Ten Billion Years of Brightest Cluster Galaxy Alignments

[M.J. West, R. De Propis, M. N. Bremer & S. Phillipps, *Nature Astronomy 1 – 0157, 2017*]

[astro-ph arXiv:1706.03798]

Journal Club Astro/Cosmo @ LPSC

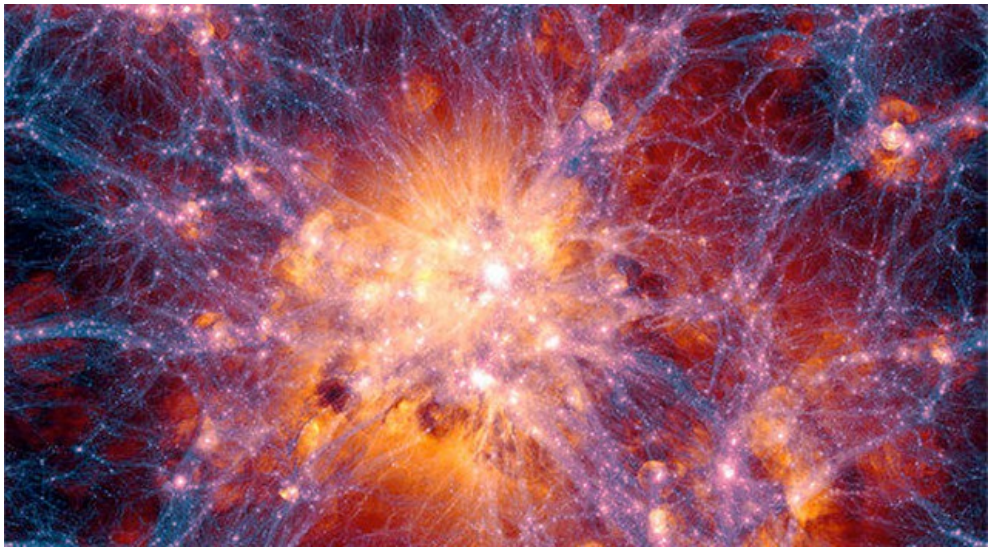
Frite-day the 23rd of June 2017

by Vincent Pelgrims

Ten Billion Years of Brightest Cluster Galaxy Alignments

Context:

- Large-scale structures of the Universe
- Multi-scale alignments (galaxy-cluster-supercluster)
  - Intrinsic alignments galaxy-galaxy
  - Alignments of central galaxy with its cluster geometry
  - Alignments of cluster geometries within their supercluster
  - …
- Alignments = close correlation between *apparent* spin-axes / rotation-axes / morphological axes of the objects



Ten Billion Years of Brightest Cluster Galaxy Alignments

Context:

- Alignments and Brightest Cluster Galaxies (BGC)

  It is 'known' that BCG have tendency to be aligned with the major axis of the cluster they are embedded in
  This has been observed since late '80s but, till now, in the low-z Universe ($z < 0.1$)

- This recent study shows that
  such alignments is observed in the range $0.19 < z < 1.8$
  i.e. up to when the Universe was about 1/3rd of its current age!

- The result suggests that BCGs are the product of a special formation history influenced by development of the cosmic web over billions years

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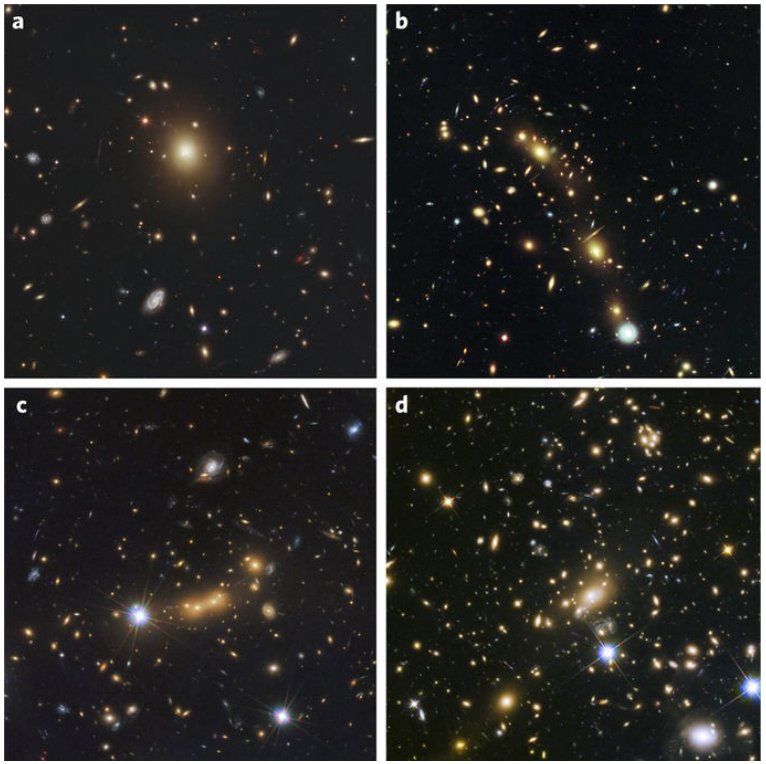
The study:

- Examination of 65 distant galaxy clusters from the HST archive
- Clusters have been first detected through
  - Optical imaging
  - Near-IR imaging
  - X-ray detection
  - SZ observation

'Although incomplete, this sample provides a representative selection of the most massive galaxy clusters at redshifts 0.19 < z < 1.8, corresponding to look-back times ranging from two to ten billion years.'



a) Abell 2261 (z = 0.224)
b) MACS J0416.1−2403 (z = 0.396)
c) MACS J0647.7+7015 (z = 0.591)
d) MACS 1149.5+2223 (z = 0.544)

Ten Billion Years of Brightest Cluster Galaxy Alignments

What they did:

- The 65 clusters contains ~100 to ~1000 red-sequence galaxies (*)
- Determination of the galaxy orientations with GALFIT
  → galaxy Position Angles (PA)
- Determination of cluster PAs using inertia tensor from the 2D distribution of the red-sequence galaxies in cluster
- Uncertainties on cluster PA through 10^5 bootstrap resampling.
  - σPA ~ 10° – 20°
  - Rejection of 13 clusters with σPA > 25°
- Additionaly, some clusters are in CLASH sample (gravitational lensing),
  → cross-check with fitted ellipses to gravitational potentials
  → median difference of cluster PA is 11°

(*) The red-sequence is a well-defined region in color-magnitude space occupied by passively evolving early-type galaxies, mostly elliptical galaxies.
→ that relation can be used to say if the galaxy belong to the cluster of not

Ten Billion Years of Brightest Cluster Galaxy Alignments

What they got is:

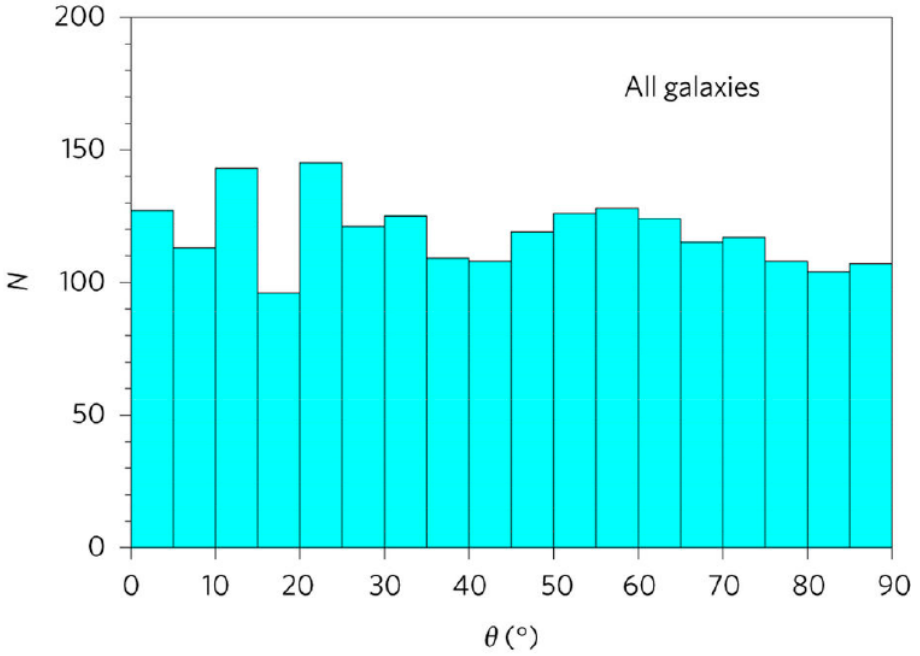
- 52 clusters with
  - ‘reliable’ PA estimates
  - PA estimates of all their components (galaxies) [several dozens of PA]

They compared the clusterPA with the galaxyPA within cluster

- All galaxies:
  Nothing to be said except that the distribution is uniform
  (which is not uninformative btw)

  Here within the 22 CLASH clusters, the histogram of the 2137 ΔPA

  Stat. tests confirm it is uniform.



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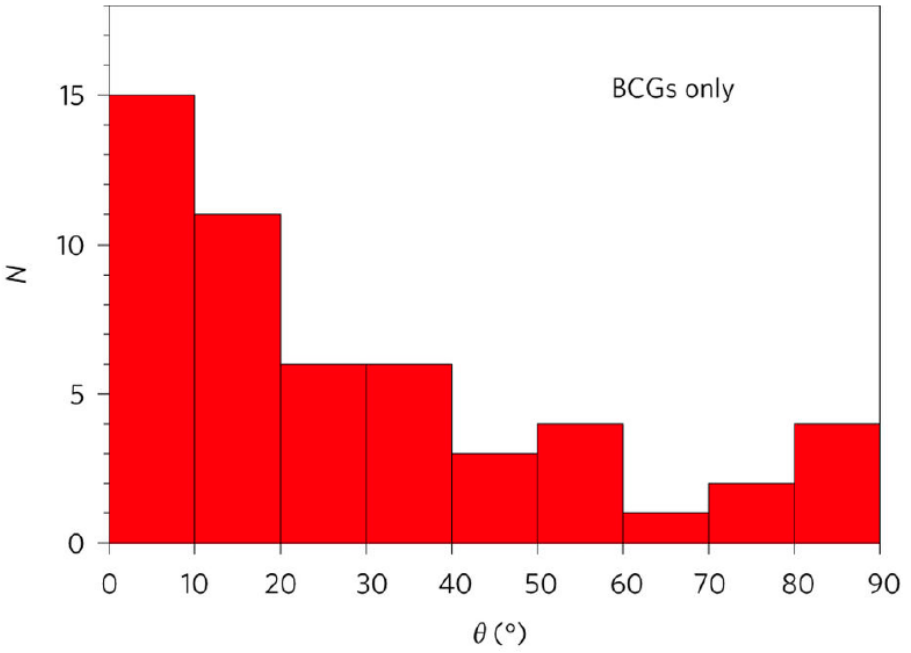
- All galaxies: uniform
- ONLY BCG (~central one) in the 52cls:

  ‘WOW, this is aligned!’

  There is a clear tendency for the major axes of the BCGs to be parallel to that of the clusters

$P_{bin}(\Delta PA<45°) = 0.014\%$
$P_{Kuiper} = 0.0016\%$



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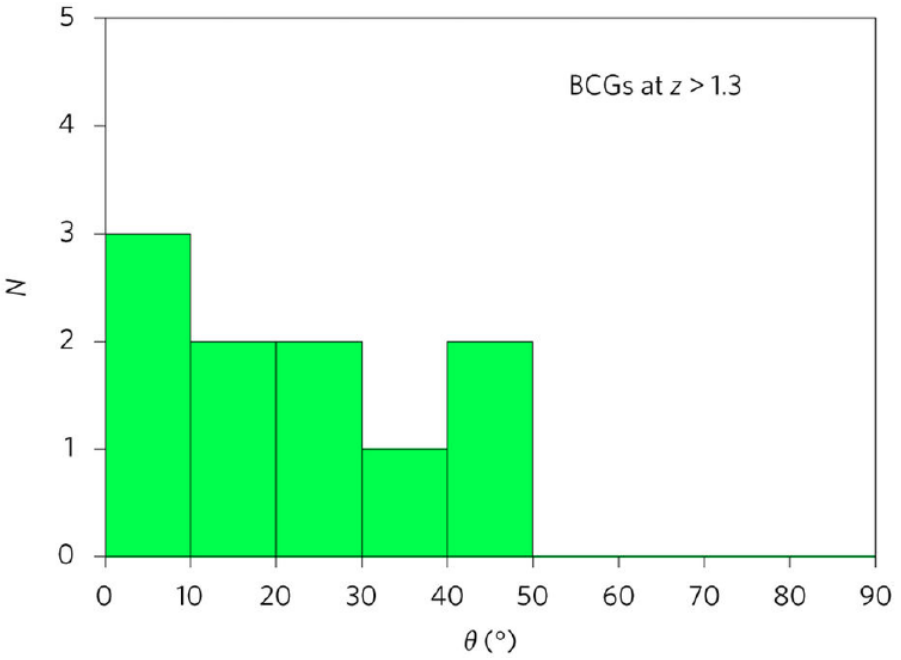
- ONLY BCG (~central one) in the 52cls:
  → alignment tendency
- ONLY BCG at high-z ($z > 1.3$)

‘WOW, the alignments can be observed at high redshift !!!



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- ONLY BCG (~central one) in the 52cls:
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- ONLY BCG at high-z ($z > 1.3$)
  → alignment tendency !
  [THE result of the paper]
- They search for correlation between ΔPA and (for all gal.)
  - Galaxy absolute magnitude
  - Galaxy surface brightness
  - Galaxy ellipticity
  - Difference of magnitude between 1st brightest and 2nd brightest Galaxy

  → no correlation found.

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Results:

- BCG have tendency to align their major axis with that of host cluster
- This is true at high redshift → this was not known
- The primary factor that determines whether a galaxy is aligned or not with the host cluster is that it *must* be the brightest galaxy in the cluster

  → something special about the birth and the evolution of the BCG

Plausible theories for BCG alignments:

- Anisotropic infall of matter into cluster along the preferred directions [e.g. filaments,...]
- Primordial alignment with the surrounding matter distribution at the time of galaxy formation
- Gravitational torques that gradually align galaxies with the local tidal field
- ... some combinations ... And I am sure cosmic string could do the job as well!

→ The observations here do not points towards one specific possibility but just says that the mechanism should be efficient for the alignments to be already in place at high-z !

Ten Billion Years of Brightest Cluster Galaxy Alignments

Take away:

- Do not forget about the alignments of galaxy spins within the Universe!
- Bon appétit
- Do not forget to speak about something crispy in a next Journal Club …
- Thank you
  Merci
  Dank u