Outer “normal” haloes in integrated light

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An un-talk, un-review, un-summary talk about issues and prospects of deep imaging
Revisiting Stephan’s Quintet with deep optical images

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Stephan's Quintet: a compact group of 5 galaxies

At 85 Mpc
NGC 7331

NGC 7320

At 13.5 Mpc
A distance of 13 Mpc resolves the claimed anomalies of the galaxy lacking dark matter

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Issue 1: measuring distances for LSB objects is tricky!
Many LSB structures, including UDGs, known in the 50-70s with photographic plates, and now rediscovered
Issue 2: do we discover anything new with new deep imaging surveys?
A great time for LSB science!
• LSB exploration not recent, but new instruments, observing strategies, data processing techniques
• Dealing with modern CCD arrays and complex optical cameras: an optimized observing strategy and data reduction to remove instrumental artefacts
Issue 3: the limiting surface brightness
Which image is the **deepest**?
Difficult comparison of the surface brightness limit due to a lack of a common definition

- **Integrated** light profile
- **Local**: 3 sigma, 10″x10″
- Percentage of the **sky background**, 0.3%

*van Dokkum et al., 2014*
Surface brightness limit required to compare observations with mock simulations
Determining the surface brightness limit is tricky but required to compare observations and simulations.
A diversity of halo brightness around LTGs?

or of methods for measuring it?

Harmsen et al., 2017

Merritt et al., 2016
Issue 4: dealing with foreground emission
NGC 7331: a tidal stream from a disrupted satellite?
Cirrus contamination in the field of NGC 7331

- The good match between diffuse LSB optical features and MIR emission reveals the presence of cirrus from nearby dust clouds in the Solar vicinity
- Cirrus present at any Galactic latitude: they are hard to avoid
Study the structure of the ISM at unprecedented high spatial resolution with the scattered optical emission of nearby Galactic cirrus

Do not avoid regions with Cirrus emission! Just collaborate with ISM people!
Issue 5: dealing with instrumental artefacts
The halo of NGC 7331
The halo of NGC 7331
The halo of NGC 7331
Image deconvolution required to get proper outer light and color profiles
Issue 6:
How many galaxies are needed to check cosmological predictions?

Hundreds?
Which telescope is the most efficient?

- **Dragonfly**: 32, g, int (35 hours)
  - van Dokkum et al., 2014

- **Gossau (CH)**: 28.9, r, loc (24 hours)
  - Javanmardi et al., 2016

- **Teide, 0.8m**: 28.7, r, loc (13 hours)
  - © Trujillo

- **CFHT**: 27.8, r, loc (131 sec, 1 hour)
  - CFIS collaboration

- **C28**: 30, L, loc (30 hours)
  - © HERON

- **HST+Burrell**: 30.9, V, loc (11 hours)
  - Mihos et al., 2018, In Sung Jang
Initially: a volume-limited sample of 260 massive ETGs with $D < 42$ Mpc (Altas$^{3D}$).

**Bonus:** 100 spiral galaxies in the ETG fields

hundreds of LSB dwarfs and UDGs

Thousands of GC candidates thanks to exclusive IQ

- Observed with the large field of view camera MegaCam (multiband:u,g,r,i) on the CFHT, as part of two large programs NGVS for Virgo, and MATLAS for field/groups.
Initially: a volume-limited sample of 260 massive ETGs with $D < 42$ Mpc (Altas$^{3D}$).

**Bonus:** 100 spiral galaxies in hundreds of LSB dwarfs.

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Statistics on morphological class based on fine structures
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- Above $10^{11} \, M_\odot$, the fraction of galaxies with evidence of minor and major merger is multiplied by 3.

- The scatter plot shows a relationship between mass and size, with points categorized by their morphological class.

- The pie chart illustrates the distribution of morphological classes, with labels indicating different ranges of mass.
Statistics on morphological class based on fine structures
Issue 6: How many galaxies are needed to check cosmological predictions? Thousands?
Which survey is the cheapest?
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Those that are already planned but were not initially aimed at doing LSB science
In the survey field of view: about 1900 galaxies with angular diameter above 1.0 arcmin, among those about 450 with D<40 Mpc.

**From the ground**

**CFIS @ CFHT:** 5000 square degrees observed in r-band in LSB compliant mode and improved PSF, thanks to filter change.

In the survey field of view: about 1900 galaxies with angular diameter above 1.0 arcmin, among those about 450 with D<40 Mpc.
• From **Space**

- 15 000 square degree
- Observing strategy is LSB compliant (background subtraction)
- The large optical band (VIS) is great for LSB science
- A pristine PSF and enhanced baffling
- The high image quality is great for star-galaxy separation and thus for LG galaxy archeology with star counts
- But signal might be erased by the pipeline!
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WE NEED YOU
What about the Stephan’s Quintet?
The bridge proving the role of the 5th galaxy, NGC 7320c, confirmed

An extended halo around NGC-7317, a galaxy so far totally ignored, though it might be the oldest in the group!

Duc et al., 2018
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Renaud et al., 2010
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Thanks