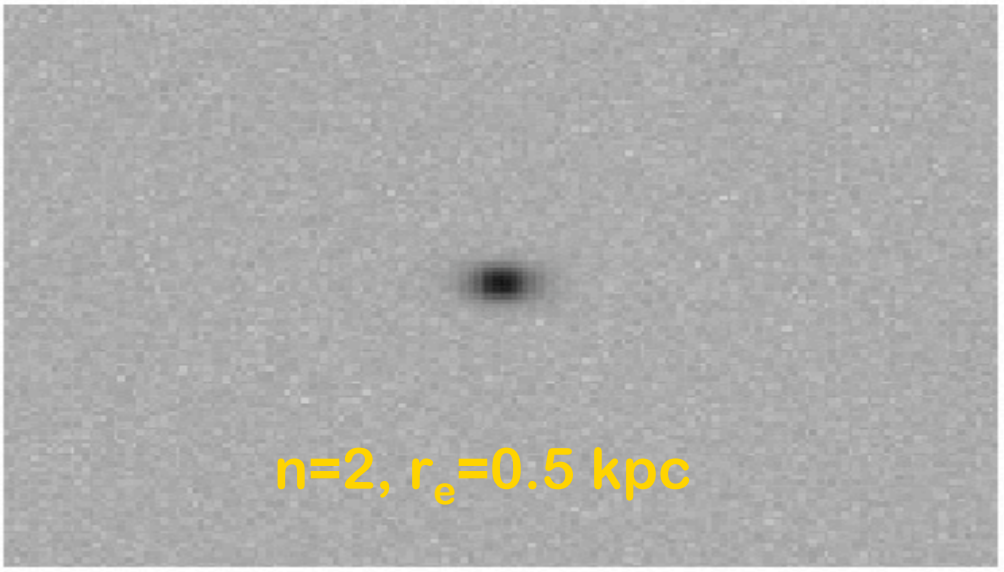
Simulations

V=21 and b/a=0.6



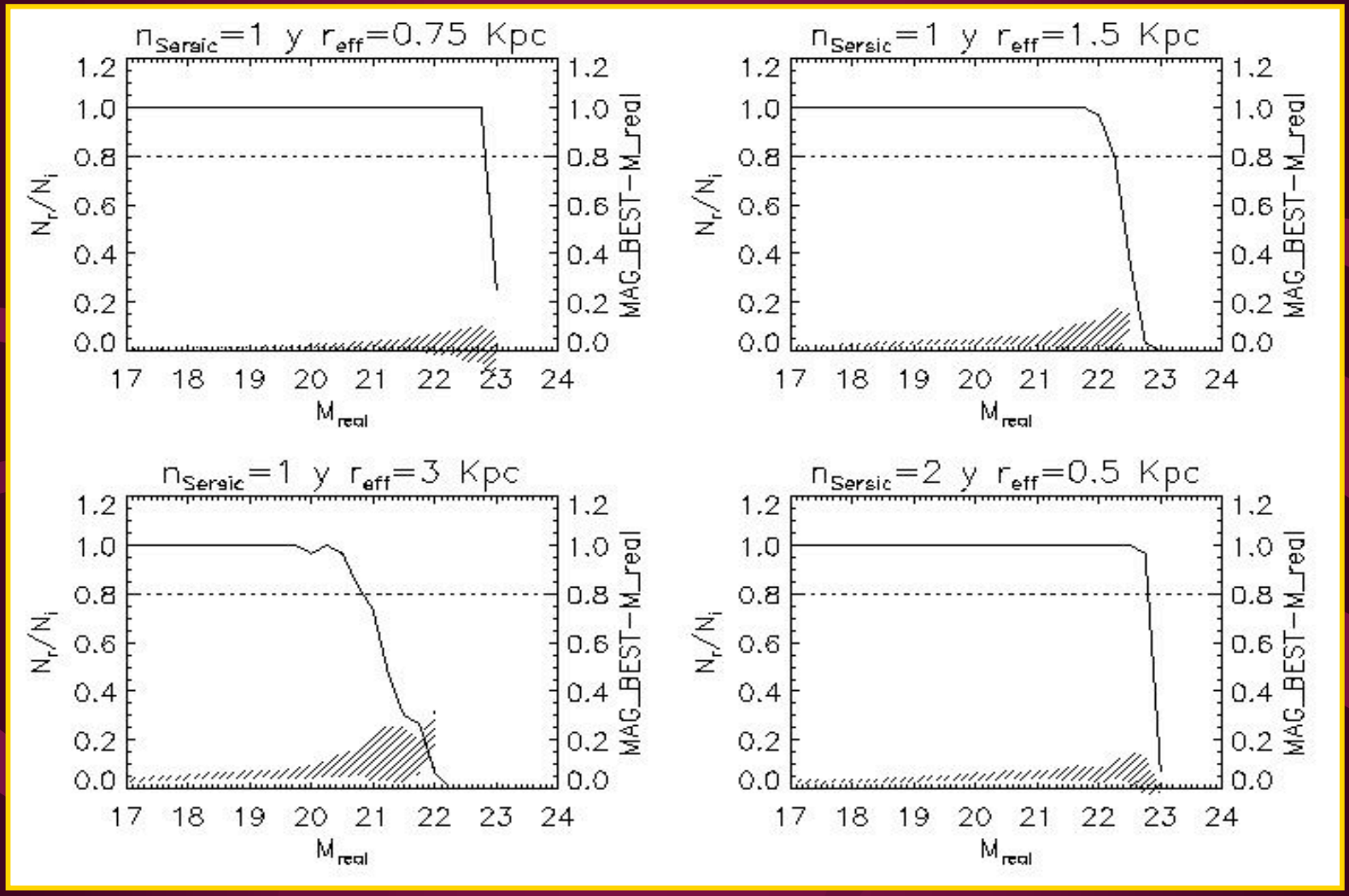






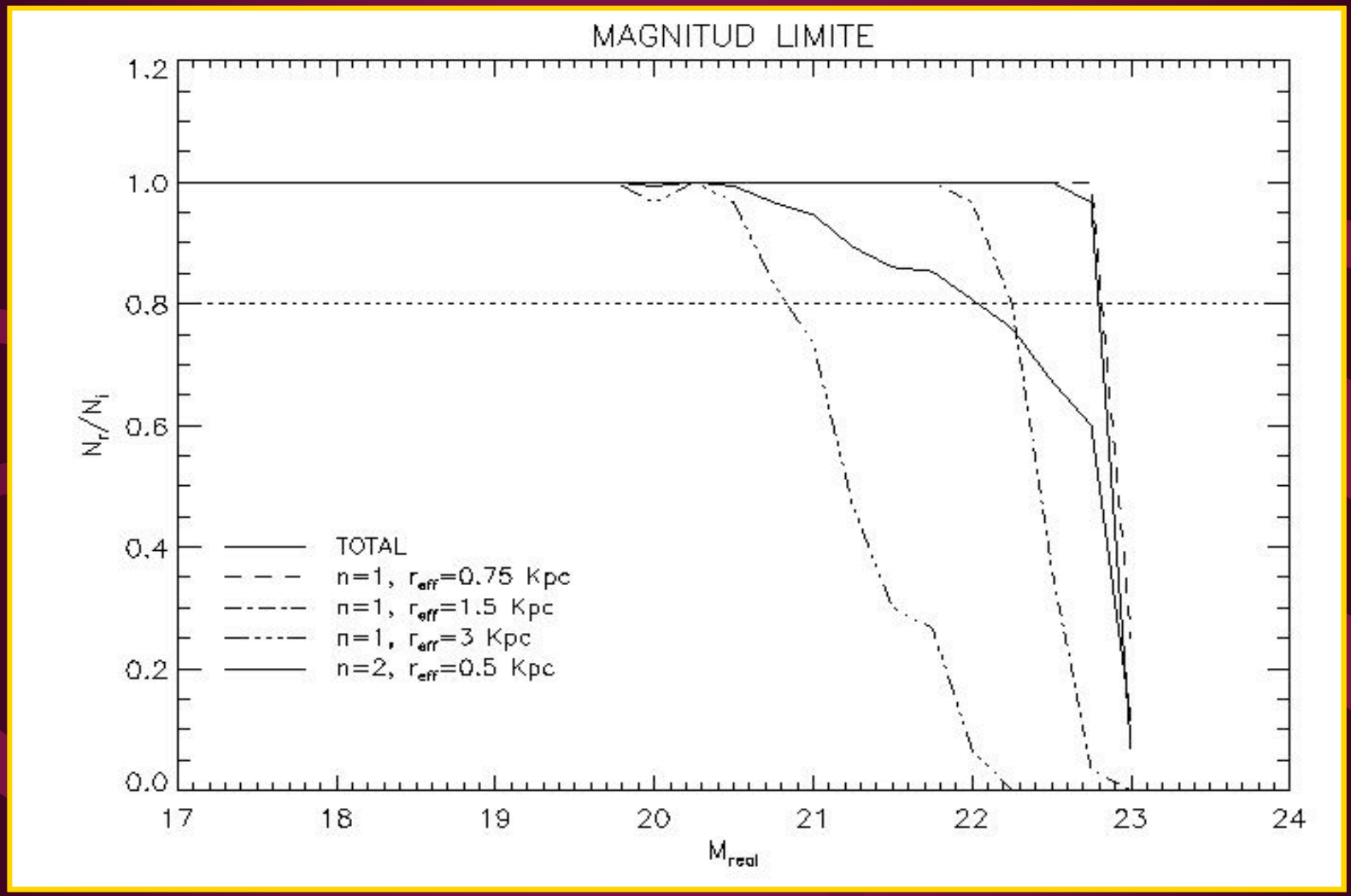
Simulations

Results



Simulations

Results

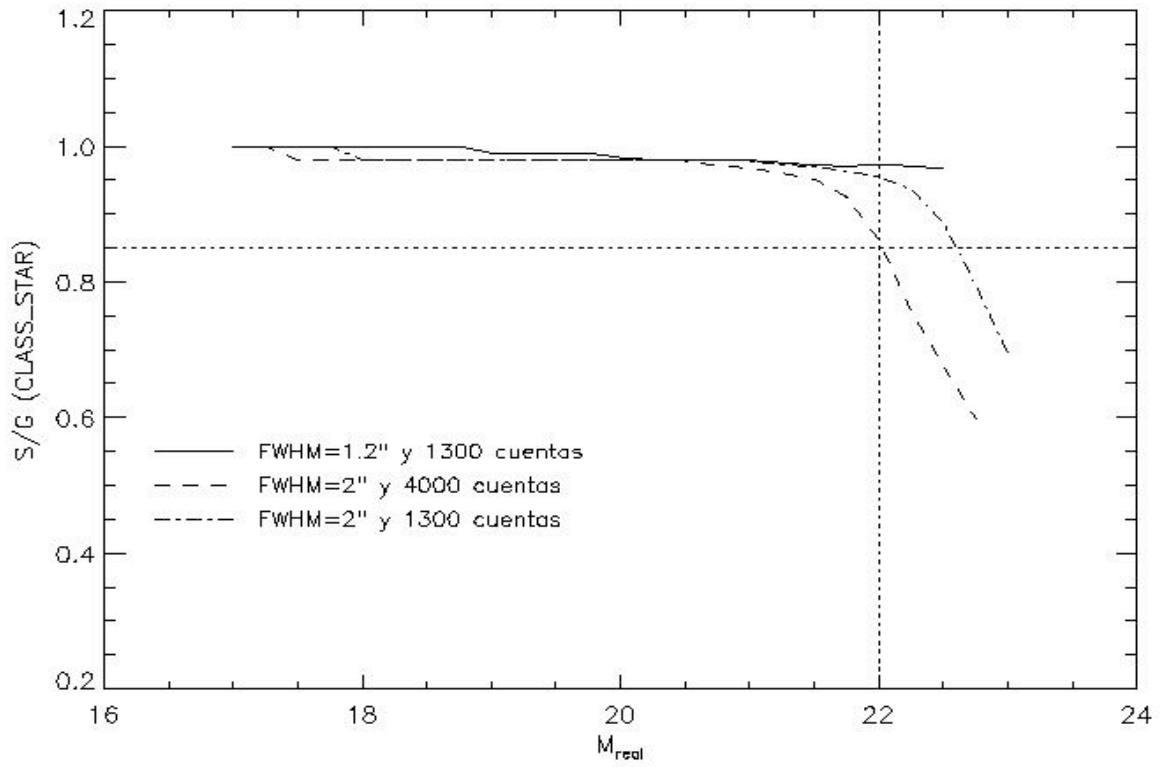


Simulations

Results

STARS

- Gaussian isolated stars recovered using the same conditions as in the real frames.



Stars below our limiting magnitude recovered with **S/G > 0.85**

Photometric precision better than 0.1 mags in the whole range

The LF of galaxies in A2151

Cluster galaxies have the advantage of all cluster members being at essentially the same distance→ apparent magnitudes m , after appropiate binning, provide ϕ(m).

One problem arises→ how to identify real cluster members?

Usage of colours, surface brightness and/or morphologies (Sabatini et al. 2003, Conselice et al. 2002, Secker et al. 1997).

Spectroscopic data (Mobasher et al. 2003).

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One pro al cluster
memb

Morphologies and velocities are usually poor, restricted to brightest galaxies (but see again Mobasher et al. 2003)

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→ Final result depends critically on the background counts used for the substraction.

→ Ignorance of which are cluster members. We only obtain the number, not the identities.

The LF of galaxies in A2151

Four main error sources are introduced when constructing the LFs:

- Poisson noise → that of discrete distributions
- Cosmic variance → takes into account that background counts fluctuate more than $n^{1/2}$ from region to region (Huang et al. 1997). So we do not assume that the background in the cluster l.o.s. is exactly that of the control field.
- Photometric Zero Point error → those of photometric calibration.
- Magnitud error → given by SExtractor. It is very small in comparison with the others, so we ignore it.

The LF of galaxies in A2151

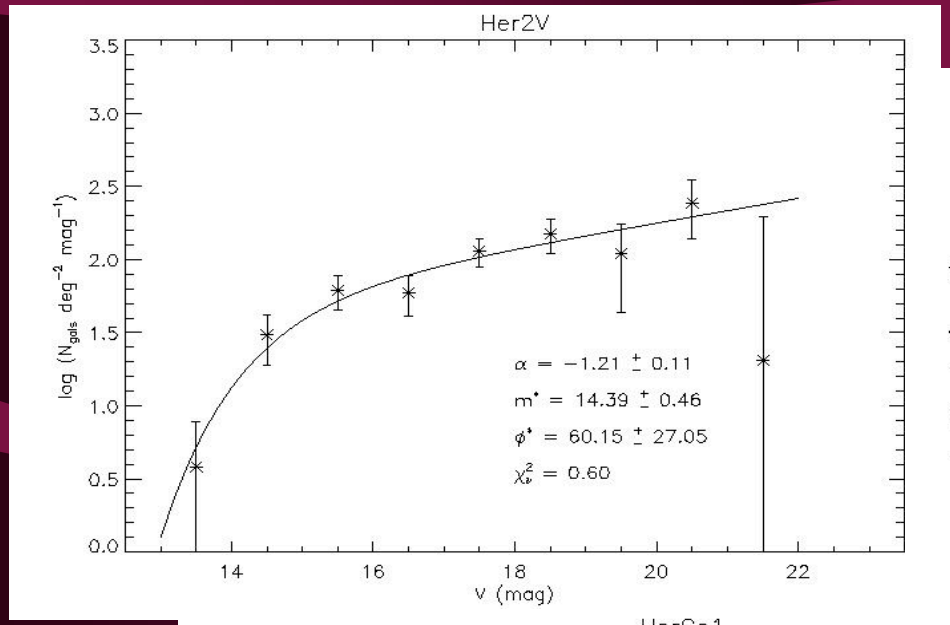
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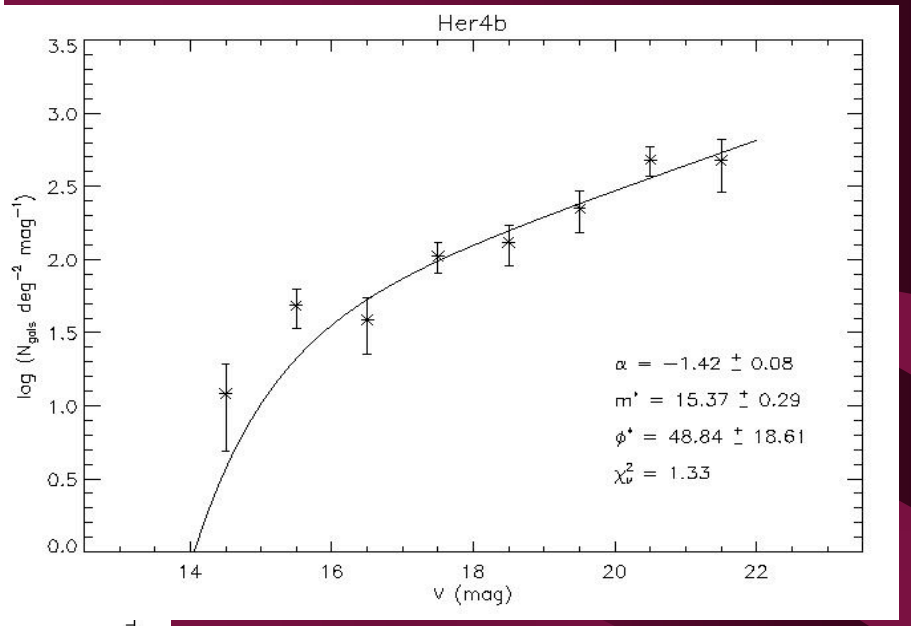
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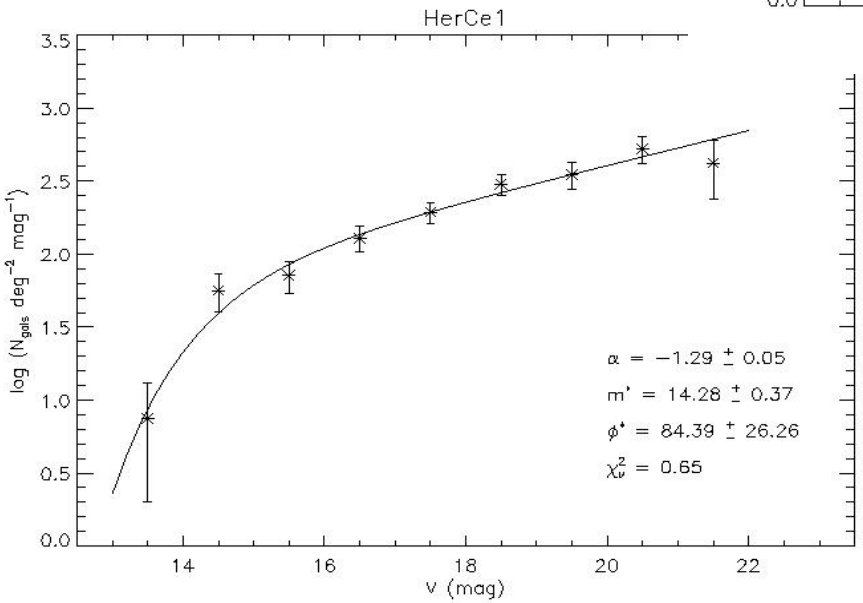
For simplicity we assume that all these sources of different nature can be added in quadrature.

The LF of galaxies in A2151

Schechter parameters







α = -1.29

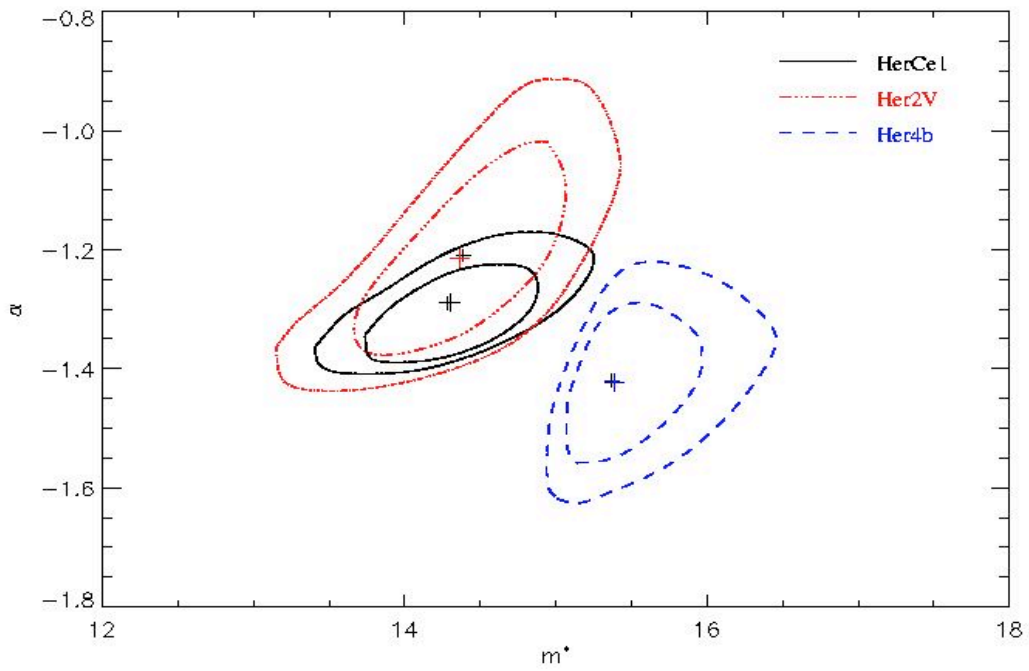
α = -1.21

α = -1.42

The LF of galaxies in A2151

Schechter parameters

	α	m^*	ϕ^*
HerCe1	-1.29	14.28	84.39
Her2V	-1.21	14.39	60.15
Her4b	-1.42	15.37	48.84



- The faint-end slope steepens as we move from high density to low density environments

- This was early observed by Lugger (1989) for 9 Abell clusters. More recently, Sabatini et al. (2003) in Virgo and Beijersbergen et al. (2002) and Iglesias-Páramo et al. (2003) for Coma, have found that α is steeper in the outskirts than in the central regions of these clusters.

The LF of galaxies in A2151

Schechter parameters

- It is found that α takes steeper values in clusters than in the field, though great dispersion exists in the literature ($-1.5<\alpha<-1.1$ for clusters and $-1.1<\alpha<-0.7$ in the field). See Table 4 of Yagi et al. (2002) for a review.

- Lugger (1986) obtained the LF for A2151 in the R-band, deriving a value of $\alpha=-1.25 \pm 0.15$, which shows consistency with ours (even though great differences exist between the two works). In Lugger (1989) she used different background counts and obtained $\alpha=-1.09 \pm 0.20$, which is significantly different from her previous value.

- This value is also compatible with that of other nearby clusters. Beijersbergen et al. (2002) found values for the LF in Coma that range between $-1.37 < \alpha < -1.16$. Iglesias-Páramo (2003) have derived a somewhat steeper slope ($\alpha=-1.47$)

Conclusions

- We have studied Abell 2151 (the Hercules cluster) in the optical (V-Harris) using the WFC on the INT.
- The automated code SExtractor has been used to extract the sources. Input settings that optimize the extraction have been used. Using these galaxy counts and by means of background counts substraction we have determined the LF of A2151 in an area of ~4 Mpc^2 near its CM.
- We have derived best fit Schechter parameters for 3 different fields across the cluster. The LF in the central region has a faint end slope of α = -1.29 $\pm$ 0.05, which is consistent with previous results (see Lugger 1986)
- Two of the LFs are consistent with each other, while the third one is significantly different (95% confidence). This result supports previous findings which correlate steeper faint-and slopes with lower density environments.
- Simulations of galaxy images have been carried out in order to test the code´s limiting magnitude, which resulted to be V~22 at the 80% completeness. However, this result is dependent on the luminosity profile of the galaxy, being the ones with larger effective radii the most difficult to detect. Reliable star/galaxy classification has been achieved using simulated star images. SExtractor assigns a value of S/G > 0.85 to every star-like object.

Future work

- We already have 4 INT nights with which we plan to survey at least the two most important clusters (the whole A2151 and A2147) in B- and r-bands.

- With this data we will be able to determine the LF of both clusters and comparisons can be made.

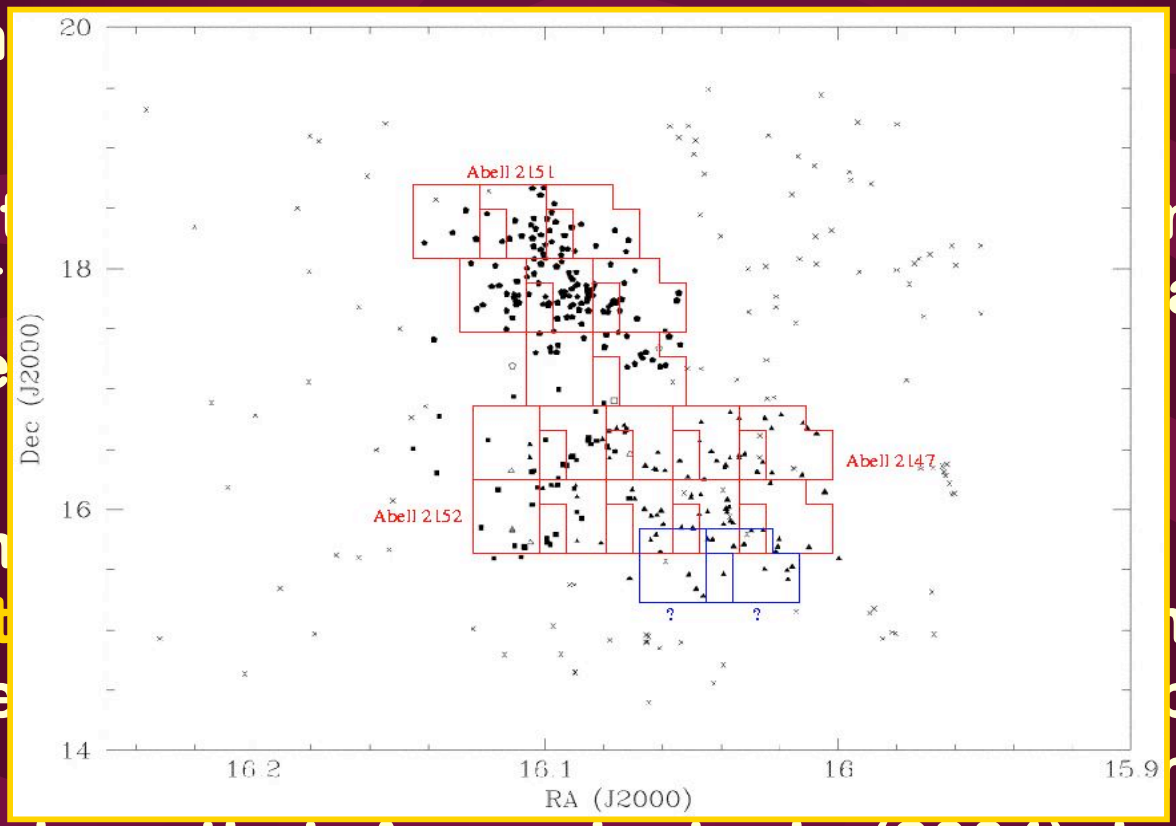
- The main goal, however, is to study quantitative morphologies of the brightest cluster members (membership is complete down to R ~ 17). We will apply the same procedure that Aguerri et al. (2004) have used in Coma.

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References

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