Direct imaging of the cosmic web in the local Universe

Amanda María del Olmo García

amandaog@iac.es

Jorge Sánchez Almeida
Casiana Muñoz Tuñón

Instituto de Astrofísica de Canarias

Universidad de La Laguna

Estallidos Workshop - May 2015

Table of Contents I

Cold-flow accretion as a mechanism of disk formation

In the current cosmological model of the Universe (Λ Cold Dark Matter), the larger structures form by mergers of smaller structures. It is evidenced in the large scale structure in the distribution of galaxies (Springel et al. 2006, Blumenthal et al. 1984).
One of the main mechanism of disk formation is the accretion of gas from the cosmic web.

- Small halo galaxies: the accreted gas is almost undisturbed and reaches the protodisk in clumps and filaments and begins forming stars. This accretion of cosmic web gas is also known as cold-flow. (Dekel et al. 2009a)
- Massive halo galaxies: the gas is heated up to halo temperature, its fall to the galaxy disk will be more homogeneous and spread in time.

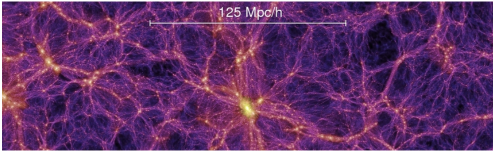
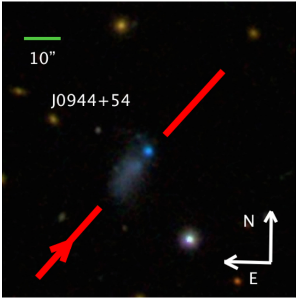


Figure: Snapshot of Millenium Simulation

XMP galaxies

Extremely metal-poor (XMP) galaxies are, by definition, galaxies with gas metallicity below 10% of the solar metallicity, so they are the least chemically evolved objects in the local universe (Izotov & Thuan 2004). These galaxies are characterized by the presence of an intense star forming region with lower metallicity than the rest of the galaxy, which may indicate recent accretion of metal-poor gas (Sanchez Almeida et al. 2013b, 2014b).

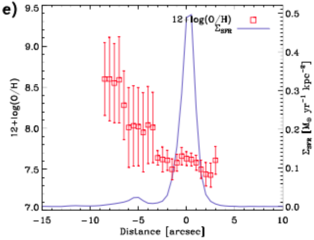
- Great fraction with cometary shape (Papaderos et al. 2008, Morales-Luis et al. 2011)
- Large reservoir of gas: $M_{gas} \geq 10 M_*$ than typical galaxies (Filho et al. 2013)
- Isolated, with little exceptions
- In cosmological simulations (Filho et al. 2015), they mostly appear in voids



XMP galaxies

Extremely metal-poor (XMP) galaxies are, by definition, galaxies with gas metallicity below 10% of the solar metallicity, so they are the least chemically evolved objects in the local universe (Izotov & Thuan 2004). These galaxies are characterized by the presence of an intense star forming region with lower metallicity than the rest of the galaxy, which may indicate recent accretion of metal-poor gas (Sanchez Almeida et al. 2013b, 2014b).

- Great fraction with cometary shape (Papaderos et al. 2008, Morales-Luis et al. 2011)
- Large reservoir of gas: $M_{gas} \geq 10 M_*$ than typical galaxies (Filho et al. 2013)
- Isolated, with little exceptions
- In cosmological simulations (Filho et al. 2015), they mostly appear in voids



Direct imaging with GTC

We aim at the direct imaging of the Hα emission of the gas in the nearby cosmic web.

Mechanisms that produce Hα emission:

- Fluorescence (Cantalupo et al. 2012, Elmegreen 2014)
- Gravity driven cooling (Dijkstra & Loeb 2009, Goerdt et al. 2010)

Expected signal of Hα: 24 - 34 mag/arcsec^2 . Taking into account:

- Lyα emission from the literature, both numerical simulations and observations (Furlanetto et el. 2003, Matsuda et al. 2004, Goerdt et al. 2010, Faucher-Giguere 2010, Rosdahl & Blaizot, 2012, Cantalupo et al. 2014, Elmegreen 2014)
- Lyα/Hα flux ratio (Miller 1974, Baldwin 1977, Atek et al. 2009, Hayes et al. 2010)
- Cosmological dimming $1/(1+z)^4$
- Gas density evolution $(1+z)^3$

Observing strategy

The observations will be made with the instrument OSIRIS, which is an optical imager and spectrograph, located in the Nasmyth focus of GTC.

- 8 h of total exposed time to reach S/N=1 on a $m_{AB} = 29.1$ mag/arcsec^2 target
- Broad band images with SDSS-r filter and narrow band images with SHARD filter
- Remove sky main emission substracting broad band from narrow band images
- Also dithering and rotation of the FOV for better sky modelling. This technique has been already proven by Trujillo and Fliri (2015 submitted) to reach 31.5 mag/arcsec^2 with 8 h integration and broad band filter.

Target Selection

Local XMP galaxies may be going through a major gas accretion (Sánchez Almeida et al. 2013, 2014a), evidenced by their star formation and metallicity. Target selection criteria:

- HI content
- No evident companions
- RA & DEC adequate for the observation date
- Redshift $\geq$ 0.01 to avoid Hα emission of the Milky Way

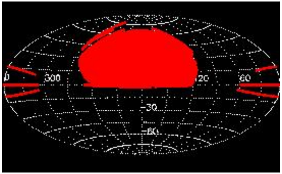
The targets will be chosen from the XMP searches in SDSS spectra catalog:

- Morales-Luis et al. (2011) classifies the spectra based on the ratio between $[NII]\lambda 6583$ and $H\alpha$
- Pérez-Montero (in prep.) uses the relationship between oxygen lines of different excitation levels ([OIII]λ4363, [OIII]λ4959,5007) with T_e, as a proxy of metallicity

IAC Stripe 82 Legacy Project

Stripe 82 is a 2.5 degree wide stripe along the Celestial Equator, that has been imaged by the Sloan Digital Sky Survey (SDSS) under several times from 1998 to 2007.
The IAC Stripe 82 Legacy Project led by Trujillo and Fliri [1] gathers these observations, combines the different expositions of each field and makes them available to the public. The images are in the standard SDSS filters *(u,g,r,i,z)*, each composed of 30 - 100 stacked images, making them 2 mag deeper than normal SDSS images.

Coordinates range: 310° $<$ RA $<$ 60° and -1.25° $<$ DEC $<$ 1.25°
XMP1: 31 out of 141 objects: $\sim$ 22 %
XMP2: 76 out of 320 objects: $\sim$ 24 %



[1] http://www.iac.es/proyecto/stripe82/

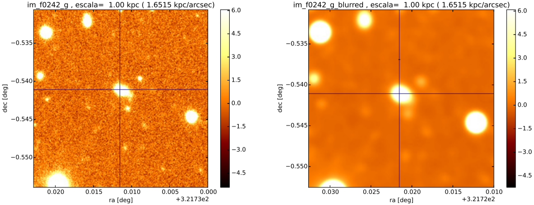


Figure: (a) Image of SDSS J2126-00 in SDSS-g with a FOV of 1.5×1.5 arcmin^2 (b) Gaussian Smoothing

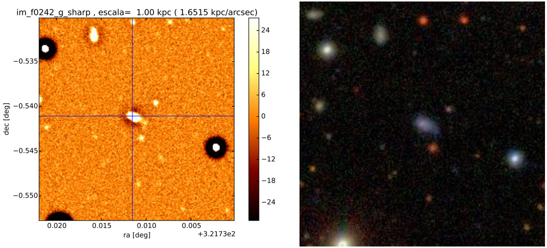
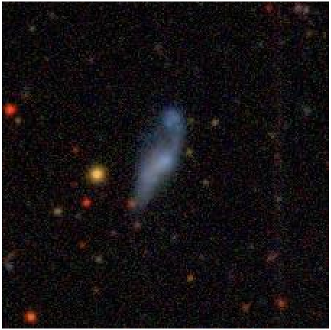
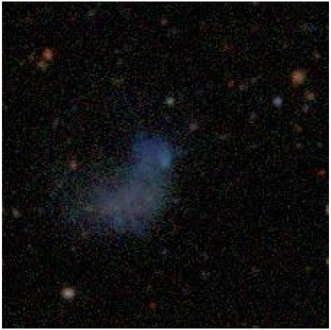
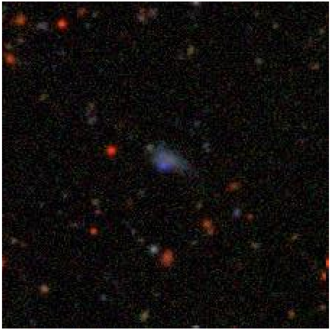


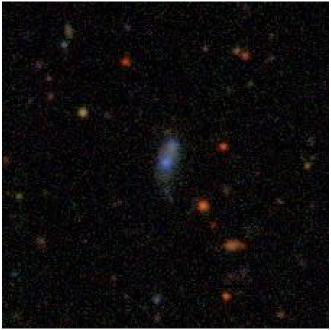
Figure: (c) Unsharp Masking (d) Color composition using filters g, r, i


(a) J234044.3-005314.9, 0.39 kpc/"

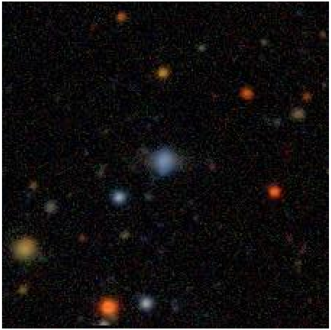

(b) J001520.67+010436.9, 0.033 kpc/"



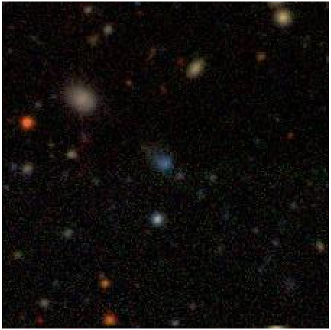
(c) J024429.0+000741.4, 0.71 kpc/"



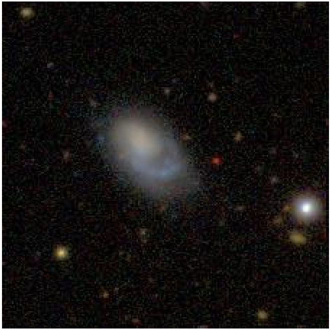
(d) J030331.27-010947.1, 0.0075 kpc/"



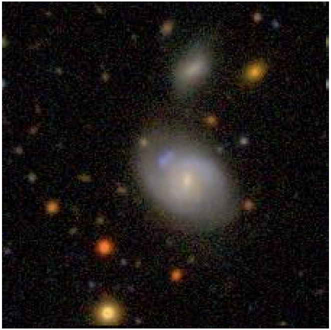
(e) J001628.3+010801.9, 0.214 kpc/"



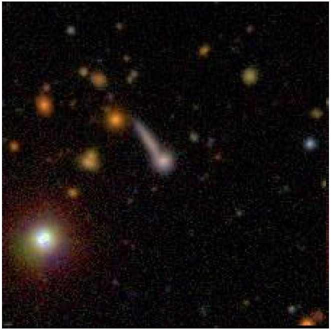
(f) J002949.49-002539.8, 0.016 kpc/"



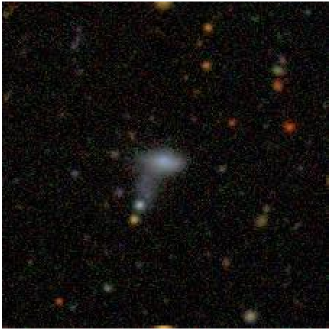
(g) J025455.1+000631.9, 0.29 kpc/"



(h) J023738.3-005415.4, 0.77 kpc/"



(i) J233540.7-002533.1, 1.46 kpc/"



(j) J233414.8+002907.3, 0.48 kpc/"

Summary

- XMP galaxies may be undergoing cold-flow accretion
- We plan to detect cold-flows around XMP galaxies
- The signal expected is reachable with the observational strategy and current instrumentation at the GTC
- In the meantime, looking for structures around XMP galaxies in the IAC Stripe 82

Thanks for your attention

Sample

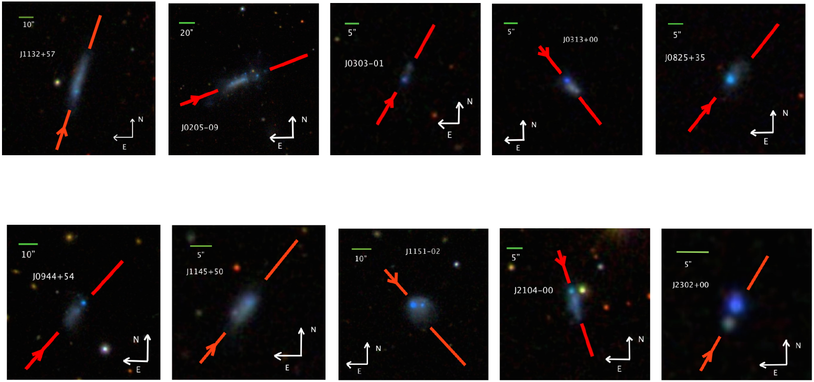


Figure: Sample of XMP galaxies, pictures form SDSS