In the search for an optimal compact groups finder

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Monday 24^{th} June, 2019

FRIENDS OF FRIENDS MEETING

FOF 2020

MARCH 30TH - APRIL 3RD, 2020
CÓRDOBA, ARGENTINA

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Juan Cabral
Laura Ceccarelli
Federico Dávila
Flavia Lovos
Ornela Marioni
Gabriel Oio
Walter Weidmann
Dante Paz

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Nelson Padilla (PUC, Chile)
Ariel Sanchez (MPE, Germany)
Hernán Muriel (IATE - Argentina)

Invited Speakers

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Stefano Cristiani (INAF, Italy)
Gian Luigi Granato (INAF, Italy)
Gabriela de Lucia (INAF, Italy)
Guillermo Bosch (UNLP, Argentina)
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Highly dense galaxy systems that contain their brightest galaxies within a small isolated region.

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Figure: First Compact Groups Identified. Left: Stephan's Quintet (1877) - Right: Seyfert's Sextet (1948)

Hickson criteria:

Population: $4 \leq N \leq 10$; $(m - m_b \leq 3)$

Compactness: $\mu \leq \mu_{\mathrm{lim}}$

Isolation: $\Theta_n > 3\,\Theta_G$; $(m - m_b \leq 3)$

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Identification Criteria of CGs

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FoF criteria:

Friends-of-Friends algorithm

Compactness criterion

Over the years, several authors have identified CGs on different galaxy catalogs replicating the original criteria by Hickson or using the percolation algorithm Friends-of-Friends.

Observational catalogs: Barton et al. 1996; Díaz-Giménez et al. 2012, 2018; Focardi & Kelm 2002; Iovino 2002; Lee et al. 2004; McConnachie et al. 2008, 2009; Prandoni et al. 1994; Sohn et al. 2016, 2015.

Mock catalogs: Díaz-Giménez & Mamon 2010; Díaz-Giménez et al. 2012, 2018; McConnachie et al. 2008.

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Mock catalogs: Díaz-Giménez & Mamon 2010; Díaz-Giménez et al. 2012, 2018; McConnachie et al. 2008.

- Different surveys (apparent magnitude limit, coverage sky)
- Different bands (R, r, Ks, u)
- Different criteria (Hickson-like, FoF-like)
- With or without spectroscopic information

Due to this, comparing compact group samples is a difficult task.

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Criteria Problems

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Completeness: $\surd$

Purity: X

Criteria affected by observational properties

Can we build a criteria free of observational biases?

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Low % Real CGs $\rightarrow$ CGs samples highly contaminated by chance alignments

Can we improve the purity of the catalogs of CGs?

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The aim of this work is to develop an independent algorithm able to identify isolated physically dense CGs, free from observational biases.

Goal

Maximize the % of real groups in the observational catalogs.

Objectives

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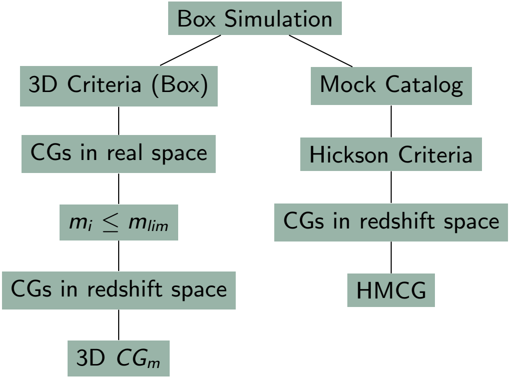

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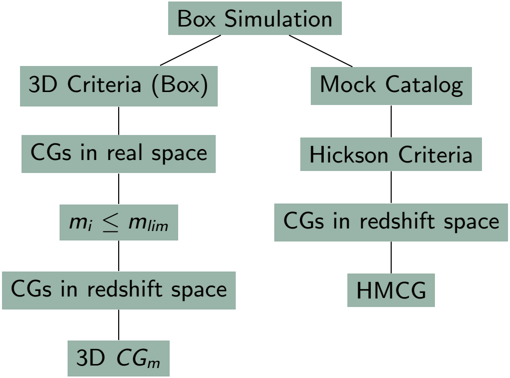

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$3D\ CG_m$: Ideal sample

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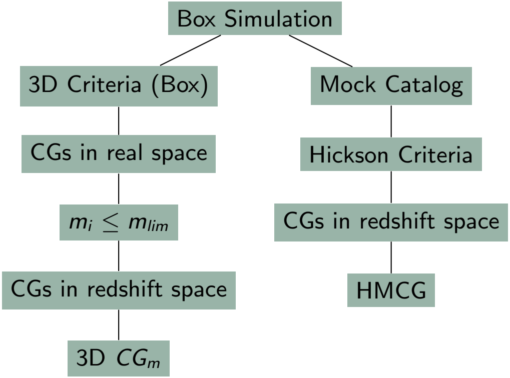

$3D\ CG_m$: Ideal sample

$HMCG$: Observable sample

With the aim of preserving the original idea of Hickson, we kept the main features of the classical criteria (Hickson, 1982): compactness, population and isolation.

Criteria:

- **Compactness**: Friends-of-Friends (FoF) algorithm in real space (Davis et al, 1985). We adopted a high over-density contrast limit to ensure the compactness of our groups,

$$\frac{\delta\rho}{\rho} \geq 1000$$

- **Population**: only groups having 4 or more members,

$$N \geq 4$$

How many selected groups are isolated?

New 3-D Criteria for identifying CGs

- **Isolation I**: we selected only the HDGs that are not substructures of loose groups.

- **Isolation II**: we selected those groups that inside of $3 * R_{vir}$ there not exist other galaxies (number density profile)

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The final real compact groups in 3-D are those groups that also fulfill the previous criterion, and we named them as *CG*s.

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Tools:

- Numerical simulation: Millennium I [Springel et al., 2005]
- Semi-analytical models of galaxy formation (SAMs):
  - Guo11 [Guo et al., 2011]
  - Guo13 [Guo et al., 2013]
  - Hen15 [Henriques et al., 2015]

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We built a super box of twice the size of the simulation box ($2 \times L_{box} \sim 1000 Mpc/h$) to reach in the future the redshift depth of the SDSS observational catalog.

Compact groups selection: $3D\ CG_m$

We apply 3D Algorithm to a superbox ($Lbox \sim 1000Mpc$)

- FoF identification with $\frac{\delta\rho}{\rho} \geq 1000$
- $N \geq 4$
- Are not a substructure of other loose groups
- Isolated system

$\Longrightarrow$ Catalog of CGs

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$\Longrightarrow$ Catalog of CGs in real space

Using the 3D catalog of CGs, we placed an observer on one corner of the simulation super-box

- we computed the r-band apparent magnitudes (**galaxy members**).
- We restricted the sample to those that have 4 or more members with $r < r_{lim}$ ($r_{lim} = 17.77$)

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SAM	**Cosmology**	$3D$-CG	$3D$-CG_m
Guo11	WMAP1	61081	211 (0.35 %)
Guo13	WMAP7	67151	222 (0.33 %)
Hen15	Planck 1	30508	115 (0.38 %)

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Introducing an observer, Hen15 SAM is the most efficient at recovering compact groups.

To compare our ideal CGs with a sample of classical CGs, we constructed a mock catalogue of galaxies in redshift space.

Our mock catalogue is built by observing the simulation from a corner of the super-box. We set an apparent magnitude limit $r = 17.77$, equal to the limit we set on the CG_m to match the SDSS spectroscopic catalog for later comparison.

- α, δ : x, y, z positions
- z: Hubble flow + radial velocities (line-of-sight direction)
- rest-frame galaxy apparent magnitudes: from the rest-frame absolute magnitudes + DM
- observer-frame apparent magnitudes: k corrections.

With this information, we identify CGs in redshift space.

Using this Modified Hickson algorithm to identify CGs:

- Four or more galaxy members ($\Delta r \leq 3$)
- isolated in a cylinder ($\Delta r \leq 3$),
- Compact ($\mu_r \leq \mu_{limit}$)
- All of the members are velocity concordant

HMCGs identified:

- G11: 478
- G13: 288
- H15: 188

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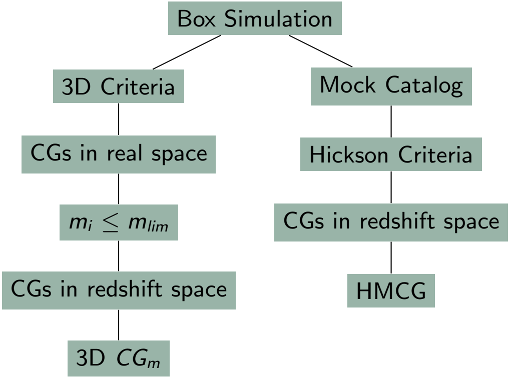
Comparison between 3D CG_m and $HMCG$



1 octant (radius $2 \times L_{box}$)	G11	G13	H15
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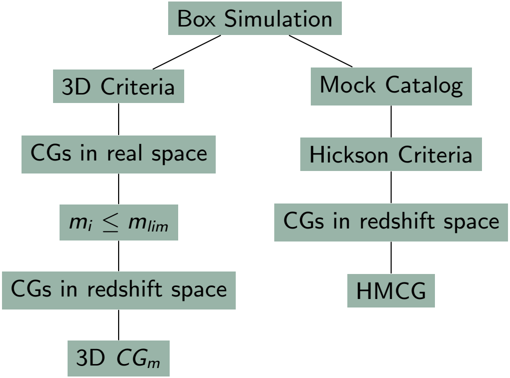
Comparison between 3D CG_m and *HMCG*



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What about the completeness and purity of the HMCG sample?

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Completeness: How many 3D CG_m are *HMCG*?

- Guo11: 42 out of 211 (20 %)
- Guo13: 21 out of 222 (11 %)
- Hen15: 13 out of 115 (15 %)

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Purity: How many 3D CG_m recover the *HMCG*?

- Guo11: 42 out of 478 (11 %)
- Guo13: 21 out of 288 (10 %)
- Hen15: 13 out of 188 (12 %)

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- We designed a new algorithm in real space and applied it to semianalytical galaxies.
- We study the 3D CG_m in redshift space and we compare it with the HMCG sample.

The Hickson-like samples have low purity and completeness compared to our ideal 3D CG.

Conclusions and Future Work

- We designed a new algorithm in real space and applied it to semianalytical galaxies.
- We study the 3D CG_m in redshift space and we compare it with the HMCG sample.

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Work in progress

What are the observational constraints that best recover the 3D sample?

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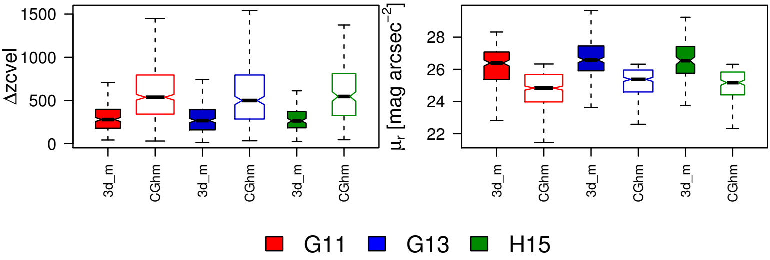
Preliminary result: we found that the observational properties of Hickson-like samples do not reproduce well those of the 3D CGs.



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Gracias

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