Characterisation of an Isolated Galaxy Sample and the Influence of the Environment

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Universidad de Granada







Stellar Cluster and Galaxy group seminar September 24th, 2014

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 Which properties are due to internal secular evolution and which to external influences

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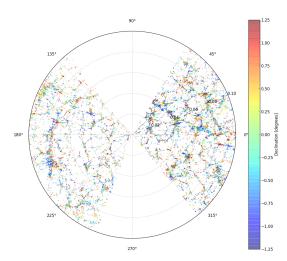
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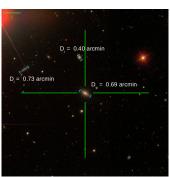
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Analysis of the interstellar Medium of Isolated GAlaxies

Catalogue of Isolated Galaxies [CIG, Karachentseva 1973]



1050 CIG galaxies 2D isolation criterion:

$$\bullet \ \ \frac{1}{4} D_P \le D_i \le 4 D_P$$

•
$$R_{iP} \leq 20 D_i$$

No similar-size galaxies in their close environments

Refinement of the sample

- Positions [Leon & Verdes-Montenegro 2003]
- Redshift and distances [Verdes-Montenegro et al. 2005]
- Morphologies [Sulentic et al. 2006]
- Isolation degree [Verley et al. 2007b,c, Argudo-Fernandez et al. 2013, 2014a]

Multiwavelength characterisation of the ISM

- Optical [Sulentic et al. 2006, Durbala et al. 2008, 2009, Sabater et al. 2008, 2012, Fernández Lorenzo et al. 2012, 2013, 2014]
- Hα [Verley et al. 2007a]
- Near & far infrared [Lisenfeld et al. 2007]
- Radiocontinuum [Leon et al. 2008]
- Atomic gas [Espada et al. 2005, 2011]
- Molecular gas [Lisenfeld et al. 2012]
- Public database

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The SDSS

[York et al. 2000]

ttp://www.sdss3.org



Sloan Digital Sky Survey

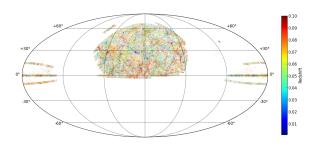
2.5 m Telescope [Gunn et al. 2006]

Apache Point Observatory, New Mexico

SDSS-DR9 [Eisenstein et al. 2011]

Photometry: 208,478,448 galaxies

Spectroscopy: 952,740 galaxies



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Quantification of the environment

[Verley et al. 2007b,c, Sabater et al. 2013, Argudo-Fernández et al. 2013, 2014a]

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Projected density to the kth nearest neighbour:

$$\eta_k \propto \log\left(\frac{k-1}{V(r_k)}\right)$$

$$V(r_k) = \frac{4}{3}\pi r_k^3$$

Tidal strength (estimation of gravitational interaction):

$$Q_{iP} \equiv \frac{F_{\text{tidal}}}{F_{\text{bind}}}$$

$$\log Q_{iP} \propto 0.4 \left(m_r^P - m_r^i\right) + 3\log\left(\frac{D_P}{R_{iP}}\right)$$

and
$$Q = \log(\sum_i Q_{iP})$$

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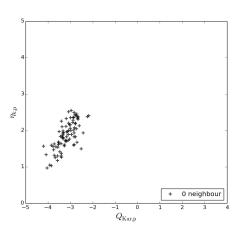
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- 636 CIG galaxies in the photometric SDSS
- 86 CIG galaxies pass the CIG isolation criterion



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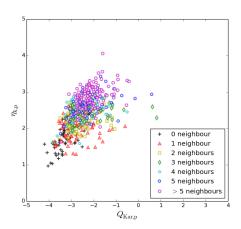
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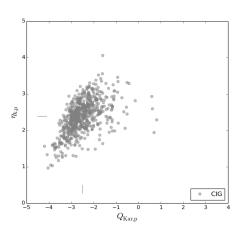
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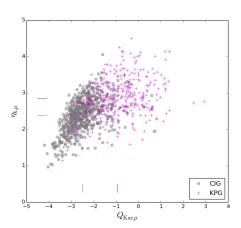
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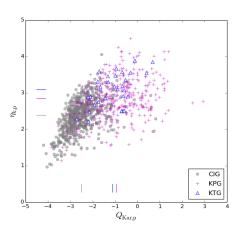
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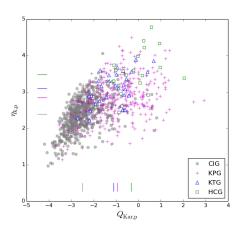
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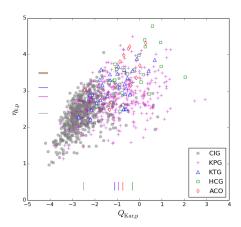
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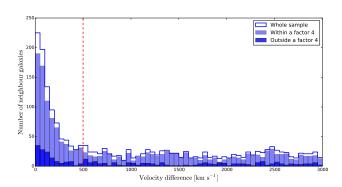
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Spectroscopic isolation criterion

- 411 CIG galaxies in the spectroscopic SDSS
- 347 CIG galaxies pass the CIG isolation criterion
- 105 CIG galaxies pass $\Delta v \leq 500 \,\mathrm{km}\,\mathrm{s}^{-1}$
- 50% of the companions by the CIG isolation criterion show very high Δv
- 92% of similar Δv are not considered as companions



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• Fainter & smaller neighbours

- Nearby dwarf galaxies not taken into account by the CIG isolation criterion
- 50% of the companions by the CIG isolation criterion are **background galaxies** showing very high Δv
- 92% of similar Δv are not considered as companions

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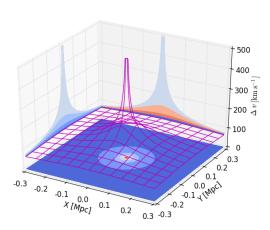
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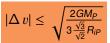
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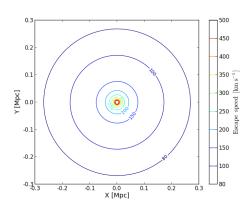
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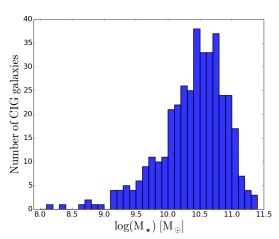
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Stellar masses

- SDSS g-, r-, and i-bands
- K correction rest-frame magnitudes and stellar masses [Blanton et al. 2007]



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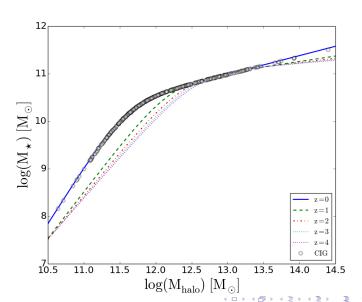
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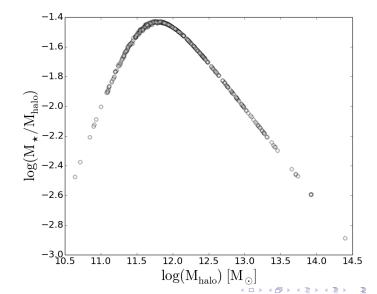


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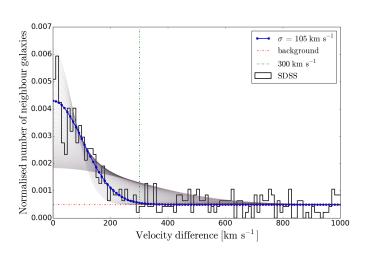
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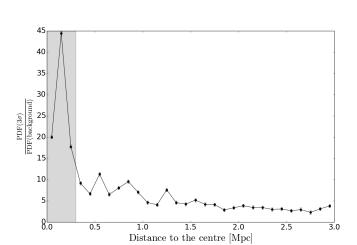
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Physically bound satellites



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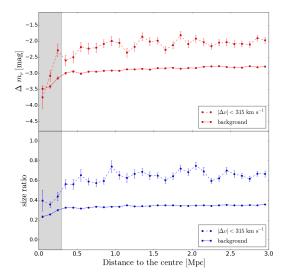
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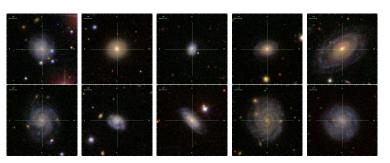


Isolation criterion

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- 386 CIG galaxies
- 37 CIG galaxies (10% of the sample) with physically bound satellites
- 10 most isolated (no neighbours within 3 Mpc):



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Large Scale Structure (LSS)



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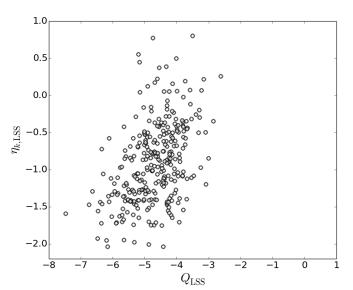
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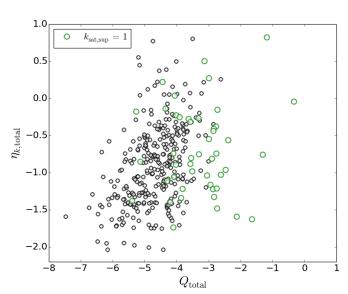
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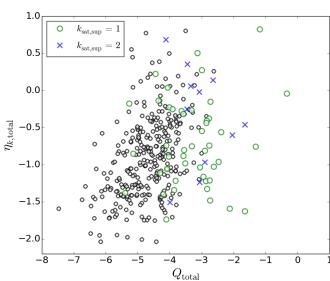
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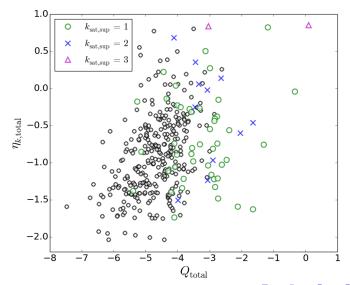
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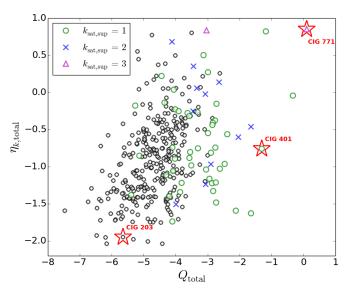
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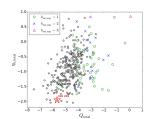
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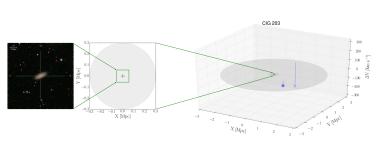


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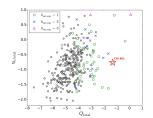


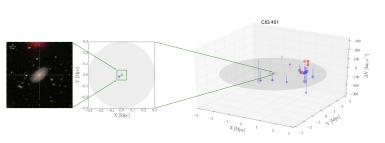


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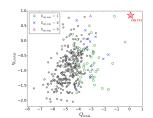


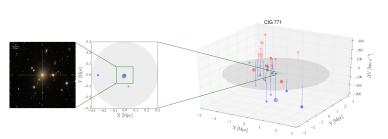


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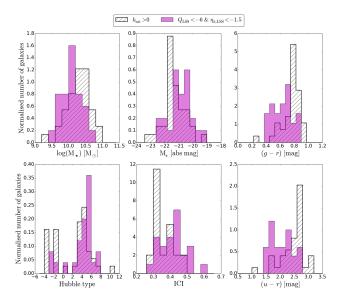
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Effects of the environment on satellites



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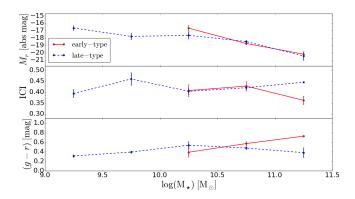
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Conclusions

10% of the sample have physically bound satellites

- 90% of the sample have no physically bound satellites but may suffer interactions with fly-by galaxies
- CIG galaxies show continuous degree of connection with the LSS
- Clear segregation between younger and older **systems**, confirmed by the nature of the physically associated galaxies

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Primary galaxies 11 < m < 15.7 0.005 < z < 0.080 80% z completeness

33.081

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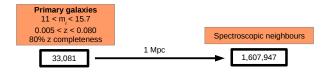
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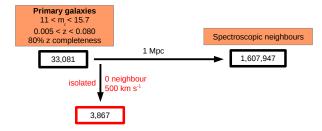
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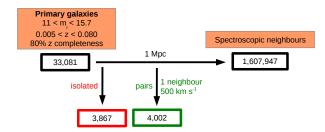
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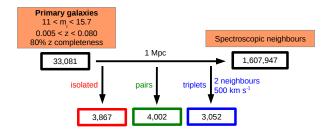
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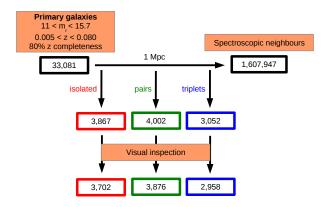
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Physical definition of isolated galaxies

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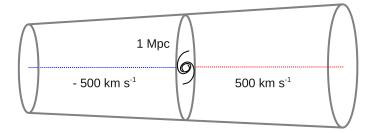
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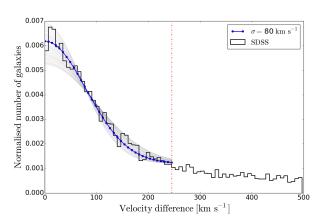
Relation to the LSS

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- Field radius of 1 Mpc: crossing time ~ 5.2 Gyr
- $\Delta v \leq 500 \, \mathrm{km} \, \mathrm{s}^{-1}$ to avoid physical associations
- 3,702 isolated galaxies



- Gaussian distribution $\sigma = 80 \, \mathrm{km} \, \mathrm{s}^{-1}$
- Pairs & triplets: $\Delta v \le 160 \, \text{km s}^{-1} \, \& \, d \le 450 \, \text{kpc}$
- Close pairs & triplets: $\Delta v \le 160 \,\mathrm{km}\,\mathrm{s}^{-1}$ & $d \le 250 \,\mathrm{kpc}$



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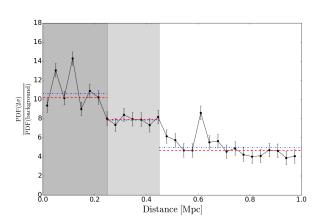
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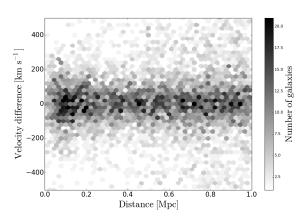
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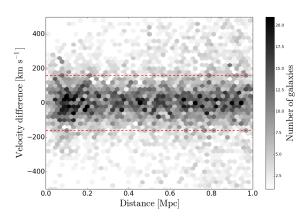
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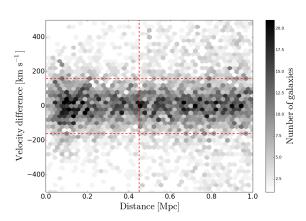
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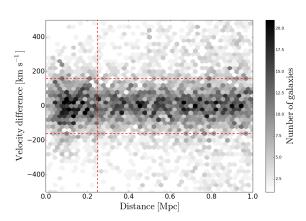
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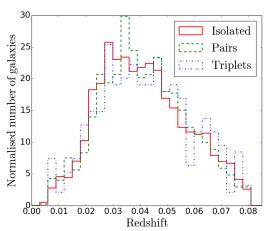
Redshift distributions

- 3,702 isolated galaxies
- 1,240 isolated pairs
- 315 isolated triplets

SDSS-based Isolated Galaxies (SIG)

SDSS-based Isolated Pairs (SIP)

SDSS-based Isolated Triplets (SIT)



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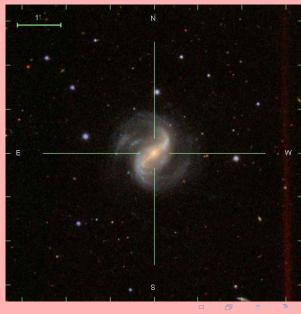
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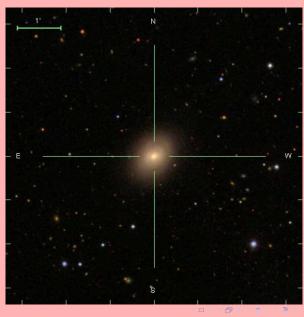
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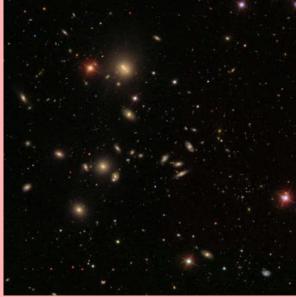
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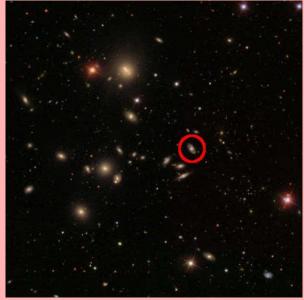
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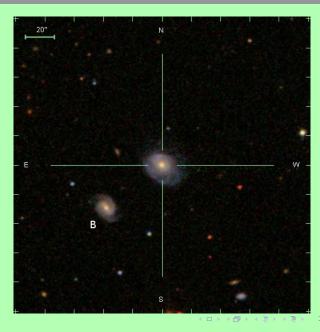
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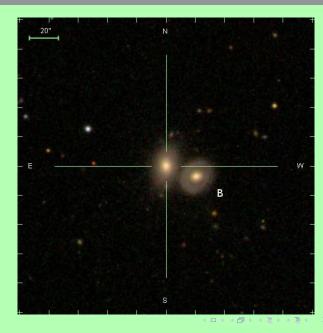
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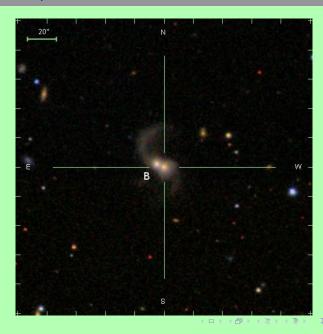
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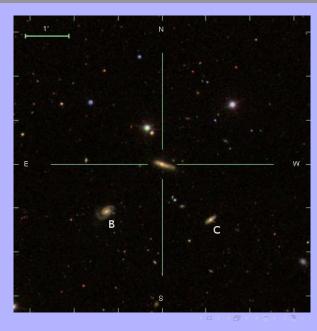
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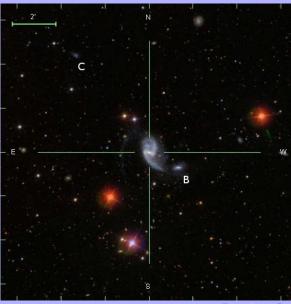
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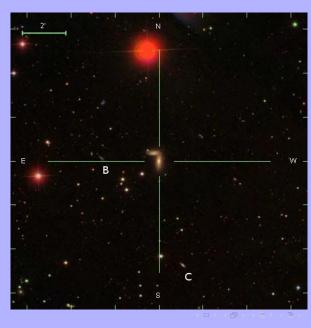
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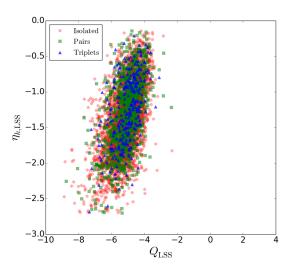
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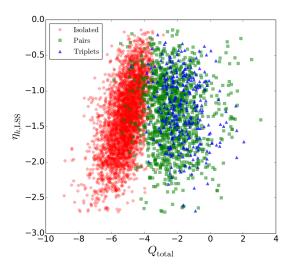
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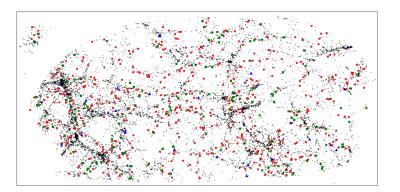
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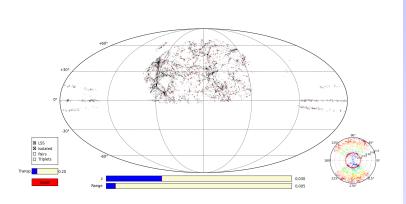
S. Duarte Puertas & E. Ramos Carmona

Mollweide projection

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S. Duarte Puertas & E. Ramos Carmona

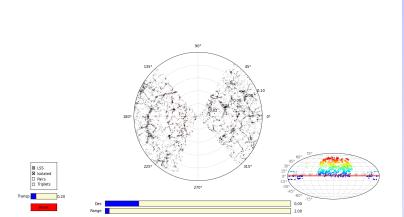
Wedge diagram

-2°<δ<2°



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Minimum Spanning Tree

[Vanderplas et al. 2012, Ivezic et al. 2013]

-1.25°<δ<1.25°



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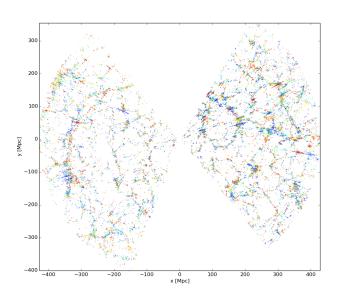
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Minimum Spanning Tree

[Vanderplas et al. 2012, Ivezic et al. 2013]

-1.25°<δ<1.25°



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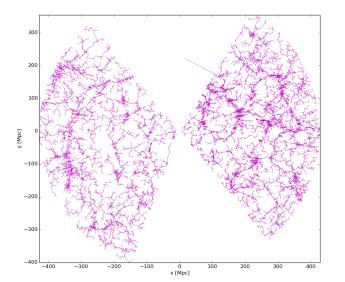
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Minimum Spanning Tree [Vanderplas et al. 2012, Ivezic et al. 2013]

Threshold 2.9 Mpc

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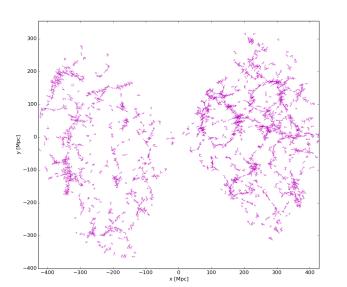
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Minimum Spanning Tree [Vanderplas et al. 2012, Ivezic et al. 2013]

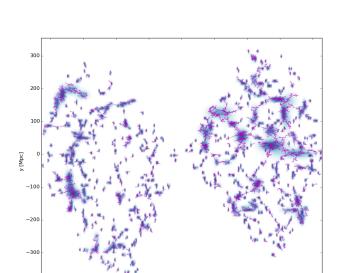
 $-1.25^{\circ} < \delta < 1.25^{\circ}$

Threshold 2.9 Mpc



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-400

-300

-200

-100

100

x [Mpc]

200

300

400

Minimum Spanning Tree [Vanderplas et al. 2012, Ivezic et al. 2013]

Threshold 2.9 Mpc $-1.25^{\circ} < \delta < 1.25^{\circ}$

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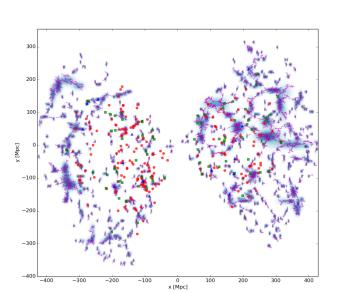
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 SIG catalogue: 3,702 isolated galaxies which represent about 11% of the considered galaxies in the local Universe

- SIP catalogue: 1,240 isolated pairs which represent about 7% of the considered galaxies in the local Universe
- SIT catalogue: 315 isolated triplets which represent about 3% of the considered galaxies in the local Universe
- Generally differ from the void population of galaxies
- Most of the isolated galaxies, isolated pairs, and isolated triplets, belong to the outer parts of filaments, walls, and clusters

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Next

Multi-wavelength studies of galaxy properties and their relation with local and large-scale environments:

- morphology Galaxy Zoo 2 (GZ2) [Willett et al. 2013],
- star formation (SFR) [Brinchmann et al. 2004],
- metallicity [Tremonti et al. 2004],
- nuclear activity BPT diagrams [Baldwin, Phillips & Terlevich 1981, Kauffmann et al. 2003],
- ..