



ATLAS

Probing the mass assembly of massive galaxies with ultra-deep imagin

CFHT User's meeting, 2013, Campbell River

Pierre-Alain Duc



Sanjaya Paudel, Etienne Ferriere, Leo Michel-Dansac, Jean-Charles Cuillandre, Michele Cappellari, Richard McDermid, Eric Emsellem, Davor Krajnovic, Frédéric Bournaud, Laura Ferrarese, Patrick Durrell, Eric Peng and the NGVS, Atlas3D and MATLAS teams

Probing the mass assembly of massive galaxies



Probing the mass assembly of massive galaxies



Three processes to produce an Early-Type like galaxy



Three processes to produce an Early-Type like galaxy



producing various types of very low-surface brightness fine structures: tails, plumes, streams, shells

• Simulated surface brightness maps





Michel-Dansac et al, 2013

• Observed surface brightness maps: from star counts (Pandas), for spirals/dwarfs galaxies in the Local Group • Observed surface brightness maps from diffuse light, allowing us to access other other types of galaxies, in particular the most massive ones

Extreme deep imaging with MegaCam on the CFHT





Extreme deep imaging with MegaCam on the CFHT



• Observed with the large field of view camera MegaCam, as part of NGVS for the Virgo ETGs, and MATLAS for the other ones

• With specific observing strategy (large offsets, sky subtraction) and data reduction technique to optimize the detection of low surface brightness features





MATLAS team

Katey Alatalo, Berkeley, USA; Leo Blitz, Berkeley, USA; Maxime Bois, Obs de Paris, France; Frederic Bournaud, CEA, France; Martin Bureau, Univ of Oxford, UK; Michele Cappellari, Univ of Oxford, UK; Patrick Cote, NRC Herzberg Institute of Astrophysics, Canada; Alison Crocker, UMass, USA; Jean-Charles Cuillandre, CFHT; Roger L. Davies, Univ of Oxford, UK; Timothy A. Davis, Univ of Oxford, UK; Tim de Zeeuw, ESO, Germany; Leiden Univ, NL; Pierre-Alain Duc, AIM, Saclay, France; Patrick Durrell, Youngstown State Univ, USA; Eric Emsellem, Obs de Lyon, France + ESO; Laura Ferrarese, NRC Herzberg Institute of Astrophysics, Canada; Etienne Ferriere, AIM, Saclay, France; Stephen Gwyn, NRC Herzberg Institute of Astrophysics, Canada; Sadegh Khochfar, MPE, Germany; Davor Krajnović, ESO, Germany; Harald Kuntschner, ESO, Germany; Pierre-Yves Lablanche, Obs de Lyon, France; Ariane Lancon, Obs de Strasbourg, France; Richard M. McDermid, Gemini Obs, Hilo, USA; Simona Mei, Obs de Paris, GEPI, France; Leo Michel-Dansac, Obs. de Lyon, France; Raffaella Morganti, ASTRON, NL; Roberto Munoz, Universidad Catolica de Chile, UMI-CFA, Chile/France; Thorsten Naab, MPA, Germany; Tom Oosterloo, ASTRON, NL; Sanjaya Paudel, AIM, Saclay, Eric Peng, Peking Univ, China; Thomas Puzia, Universidad Catolica de Chile, UMI-CFA, Chile/France; Marc Sarzi, Univ of Hertfordshire, UK; Nicholas Scott, Swinburne Univ, Australia; Paolo Serra, ASTRON, NL; James Taylor, Univ of Waterloo, Canada; Anne-Marie Weijmans, Dunlap Inst., Univ of Toronto, Canada; Lisa M. Young, New Mexico Tech, USA

Status of MegaCam observations



•60 percent of Atlas3D galaxies with at least deep g-band observations
•50 percent of Atlas3D galaxies with at least one color available

Requested time as part of MATLAS



To complete NGVS shallow images (to be observed in 2013A)

Changing the way we see Early-Type Galaxies



Changing the way we see Early-Type Galaxies



Changing the way we see Early-Type Galaxies



Probing the mass assembly of galaxies with ultra deep imaging : the MATLAS LP

Campbell River, May 2013





Probing the mass assembly of galaxies with ultra deep imaging : the MATLAS LP

Campbell River, May 2013



Probing the mass assembly of galaxies with ultra deep imaging : the MATLAS LP

Campbell River, May 2013

Disclosing Early-Type Galaxies with star-forming rings







Disclosing Early-Type Galaxies with star-forming rings



Disclosing Early-Type Galaxies with star-forming rings





Disclosing Early-Type Galaxies with spiral structures



Disclosing Early-Type Galaxies with spiral structures



Disclosing Early-Type Galaxies with spiral structures



Disclosing minor mergers



Disclosing minor mergers



Disclosing minor mergers



→ On line feeding of the stellar halo









Even ETGs may be look pretty



Even ETGs may be look pretty


Disclosing on-going tidal interactions



Disclosing on-going tidal interactions

Disclosing on-going tidal interactions

Disclosing advanced major mergers

Disclosing advanced major mergers

Disclosing advanced major mergers

Disclosing minor + major mergers

Disclosing minor + major mergers

Probing the mass assembly of galaxies with ultra deep imaging : the MATLAS LP

Disclosing minor + major mergers

Probing the mass assembly of galaxies with ultra deep imaging : the MATLAS LP

Duc et al., 2011, Paudel et al., 2013

Duc et al., 2011, Paudel et al., 2013

Fully relaxed, unperturbed, boring ETGs, even at MegaCam depth

• Not all massive ETGs/ spirals show tidal features (contrary to simulations?)

Assembled earlier? In different environments? By different processes?

• Need for a statistical analysis over a large number of galaxies

• Aim of the NGVS (in Virgo) and MATLAS projects

MATLAS challenges

Probing the mass assembly of galaxies with ultra deep imaging : the MATLAS LP

Campbell River, May 2013

MATLAS challenges: dealing with galactic cirrus

Who is interested with arcsec resolution observations of the Galactic ISM?

No obvious differences in colors with stellar tails Identified through complementary observations (FIR/ Hershel, UV/ Galex)

The stellar halos of galaxies may be hidden behind the large, complex reflection halos of stars.

But the contamination may be more subtle.

External stellar populations in ETGs probed by deep imaging

• The blueing of the outer color profile consistent with cosmological simulations predicting a mass growing of ETGs thanks to multiple mergers by low-mass, low-metallicity satellites

Stellar populations in the outermost regions of galaxies

DEEP SURFACE BRIGHTNESS PROFILES OF SPIRAL GALAXIES FROM SDSS STRIPE82: TOUCHING STELLAR HALOS

JUDIT BAKOS & IGNACIO TRUJILLO

Instituto de Astrofísica de Canarias, C/ Vía Lactea S/N, La Laguna, Tenerife, Spain and Departamento de Astrofísica, Universidad de La Laguna, E-38205, La Laguna, Tenerife, Spain Draft version April 16, 2012

ABSTRACT

Using SDSS Stripe82 data we have obtained deep radial surface brightness profiles of 7 face-on to intermediate inclined late-type spirals down to $\mu_{r'} \sim 30$ mag arcsec⁻². We do not find any evidence for a sharp cut-off of the light distribution of the disks but a smooth continuation into the stellar halos of galaxies. Stellar halos start to affect the surface brightness profiles of the galaxies at $\mu_{r'} \sim 28$ mag arcsec⁻², and at a radial distance of $\gtrsim 4 - 10$ inner scale-lengths. We find that the light contribution from the stellar halo could be responsible of previous classification of surface brightness profiles as Type III in late-type galaxies. In order to estimate the contribution of the stellar halo light to the total galaxy light, we carried out a Bulge/Disk/Stellar Halo decomposition by simoultaneously fitting all components. The light contribution of the halo to the total galaxy light varies from ~ 1% to ~ 5%, but in case of ongoing mergers, the halo light fraction can be as high as ~ 10%, independently of the luminosities of the galaxies. We have also explored the integrated (g' - r') color of the stellar halo of our galaxies. We find (g' - r') colors ranging from ~ 0.4 to ~ 1.2. By confronting these colors with model predictions, we encounter problems to fit our very red colors onto stellar population grids with conventional IMFs. Very red halo colors can be attributed to stellar populations dominated by very low mass stars of low to intermediate metallicity produced by bottom-heavy IMFs.

Stellar populations in the outermost regions of galaxies

Halos of bright stars

Halos of galactic nuclei

Redenning of the color profiles in the outskirts of galaxies likely due to the reflection galos of the galaxy nucleus...

Number of tidal tails

Statistics (fine structure index) made by eye

Probing the mass assembly of galaxies with ultra deep imaging : the MATLAS LP

Campbell River, May 2013

Other science goals: Death, evolution and birth of satellite dwarf galaxies

Other science goals: Death, evolution and birth of satellite dwarf galaxies



Other science goals: Death, evolution and birth of satellite dwarf galaxies





• 3 HI-rich, metal-rich dwarf galaxies along the filamentary structure: Tidal Dwarf Galaxies

Probing the mass assembly of galaxies with ultra deep imaging : the MATLAS LP

Other science goals: Globular Clusters as probe of the large scale environment



Filters chosen to optimize the detection of GCs around the field of ETGs of MATLAS

ng : the MATLAS LP Campbell Riv

192

190

188

7.5

Campbell River, May 2013

186

182

Probing the mass assembly of galaxies with ultra deep imaging : the MATLAS LP



Other science goals: Origin of the free floating HI clouds around galaxies



Accretion or **ejection**?

Disclosing the collisional origin of the giant HI ring in Leo

> The sensitivity of the survey allows to detect stellar counterparts to HI structures, telling about their origin

Michel-Dansac et al., 2011

Still three years to go: hoping for the best

Monsieur et Madame Constantin SIREUIL-ABRAHAM, Madame Marie- Louise SIREUIL, Monsieur et Madame Serge SIREUIL-LEFEVRE,

ses enfants;

Joël, Alain, Orélien, Olivier,

ses petits-enfants; ses arrière-petits-enfants;

Julia, Laurie, Maud,

Et toute la famille apparentée ont la profonde douleur de vous faire part du décès de

MADAME Adrienne MATLAS

Adrienne MAILAS

veuve de Monsieur Jean-Baptiste SIREUIL

née à Élouges le 25 juillet 1933 et décédée à Gilly le 25 mai 2012.

Les funérailles civiles auront lieu mardi 29 mai 2012 à 14 h 30, caveau familial au cimetière de Dour.

Dans l'attente des funérailles, le corps repose au funérarium Gobert J.-M., rue de la Victoire, 12, à Frameries. Les personnes qui désirent rendre un ultime hommage au défunt pourront se recueillir au funérarium Gobert, rue de la Victoire, 12, 7080 Frameries, le lundi 28 mai de 17 h à 19 h.

> Cet avis tient lieu de faire-part. P. F. A. DESCHAMPS, Erquennes, 20 rue A. Deschamps. Tél. 065/65.29.15



 From the ground: Extending the survey to other type of galaxies, environments, distances
Megacam-red

From space, with dedicated telescopes: Reaching even lower surface brightness levels: 29 -> 32 mag/arc-2, to reconstruct the mass assembly of galaxies at earlier epoch
MESSIER concept

•CFHT 2012 calendar w. Coleum