STELLAR POPULATIONS OF BULGES IN GALAXIES WITH A LOW SURFACE-BRIGHTNESS DISC

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Definition of Low Surface Brightness (LSB)

Galaxies with central face-on surface brightness fainter than 22.6 mag arcsec$^{-2}$ in the B band.

The number density of galaxies plotted versus central surface brightness.
INTRODUCTION

Properties of LSB

- They are common (up to 50% including dwarf) of the galaxy population (Bothun et al. 1997)
- They cover a wide range of morphological type and color, different evolutionary path
- Low gas density do not condense atomic gas in molecular gas, Low star formation, Slow evolution of the galaxy

Most of them are bulgeless, but even LSBs with a prominent bulge (Pizzella et al. 2008), photometrically similar to the bulge of HSB, exist.

The aim

- WHICH ARE THE PROCESSES OF FORMATION OF LSB
- WHICH ARE THEIR CONNECTIONS WITH HSB

Are they exotic, faint, High Surface Brightness (HSB) or are they an independent type of object?

STELLAR POPULATIONS OF BULGES HOSTED IN LSB DISC GALAXIES – CONNECTION BETWEEN LSB AND HSB?
Formation and Evolution of Bulges

**INTRODUCTION**

**Dissipative collapse**

- Presence of metallicity and $\alpha/\text{Fe}$ gradient (Kobayashi 2004).
- Presence of metallicity gradient with flat profile of $\alpha/\text{Fe}$ (Pipino et al. 2008).

**Merging events**

- Absent (or very shallow) gradients in bulges (Bekki & Shioya 1999).
- Metallicity gradient rarely enhanced by secondary events of star formation (Hopkins et al. 2009).

**Secular evolution**

- Gradients eventually present could either be amplified (change of scalelength) or erased (disc heating) (Moorthy & Holtzman 2006).
- More constraints from comparison of stellar populations of disk and bulge.

**IN THE CURRENT PARADIGM...**

- Classical Bulges
- Disk-like Bulges

Which is the relative importance of different mechanisms (is one dominant?)

Different formation mechanism leave differences in the stellar populations and in their radial profiles.

**Model predictions...**

- The project: Study of kinematics, stellar populations and their gradients in the LSB.
GALAXIES SAMPLE SELECTION

8 SPIRALS GALAXIES WITH A LSB DISK AND A BULGE

**OBSERVATION**

**THE PHOTOMETRIC AND SPECTROSCOPIC OBSERVATIONS FORS2@VLT**

- **Spectra taken along the major and minor axis**
- **Typical exposure time** $2 \times 3600s \quad S/N > 35-40$
- **Wavelength range** = 4500-5800 Å
- **Instrumental velocity dispersion** = 33 km s$^{-1}$
- **Spatial resolution** = 0.25 arcsec
- **R band images of galaxies**

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<th>Galaxy</th>
<th>Type</th>
<th>$T$</th>
<th>$D_{25} \times d_{25}$ (arcmin)</th>
<th>$B_T$ (mag)</th>
<th>$V_{CMB}$ (km s$^{-1}$)</th>
<th>$D$ (Mpc)</th>
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2D PHOTOMETRIC DECOMPOSITION

DISENTANGLE THE COMPONENTS OF GALAXY IS NECESSARY

- TO CONFIRM THE LSB NATURE OF THE DISC
- TO QUANTIFY THE DISC CONTAMINATION

2D DECOMPOSITION ADOPTING GASP2D (Mendez et al. 2008)

- R band images of galaxies from the VLT telescope
- Constructed model: Sersic bulge + exponential disk + bar (if present)

PGC 37759

$R_{bd}$ bulge and disc give the same contribution
KINEMATIC AND LINESTRENGTH

1) $V$, $\sigma$, $h3$ and $h4$ MEASURED WITH PPXF/GANDALF (Cappellari et al 2004/Sarzi et al 2006)

fit the galaxy spectra with a synthetic population models. Simultaneously we fit all the emission lines in the wavelength range.
1) V, σ h3 and h4 MEASURED WITH PPXF/GANDALF (Cappellari et al 2004/Sarzi et al 2006)

2) LINE STRENGTH OF LICK INDICES (Hβ, Fe5015, Mg1, Mg2, Mgb, Fe5270, Fe, 5335).

ANALYSIS OF THE STELLAR POPULATIONS
IN HIGHT SURFACE BRIGHTNESS GALAXIES (ellipticals and disk galaxies)

STRUCTURAL PROPERTIES $\sigma$ CORRELATE CHEMICAL PROPERTIES Mg$_2$, H$_\beta$, Fe

IN BULGE HOSTED IN LSB DISC?

Very similar relations for $\langle$Fe$\rangle$, Mg$_2$, H$_\beta$
NUCLEAR REGION: Age, Metallicity and $\alpha$/Fe

$\textit{H}\beta$, Mgb Fe5270 and Fe 5335 were converted to age, metallicity and $\alpha$/Fe adopting the models grids from Thomas et al 2003.

More massive are more metal-rich and characterized by a fast star formation.
NUCLEAR REGION: Age, Metallicity and $\alpha$/Fe

**LSB - HSB galaxies comparison**

Morelli et al. 2008

**Young stellar populations**

**Large range metallicity**

**Solar $\alpha$/Fe**
The gradients were set as the difference between the values at centre and at $r_{bd}$.

- **No clear gradients** found in age, metallicity, and $\alpha$/Fe.
- **All the gradient distribution** are similar to the **HSB**.
CONCLUSIONS

HSB/LSB BULGE COMPARISON

- Bulges hosted by LSB galaxies share many structural and chemical properties with the bulges of HSB galaxies. Such a similarity suggests that they possibly had common formation scenarios and evolution histories.
- Suggest NO relevant interplay between the bulge and disc components. (absence correlations stellar populations and morphological type)
  
  STELLAR POPULATIONS OF THE DISC IS NEEDED TO COMPLETE THE PICTURE!

FORMATIONS MECHANISM

- The bulges in LSB discs are characterized by a very young stellar population, a large range of metallicity values and a solar $\alpha$/Fe.
- Most of the sample bulges show no gradient in age and [$\alpha$/Fe] radial profiles.
- Most of the sample galaxies show no gradient in metallicity.

  No pure dissipative collapse. Mergers or acquisition events needed.