Why do extremely metal poor galaxies have cometary shape?

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Summary

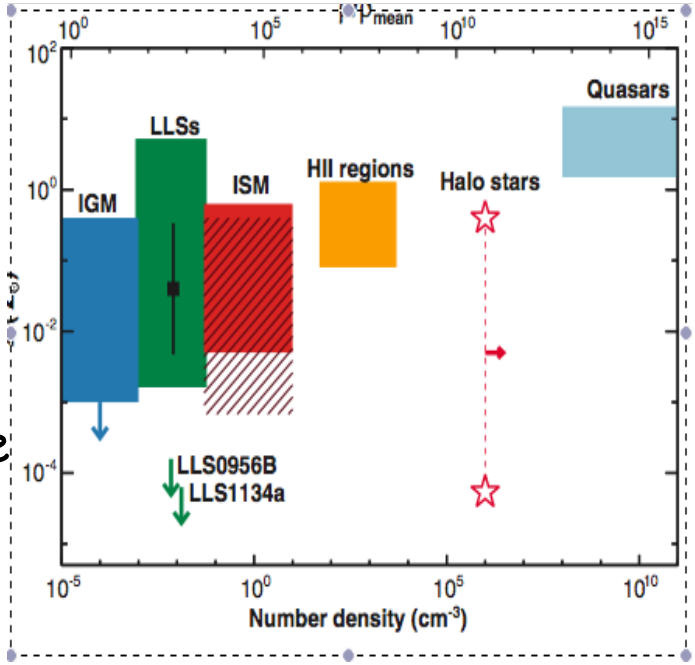
- Interest of eXtremely-metal poor galaxies
- Systematic search for X metal poor galaxies
- Why X metal poor are tadpoles galaxies?
- Local tadpole galaxies
- Conclusions

Interest of eXtremely metal poor galaxies

The Big-Bang just produces H and He (plus traces of Li, Be, and B).

Low metallicity targets (from the IGM to stars) are therefore primitive unevolved systems.

Many such unevolved galaxies are to be expected according to the ΛCDM paradigm.



Fumagalli et al. (2011,Science)

$Z/Z_o \geq 10^{-2}$ for all local galaxies (HII gas metallicity)

Galaxies with $10^{-1} \geq Z/Z_o \geq 10^{-2}$ are rare

XMP galaxies have been used as time-capsules from the primitive universe, e.g.,

- to measure Big-Bang He abundances (e.g., Peimbert & Torres-Peimbert 1974; Pagel et al. 1992)

- to constrain the composition of the first popIII stars (e.g., Thuan & Izotov 2005)

- studying the primitive low-metal interstellar medium (e.g., Izotov & Thuan 2004, 2007), including star formation al low metallicities

Systematic search for extremely metal poor galaxies

Morales-Luis et al.(2011ApJ...743...77M)

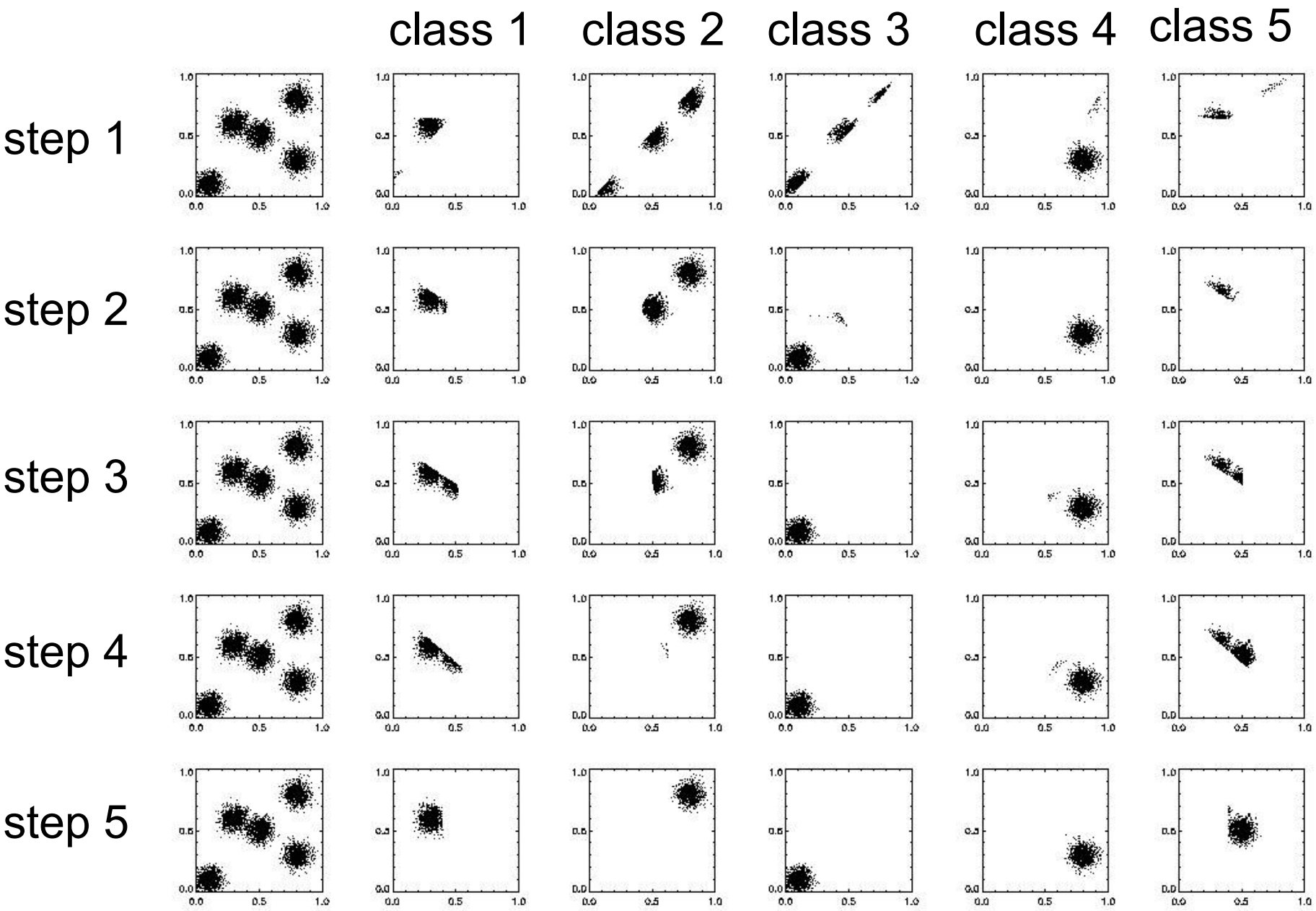
⌘ In view of the small number of XMP and on its potential interest, we carried out a systematic search for these galaxies in the SDSS-DR7 (the largest data release available a the starting time).

- How many XMP galaxies are known?
- Fraction of XMP galaxies are compared to other types of dwarf galaxies?
- Can we add new targets to the XMP list?

⌘ We have been exploring the use the algorithm k-means as a tool to carry out the classification and analysis of massive data sets

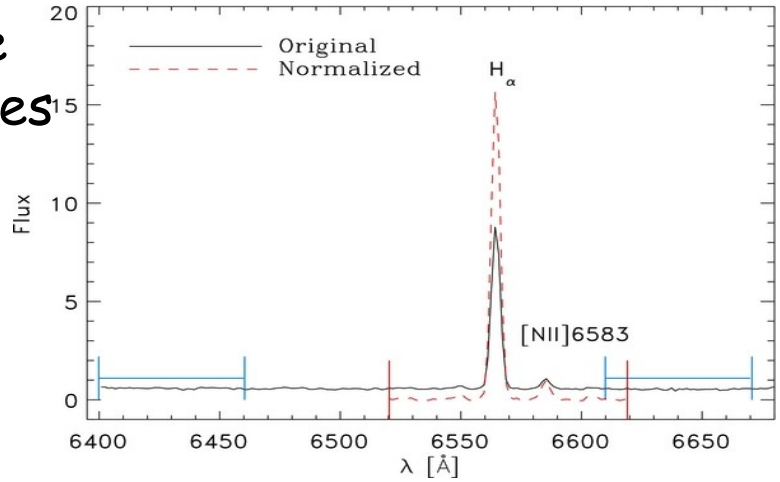
- It is simple to program
- It is robust, and so copes with very different situations
- able to deal with huge datasets with the current computer facilities
- admits hierarchical application, for fine tuning of the classification

How does k-means work?

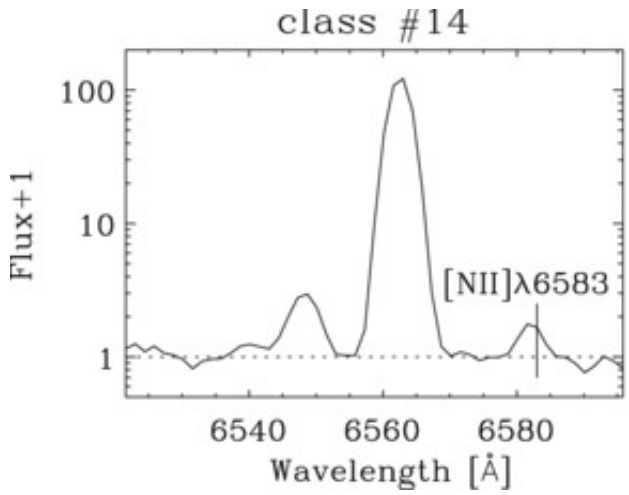


- we search for XMP galaxies by classifying the 10^6 galaxy spectra in SDSS/DR7 in a narrow band next to Ha

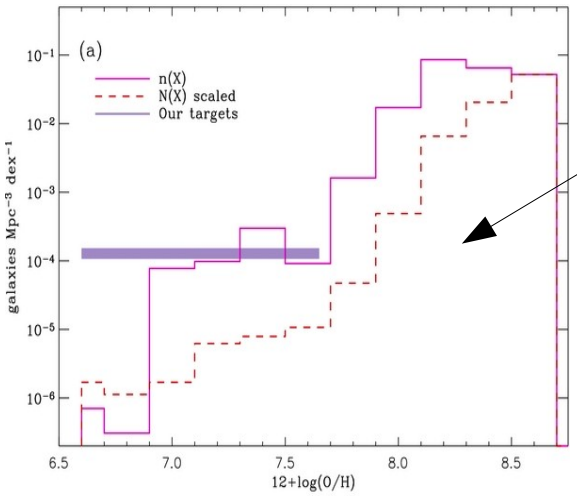
-classes with the highest Ha/[NII] are formed by extremely metal poor galaxies (XMP).

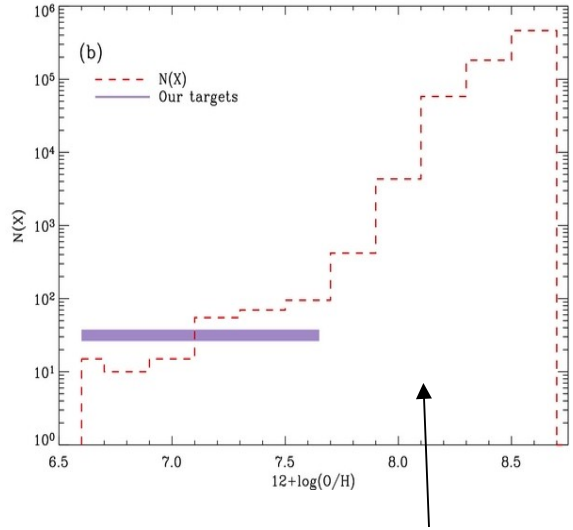


Found 32 XMP galaxies, 11 new, which represent 10% of all the know XMP galaxies



- Our comprehensive bibliographic search showed only 130 known XMP





- Extremely rare (0.1% of the galaxies in local universe (thanks to SDSS being a magnitude-limited sample).

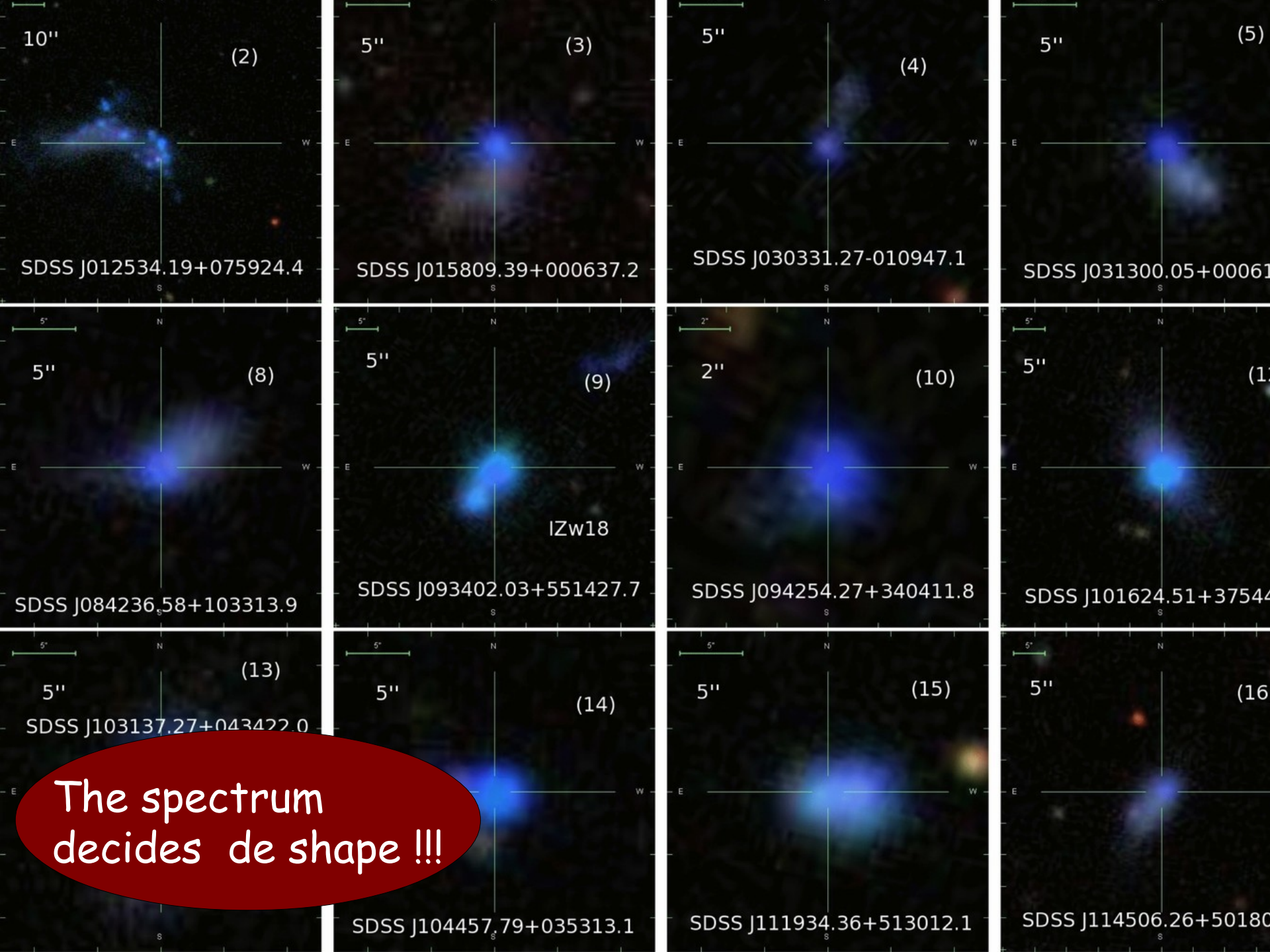
- Most of them are Blue Compact Dwarf (BCD) galaxies (which was known).

- 12+log(O/H)≈7.61 ± 0.19

- Most of them (24/32) turn to have cometary shape!!

- Extremely rare (0.01% of the galaxies with emission lines in SDSS/DR7).

The spectrum decides de shape !!!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SDSS J031300.05+00061
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(8)
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IZw18
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SDSS J094254.27+340411.8
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SDSS J103137.27+043422.0
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SDSS J104457.79+035313.1
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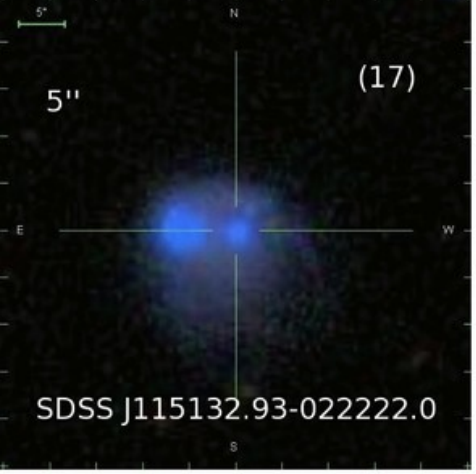
The spectrum decides de shape !!!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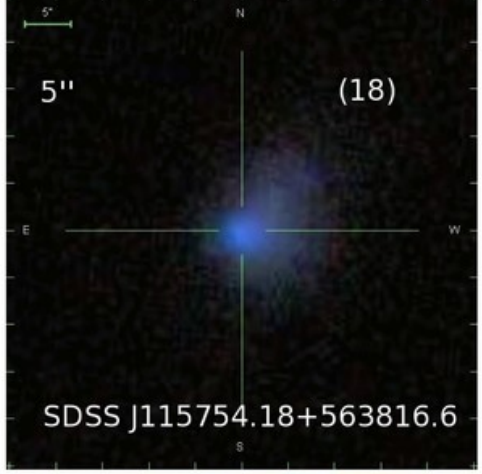
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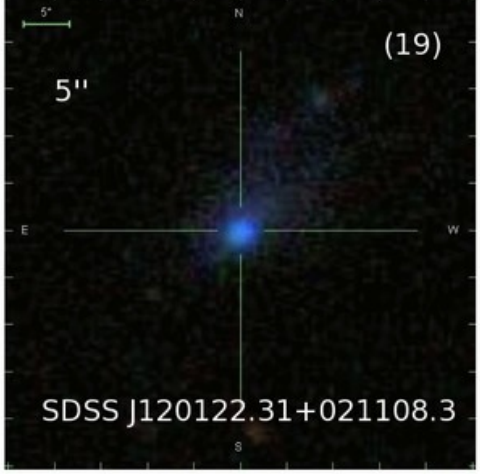
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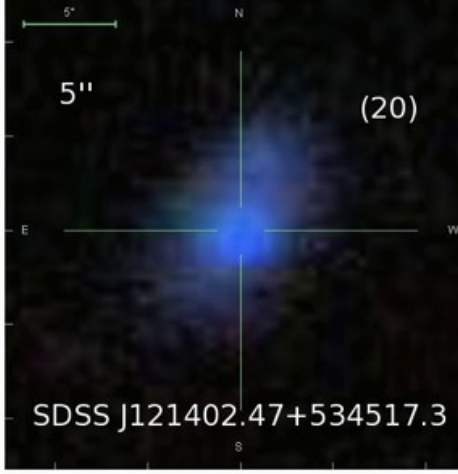
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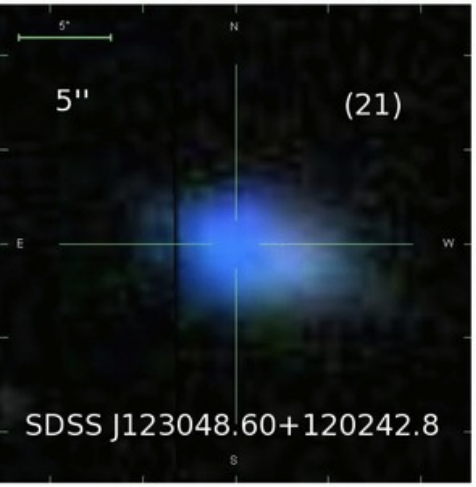
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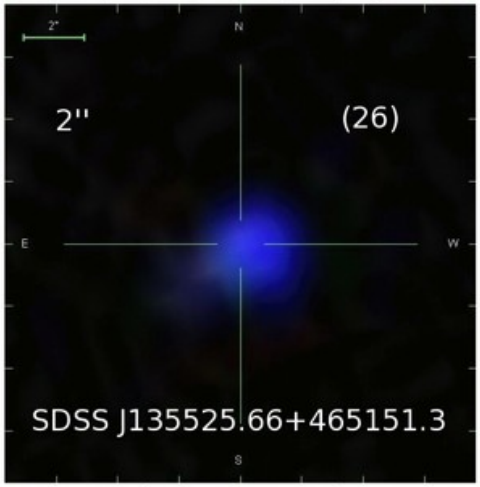
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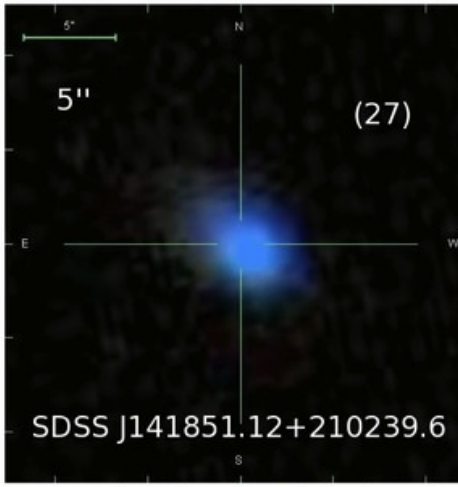
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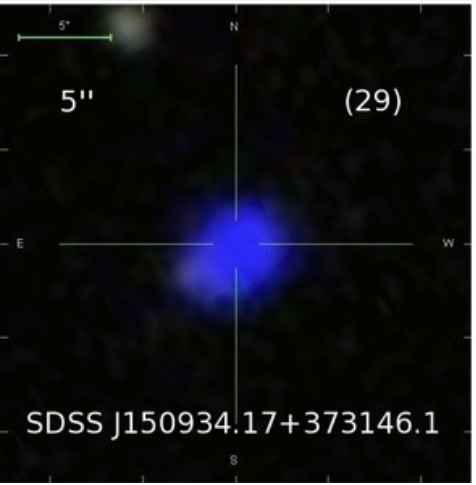
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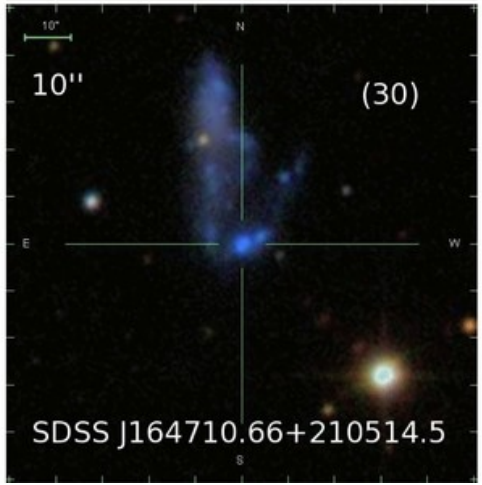
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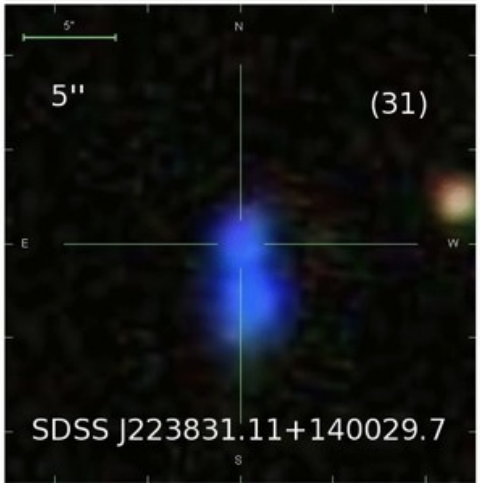
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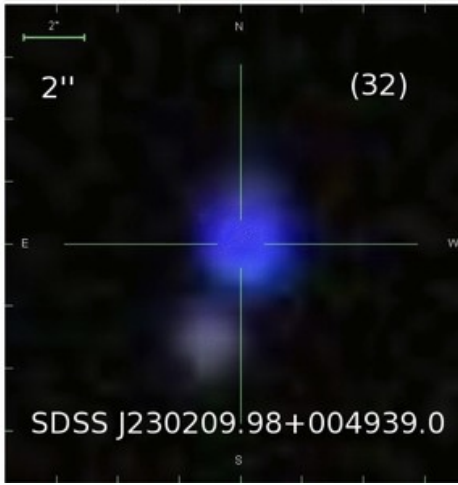
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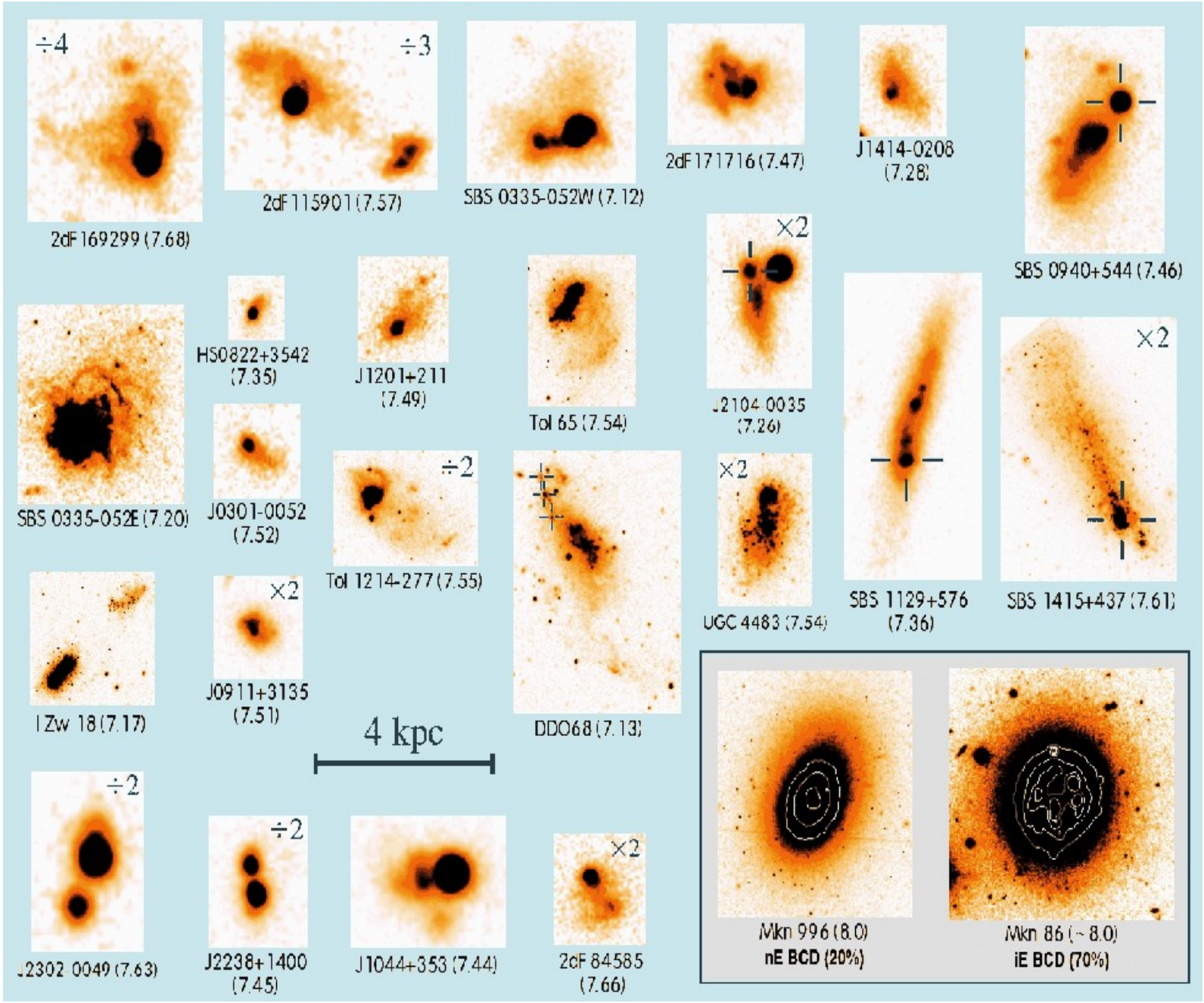
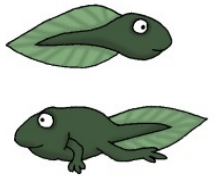


Papaderos et al. (2008, *A&A*, 491, 113) found it for the first time

Why are XMP galaxies tadpole-cometary galaxies?

We do not know ...

but answering the question is of interest beyond the field of XMP galaxies

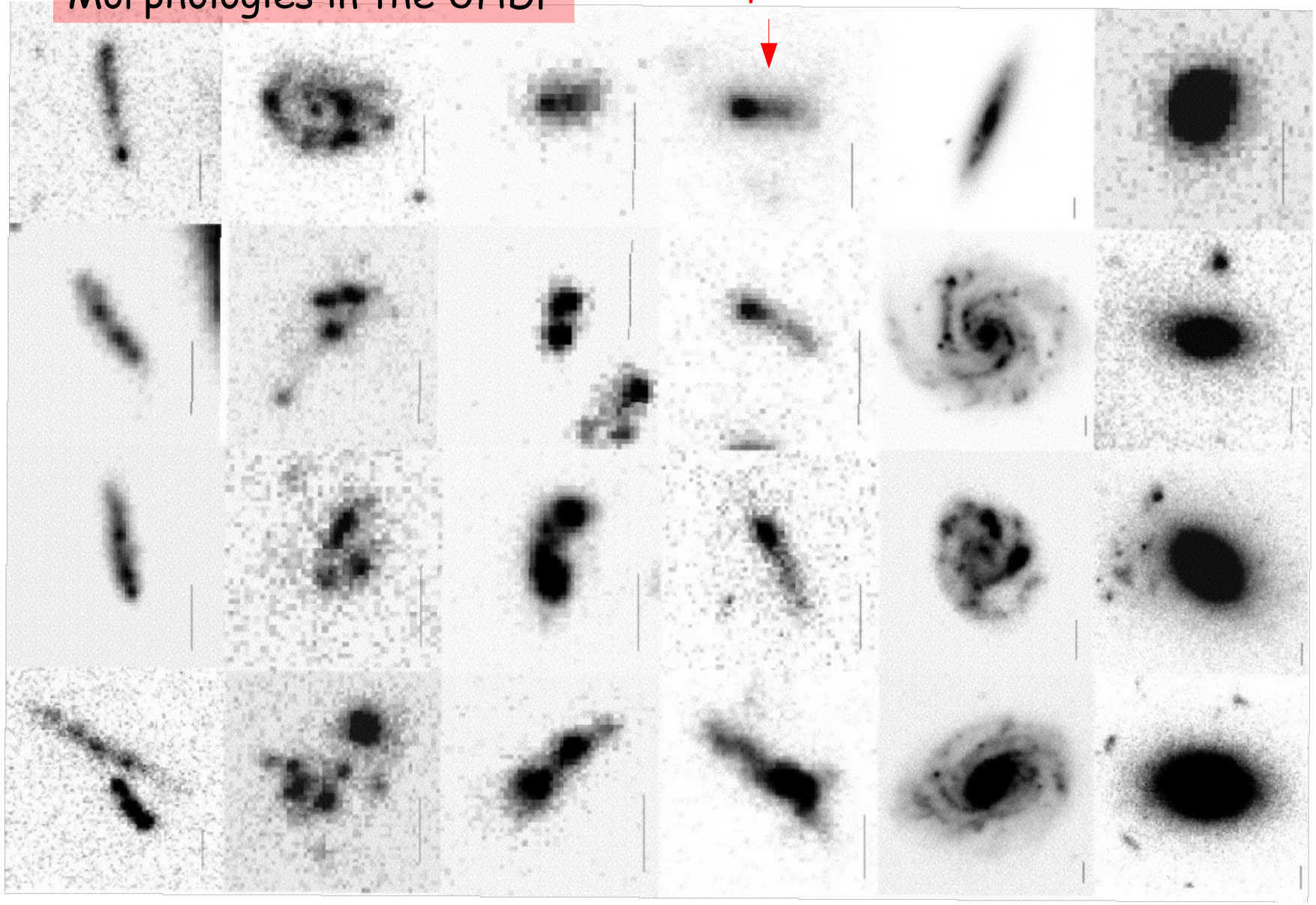


Why is this question interesting at all?

(more than a mere curiosity)

- Tadpole (cometary) galaxies are rare objects in the local universe (0.1% of the Kiso galaxies; Elmegreen et al. 2012), but very common at high redshift (10% of galaxies larger than 10 pix in the UDF Elmegreen et al. 2007).

Morphologies in the UHDF



Elmegreen et al. 2005, ApJ, 361, 85

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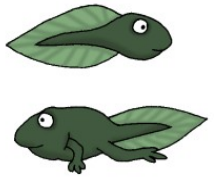

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-They may be disks in an early phase in the process of formation: gas falling in, self excited gravitational instability, interaction with DM clumps or dwarf galaxies, ram pressure striping ...

-XMP are primitive objects from a chemical point of view, but the they may also be primitive with a dynamical point of view.

-Do XMP Gs represent disk-forming systems?

- Do XMP Gs represent nearby laboratories to study disk formation? (in pristine conditions?)

- Cometary shape due to mergers? Major mergers seems to be discarded (XMP are isolated) but faint minor mergers remain as a possibility.

- Star formation propagation (in a pre-existing) ellongated structure disk? (Papaderos et al. 2008)

- Infall of metal-poor gas on a pre-exiting disk, as shown by distorted HI morphologies associated with XMP galaxies (Ekta et al. 2008, 2010)

- It may also be the signature of gas stripping forced by the interaction with the intergalactic medium (e.g., Gavazzi et al. 2001; Elmegreen & Elmegreen 2010).

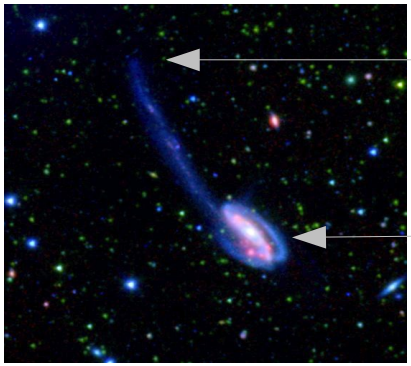
-Self excited gravitational instabilities, that form large clumps depending on the phyiscal conditions (Elmegreen et al. 2012)

-Triggered by gas compression on the leading edge of a disk xsing a filamement of the intergalactic medium.

-bar-like structures (intrinsically elongated disks; Binggeli & Popescu, 1995)

Most possibilities could be distinguished measuring how age, metallicity, velocity, and line broadening (and polarization) vary within the galaxies, e.g.,

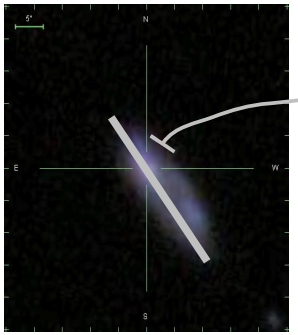
(1) Merger: one would measure two decoupled kinematic components

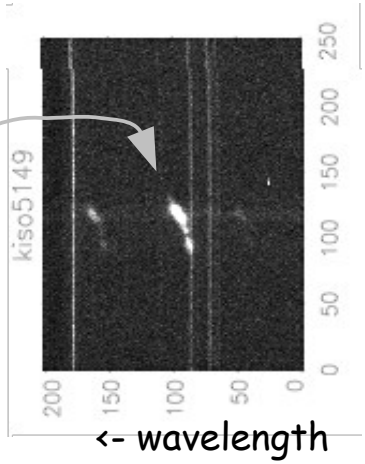


2nd component associated with merger

Target galax.

(2) Lopsided star formation (self excited instability)





S-shape veloc curve means lopsided star formation

We have already set up an observing proposal to determine what is the nature of the XMP galaxies, from head to tail.

- Aim: answering the question
'are the XMP disks being formed in the local universe?'

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PETICIÓN DE TIEMPO DE OBSERVACIÓN (CAT NOCTURNO)
Observatorios del Roque de Los Muchachos y del Teide

1. Título (máximo diez palabras)
The remarkable shape of extremely metal poor galaxies

2. Datos personales

2.1. Investigador principal

Jorge Sanchez Almeida	Instituto de Astrofísica de Canarias

2.2. Coinvestigadores

Polychronis Papaderos	Universidade do Porto, Centro de Astrofísica
Ricardo Amorin Barbieri	Instituto de Astrofísica de Andalucía
Yago Ascasibar Sequeiros	Universidad Autónoma de Madrid
Jean Michel Gomes	Universidade do Porto, Centro de Astrofísica
Patricio Lagos	Universidade do Porto, Centro de Astrofísica
Andrew Humphrey	Instituto Nacional de Astrofísica, Optica y Electrónica
Debra Elmegreen	Vassar College
Jose Manuel Vilchez Medina	Instituto de Astrofísica de Andalucía
Bruce Elmegreen	IBM Watson Research Center
Casiana Muñoz Tuñon	Instituto de Astrofísica de Canarias
Ana Belén Morales Luis	Instituto de Astrofísica de Canarias
Jose Alfonso Lopez Aguerri	Instituto de Astrofísica de Canarias

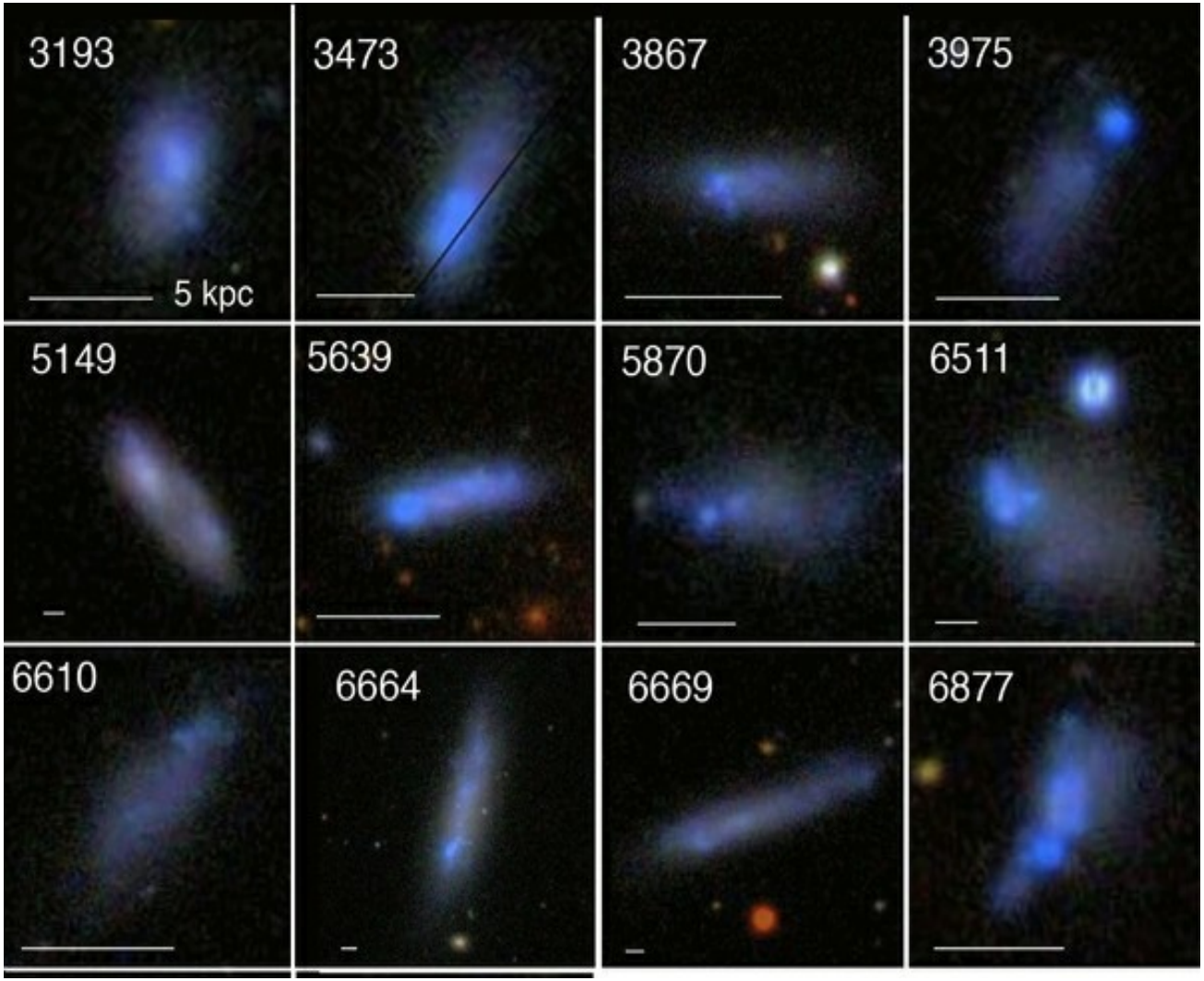
- Observation: measuring ages, metallicities, of the gas and stars, from head to tail. Measuring also kinematic information (organized and random motions)

- Representative sample: 10 targets (10% of all known XMP galaxies)

- Moderate observational requirements:
12 OSIRIS@GTC hours +
24 ISIS@WHT hours

- Extension to determine the neutral gas content (radio; lead by M. Filho)

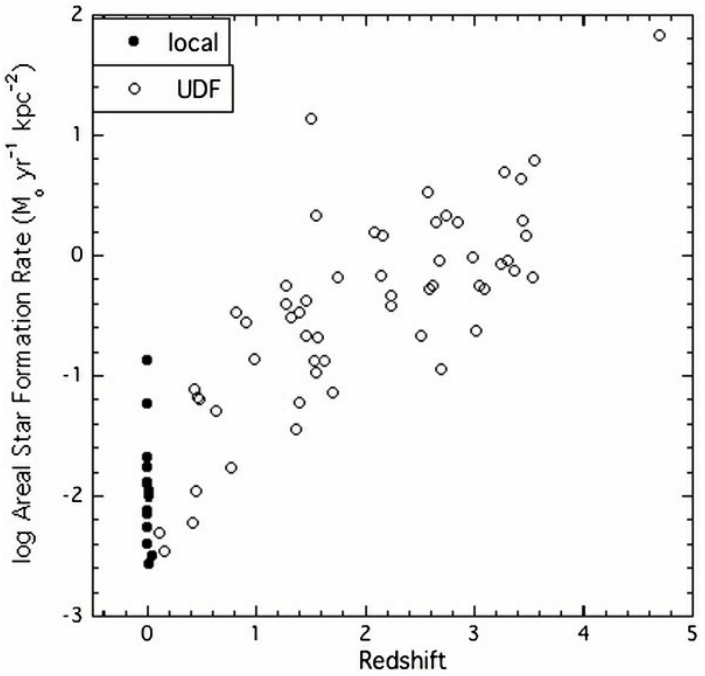
Local tadpole galaxies



14 selected from Kiso survey of UV-bright galaxies, to be and we compared with tadpoles in the Hubble Ultra Deep Field.

Rare objects in the local universe (0.1% of the Kiso galaxies) but very common at high redshift (10% of galaxies l in the UDF; Elmegreen et al. 2007).

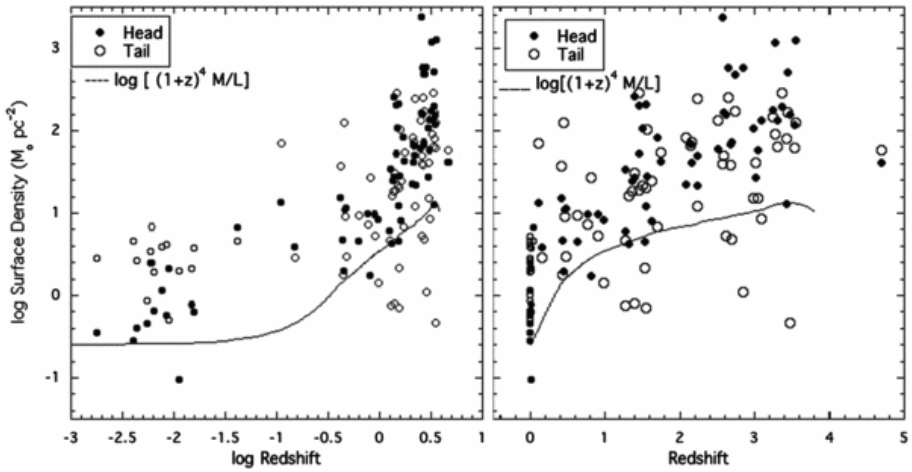
Elmegreen et al (2012ApJ...750...95E)

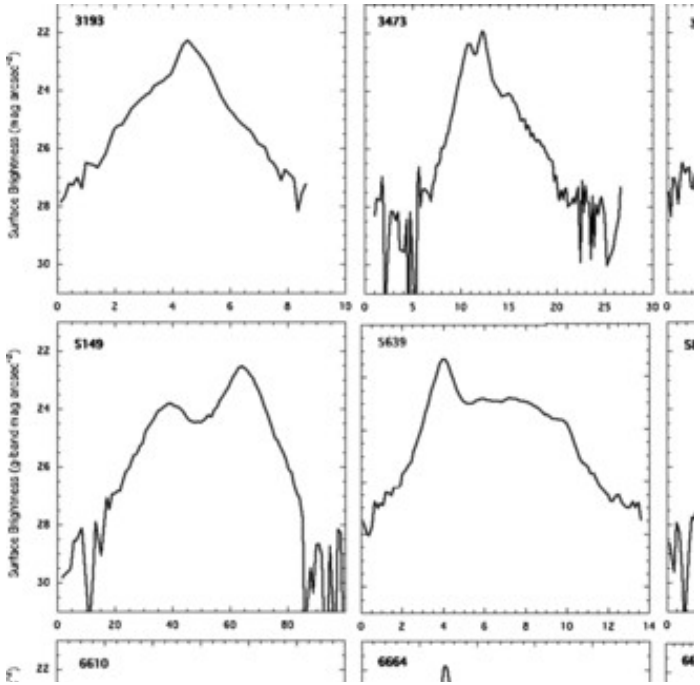


Results:

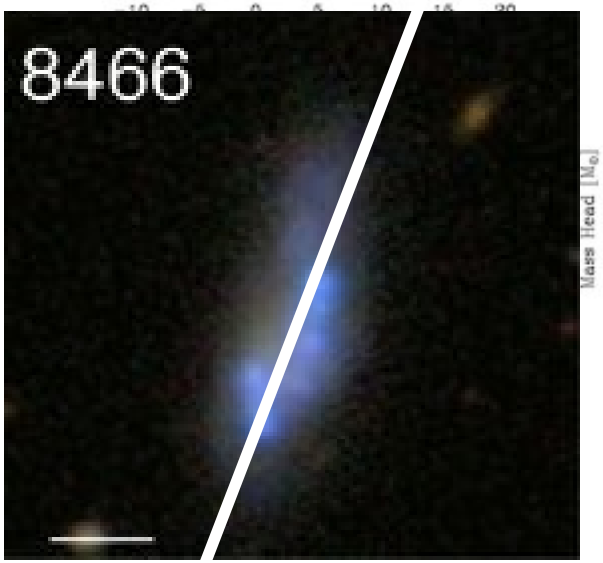
- scaled down versions of UDF tadpoles

-underlying exponential profiles? disk-like?

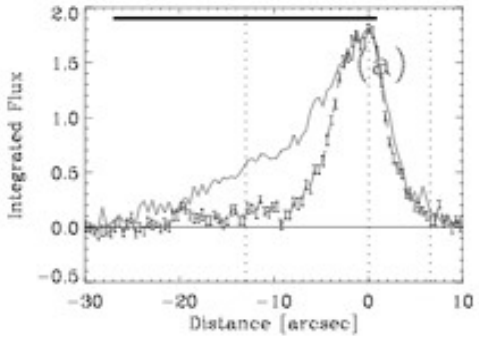


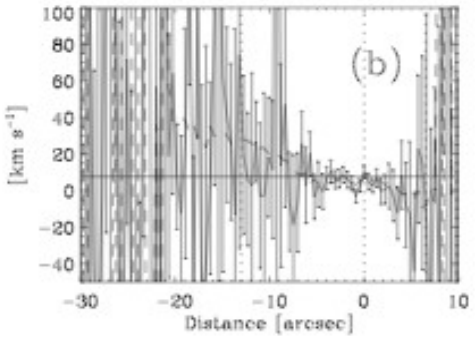


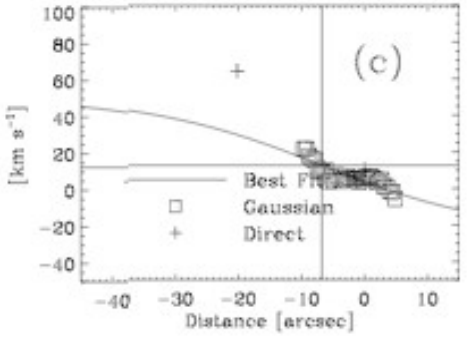
We are analyzing the dynamics of a representative subset (7 targets)

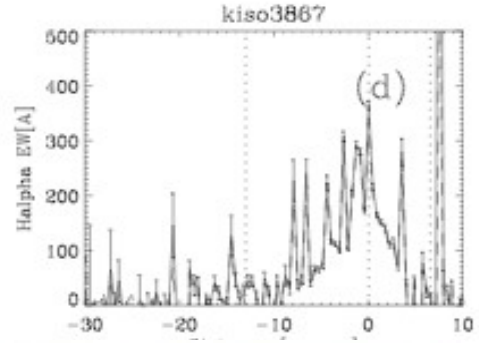


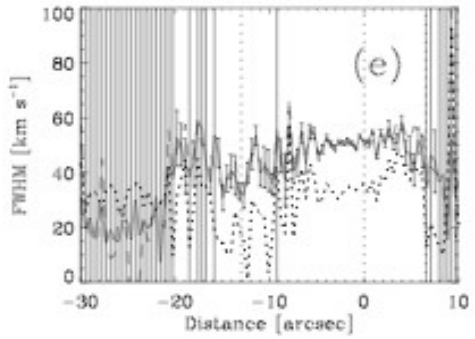
Rotation with lopsided starburst
in a very asymmetric disk

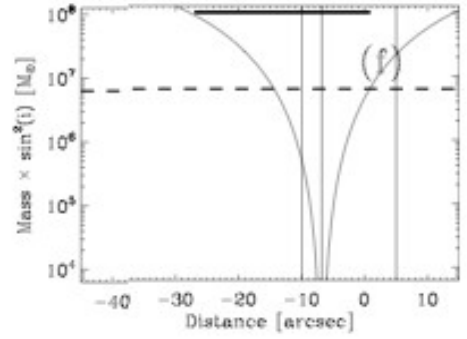


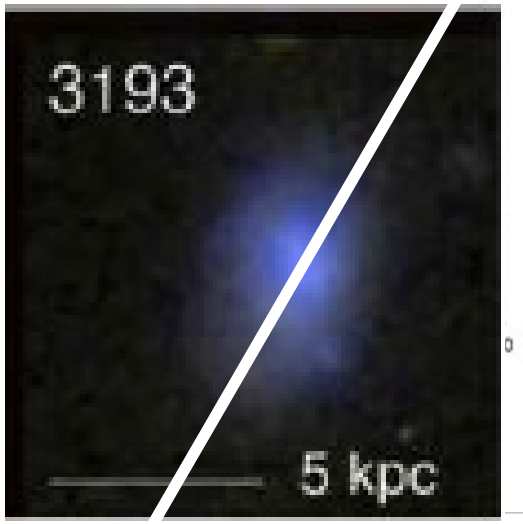


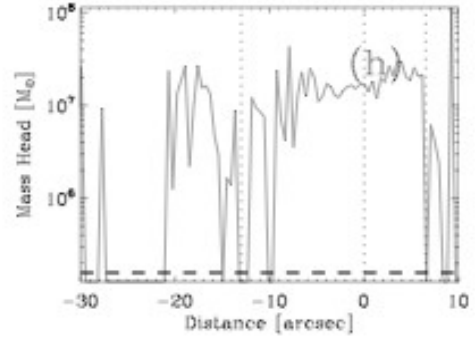


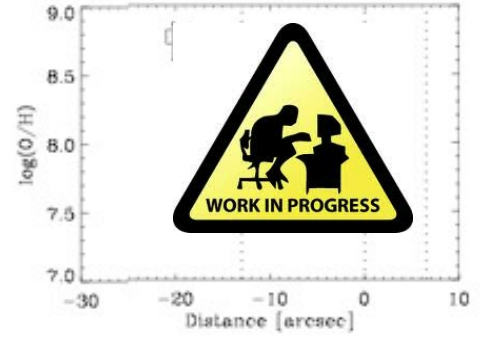












Turbulence-supported dwarf galaxy

Conclusions

- Extremely metal poor (XMP) are chemically primitive objets

- Surprisingly, XMP galaxies turn out to be tadpole or cometary

- Why? Unknown, but the answer important beyond XMP galaxies.

- **Tadpoles** are rare in local universe, but **common at high-z**, where they are commonly interpreted as disks being formed

- XMP galaxies may be **disks being assembled** as well. (It is conceivable that they are not only chemically primitive but also **dynamically primitive**).

- If so, they represent a **nearby laboratory to study disk assembly**, a critical process, not understood, and impossible to study in detail at high-z.

- We are **setting up an observing** proposals to determine the **nature** of the **shape** of the XMP galaxies

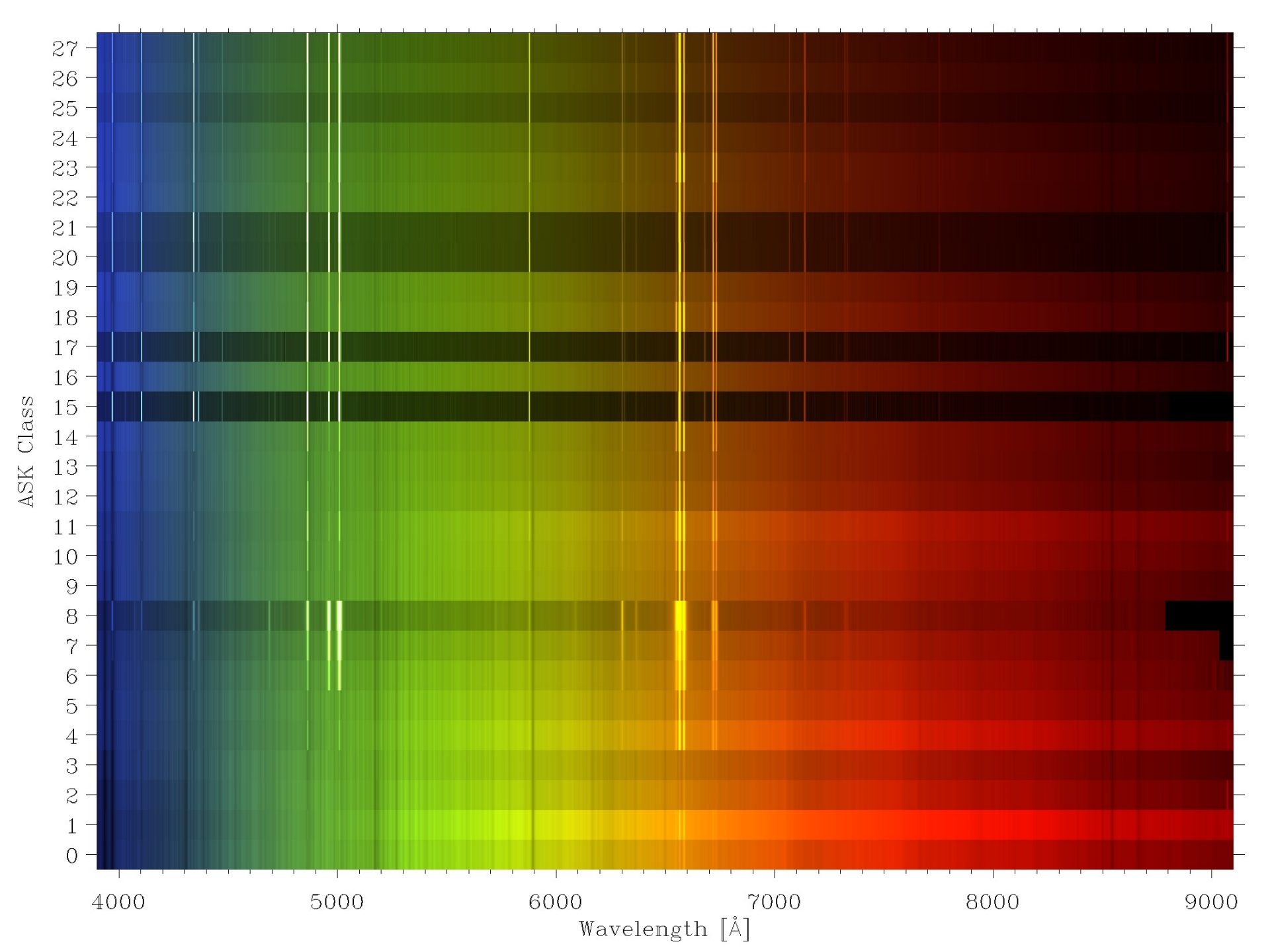
Are they disks been assembled right now?


Flammarion woodcut
Urbi et Orbi

Spectroscopic classification of all SDSS/DR7

ASK : Automatic Spectroscopic K-mean based

- It works for **SDSS/DR7** spectra. 3800 – 9300 Å, ≈1.5 Å pixels, selected spectral regions, normalized to the mean flux in the *g*-band, corrected to restframe wavelengths. Central 3 arcsec
- Local galaxies (z < 0.25 ++)
- Computationally intensive: 788677 spectra x 1637 pixels (≈11.6 GB). 50 iterations. 150 initializations. We parallelize the code
- Classification algorithm: k-means
- 99% of the 788677 galaxies can be assigned to only 17 major classes. We order them by *u-g* color.
- Freely available though VO, SDSS casjobs, IAC webpage …
- Ref: SA et al. (2010, ApJ, 714, 487)


ASK Class
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7000
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Wavelength [Å]