Cosmology in University of Seoul

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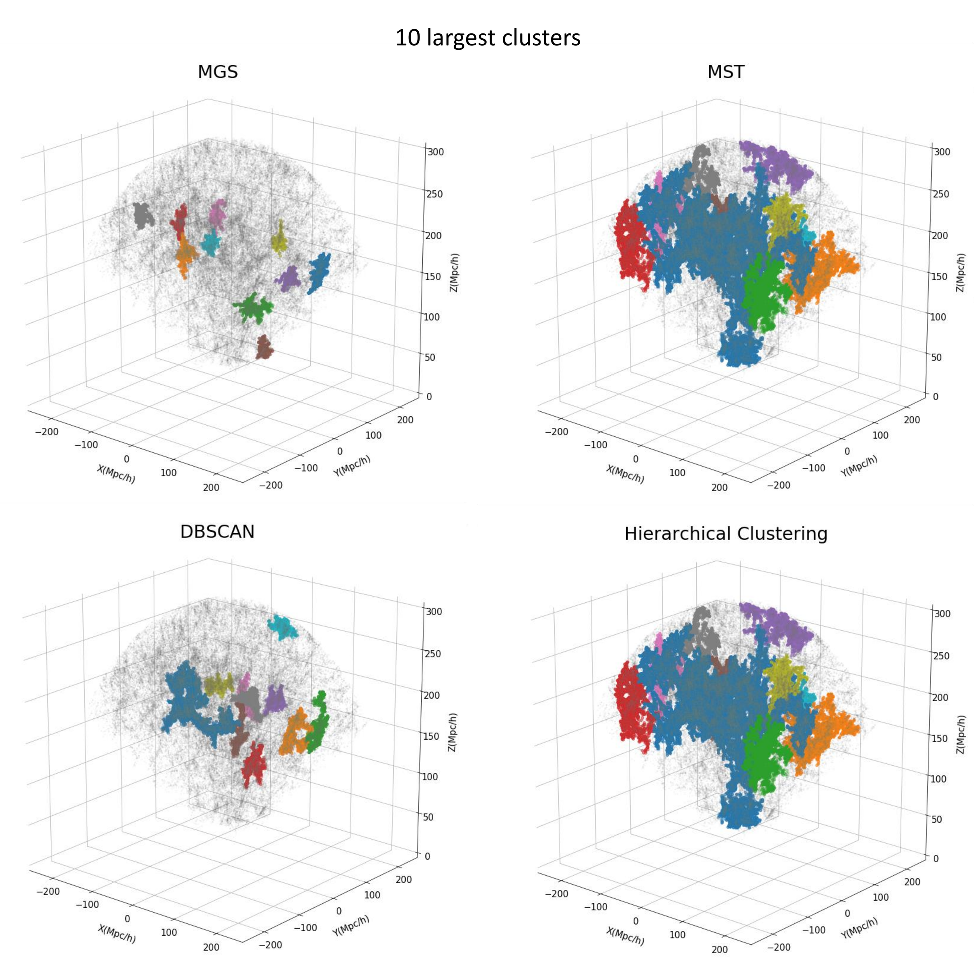
Abstract

In University of Seoul, we study various topics on cosmology such as: comparing traditional clustering algorithms to our new Mulguishin algorithms(Ju, PhD), analysis of 2-body Fuzzy Dark Matter halo collision(Koo, PhD), 2- and 3-point clustering statistics and its dependency on the cosmological model (Hwang&Kim, MD), and dynamics of dark-matter halos around the large-scale filamentary structures(Jhee, MD). We here present a brief introduction to our studies.

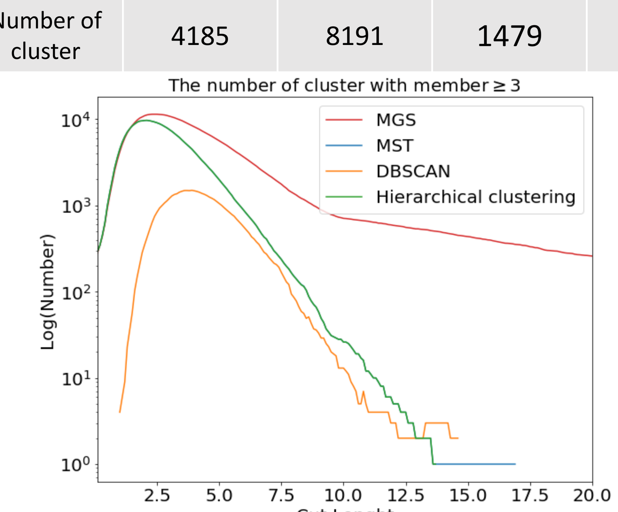
4 Clustering Algorithms

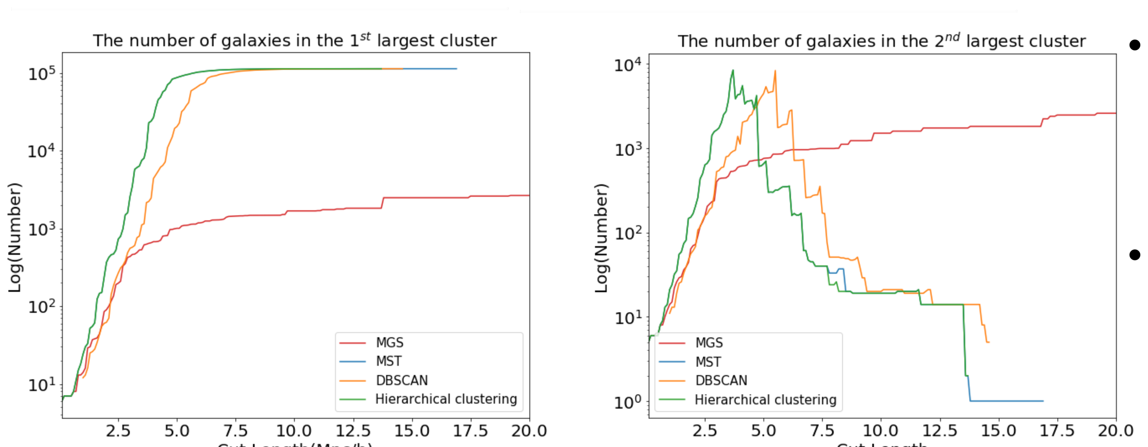
Working with InKyu Park(Univ.of Seoul) and Sungwook E. Hong(KASI)



- Here we compared our new clustering finder algorithm, **Mulguishin(MGS)** developed by Park, with other known algorithms.
- We used KIAS VAGC data with volume limited galaxy samples; $M_r - 5\log h < -20$

Cut length 4.0	MGS	MST	DBSCAN	Hierarchical clustering
Number of cluster	4185	8191	1479	4185



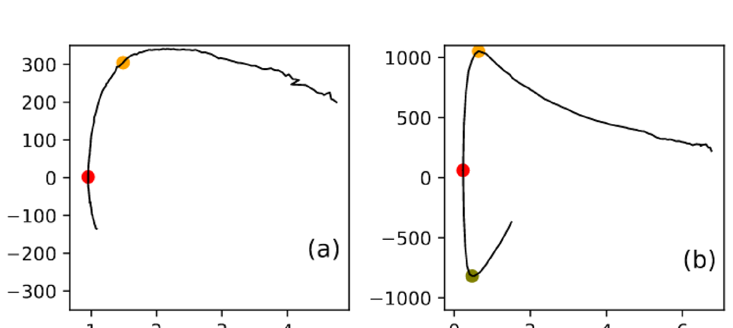


- We investigated the number of galaxies in the 1st and 2nd largest clusters by changing cut length.
- The notable feature is that the number of galaxies is consistent in large cut length for **MGS** algorithm while all of galaxies are absorbed into one largest cluster for other 3 algorithms

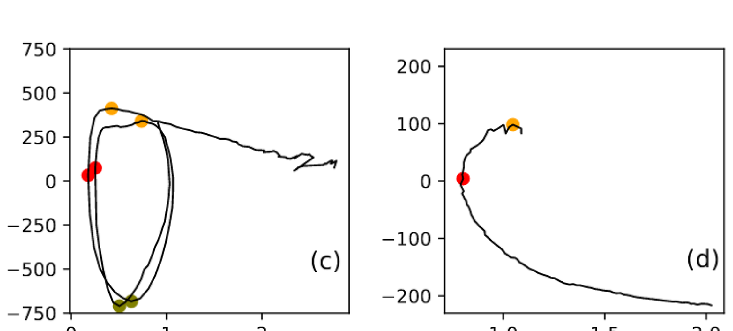
Halos around the Filaments

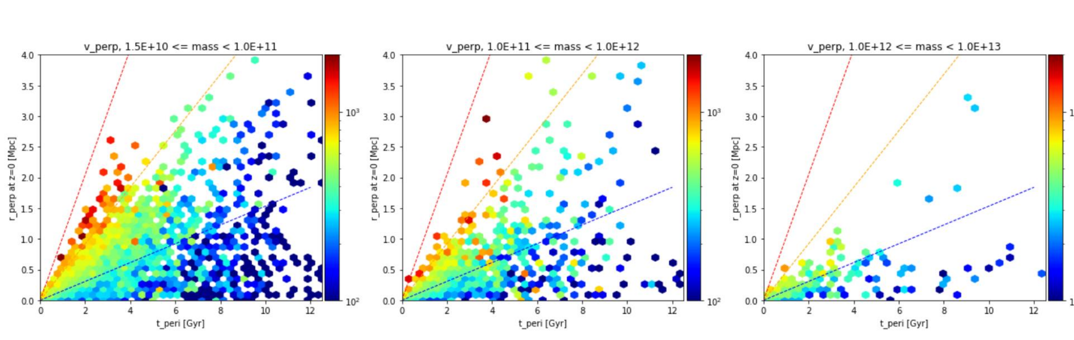
Working with Hyunmi Song(Yonsei), Rory Smith, and Jihye Shin(KASI)

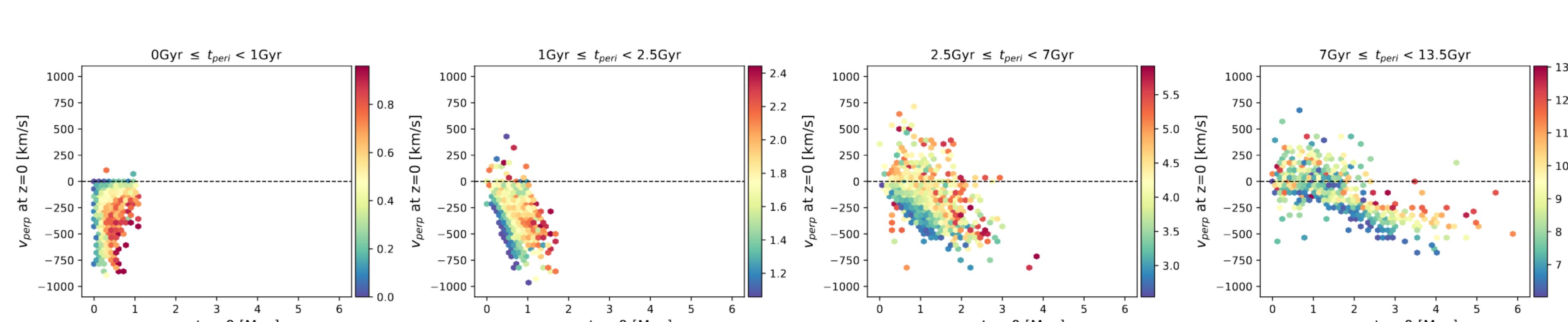
What happens when halos are falling into the gravitational potential of the 1-dimensional structure of the universe, the filaments? We do the research using the phase-space diagrams.



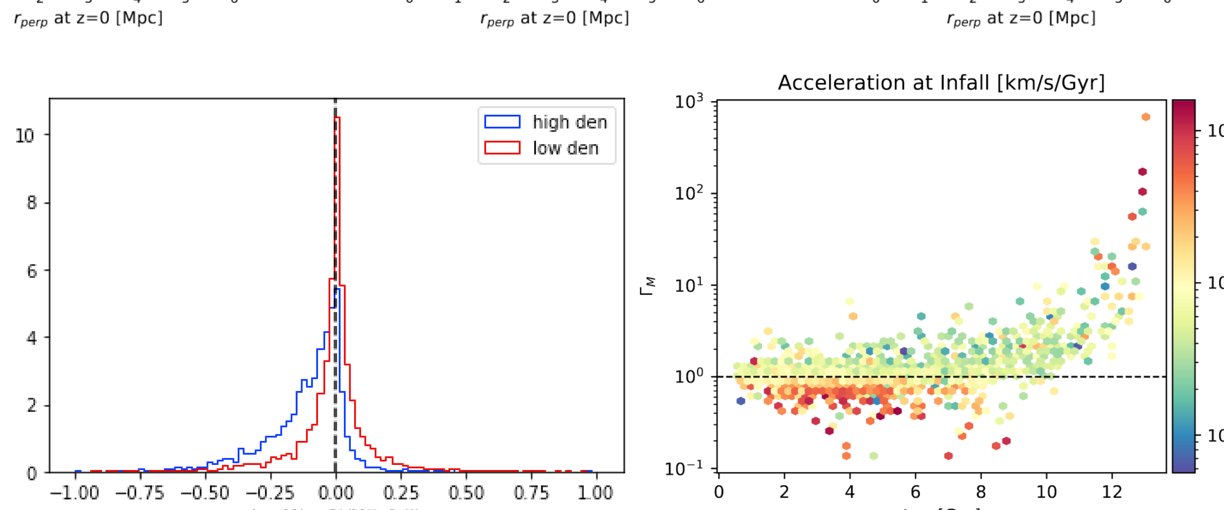
Halos either are captured by the gravitational potential of the filament structures, as in (a) and (b), or just escape as in (d). Virialization process and dynamical friction effect for high mass halos can be seen from two plots below:







Halo mass evolution is highly relevant to the acceleration (high acc makes mass loss), which is relevant to the filament density.
In the figures in the right, you you can see the density



Collision of Fuzzy Dark Matter Halos

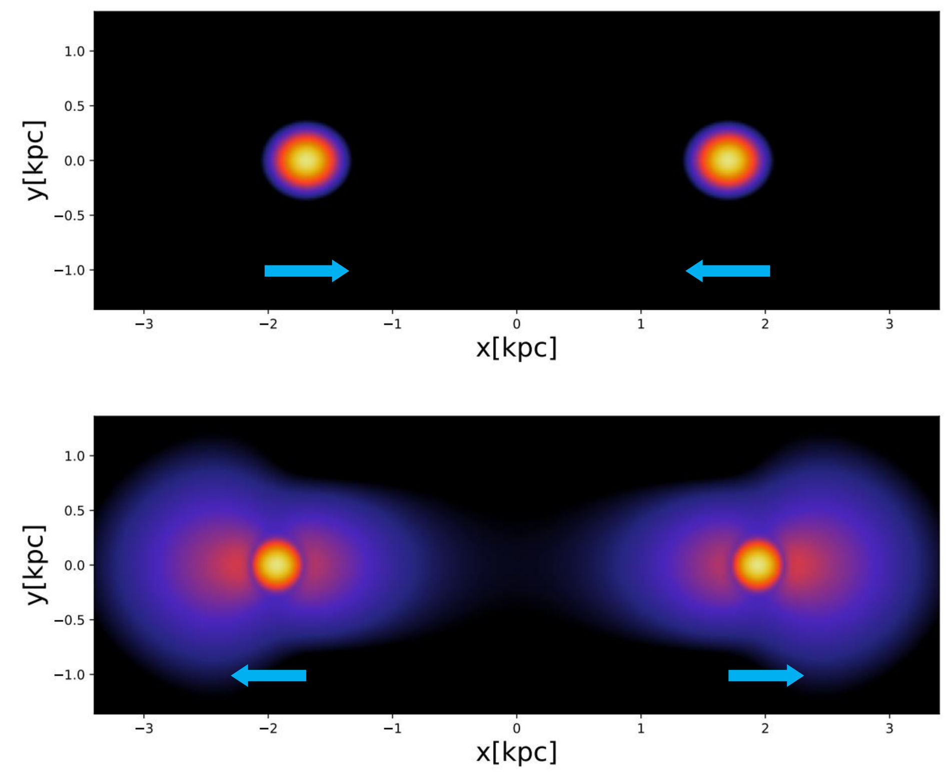
Working with Dongsu Bak, Sangnam Park(Univ.of Seoul), Jaewon Lee(Jungwon Univ.)

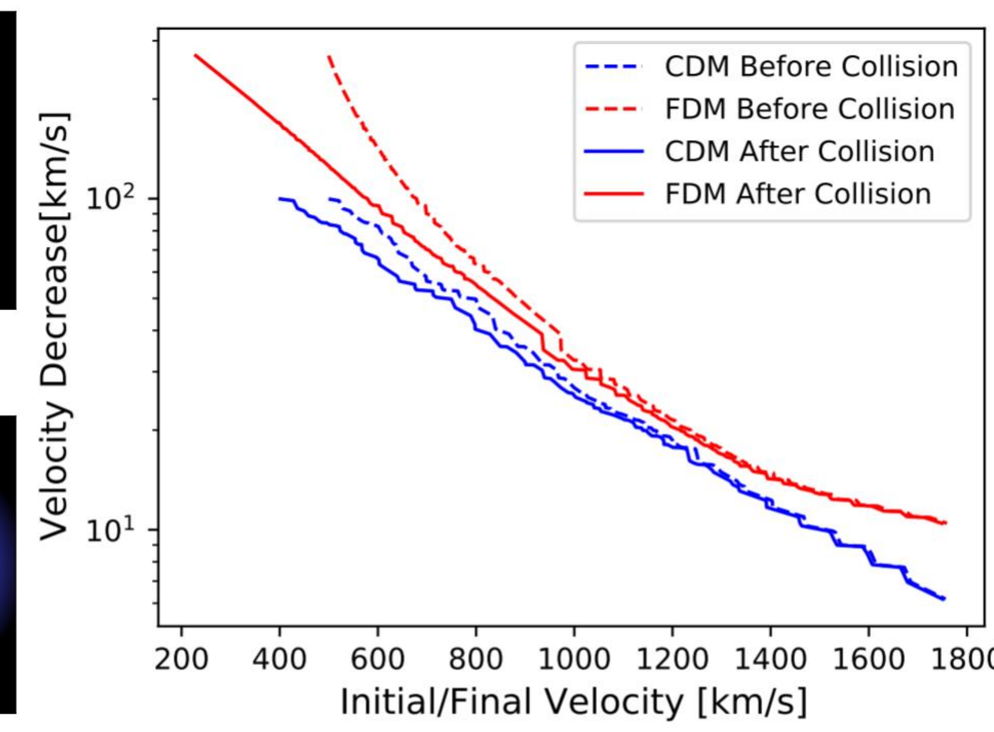
The mass density profile of Fuzzy Dark Matter(FDM) is defined from the Schrodinger-Newton equation below.

$$-\frac{\hbar^2}{2m}\nabla^2\psi + mV\psi = i\hbar\frac{\partial\psi}{\partial t} \quad \Rightarrow \quad \psi(\vec{x},t) = \alpha f(\sqrt{\alpha}|\vec{x}-\vec{v}t|)e^{i\left(\alpha\beta t+\vec{v}\cdot\vec{x}-\frac{1}{2}|\vec{v}|^2 t\right)+i\delta}$$

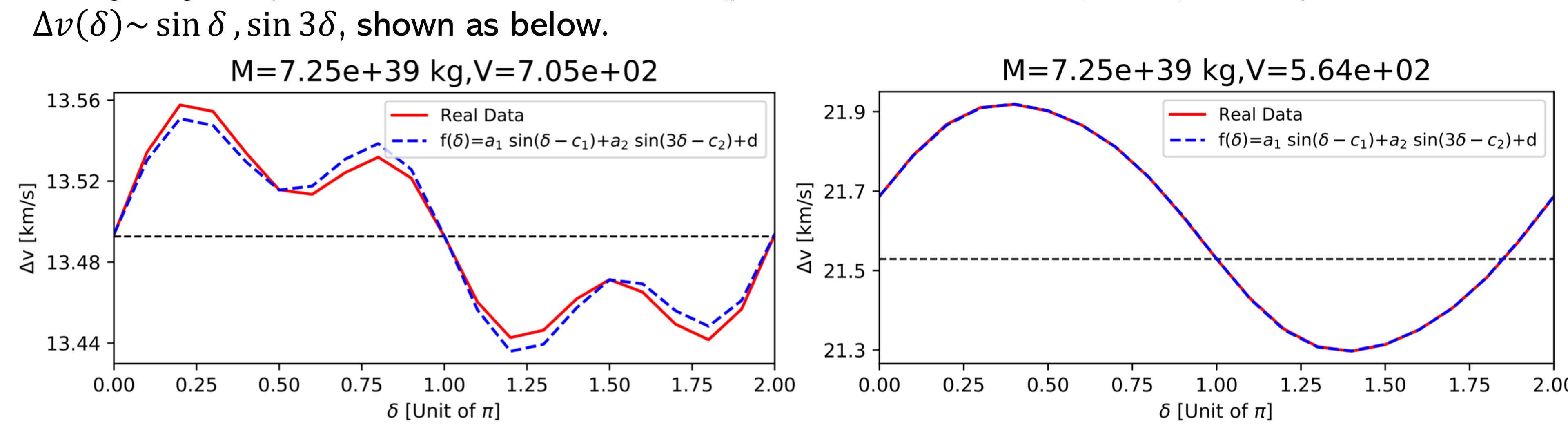
$$\nabla^2 V = 4\pi G m|\psi|^2 \qquad \rho(\vec{x},t) = |\psi(\vec{x},t)|^2$$

Two FDM Halos are getting closer with same initial speed and mass. The velocity decrease before and after collision Δv due to gravitational cooling compared with CDM could be plotted as below.



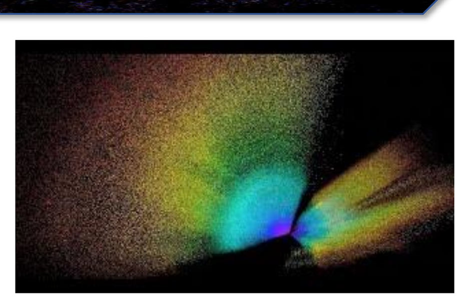


For giving the phase difference of two halos(parameter δ shown at $\psi(\vec{x},t)$), Δv depends on δ like $\Delta v(\delta) \sim \sin\delta, \sin 3\delta$, shown as below.

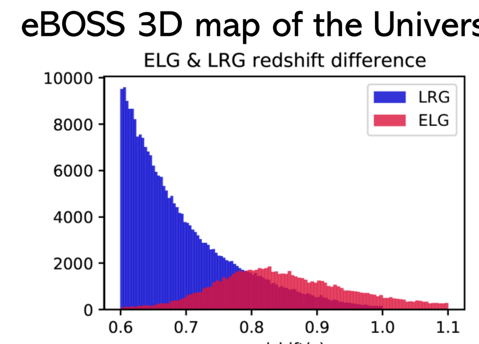


CHOA(Cosmology with Higher Order Astrostatistics)

Aim: Constrain the cosmological model using the large-scale spatial distribution of galaxies. The clustering of galaxies can inform us about the **expansion history of the Universe (Dark Energy)** and the **growth of density perturbations (Gravity)**. Our goal is to determine whether higher order clustering statistics can improve model constraints and, if so, put them into practical use.



eBOSS 3D map of the Universe



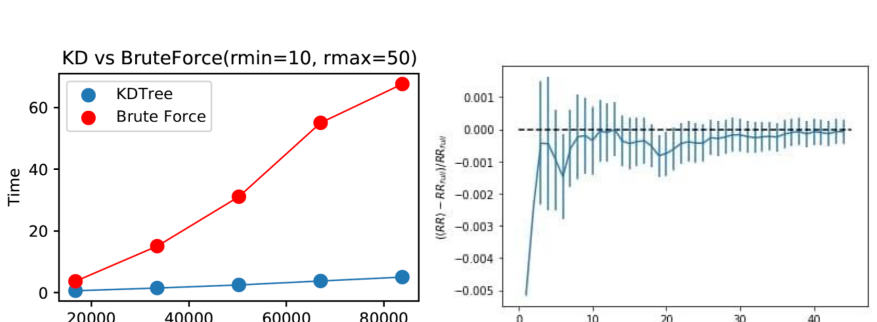
Data & Method:
We used SDSS eBOSS:
ELG (Emission Line Galaxies)
LRG (Luminous Red Galaxies)

	# of galaxies	# of random
ELG	83,769	3,728,363
LRG	255,741	13,180,418

We compute the 2- and 3-point correlation functions using the estimators below.

$$\xi = \frac{DD - 2DR + RR}{RR}, \qquad \zeta = \frac{DDD - 3DDR + 3DRR - RRR}{RRR}$$

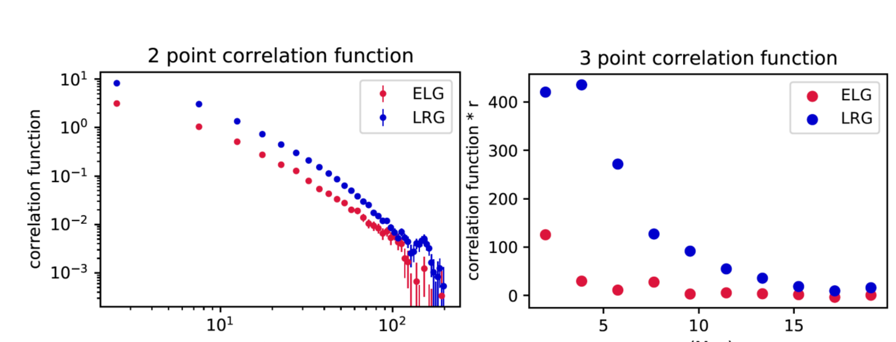
Here D means data catalog and R means random (reference) catalog. Computing these statistics is computationally expensive. So, we introduce two methods to reduce that:
1) utilize a tree-based neighbour search 2) subsample the Random catalogue



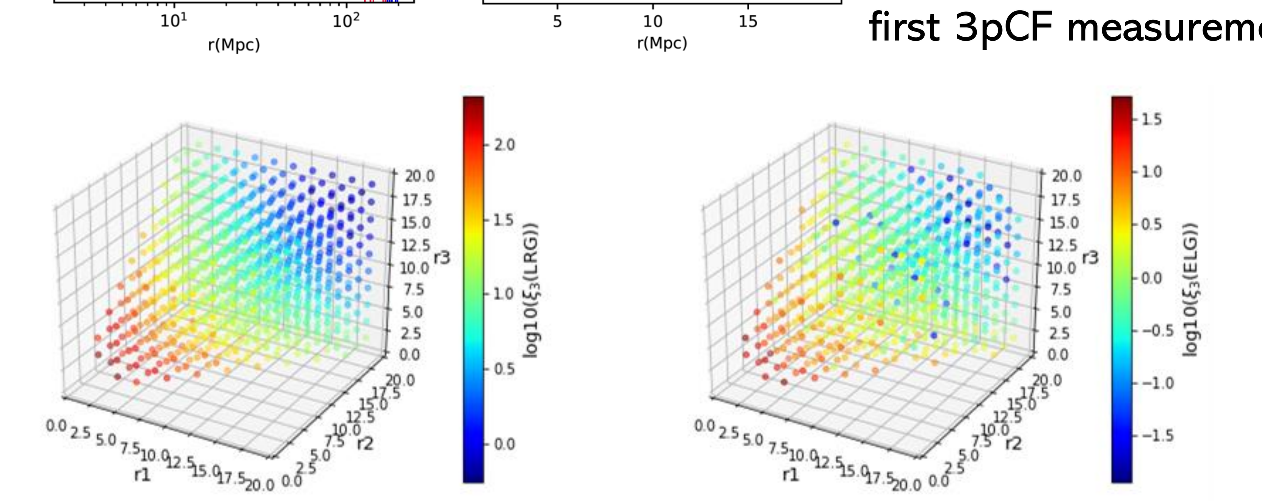
Because random data is so large it took long time to calculate, So we divide the random data into 43 chucks. each with the same number as the galaxy data and by adding one chunk at a time, the average was calculated (y-axis value).

- Black line : when we use whole large random data (not chunk), it took 8 min 40s.
- Blue line : If chunks are added and averaged (it took only 43s), you can see blue line goes closer to black line.

Preliminary Results:



In the left plot, there is 2-point correlation function with ELG and LRG(x and y are log scale). In the right plot, there is equilateral 3-point correlation function with ELG and LRG(y value is 3-point correlation function multiplied by r) Also this the first 3pCF measurements of eBOSS ELG!



← The 3-point correlation function of LRGs (*left*) and ELGs (*right*) with $0 < r_1, r_2, r_3 < 20$[Mpc] in 10 bins.