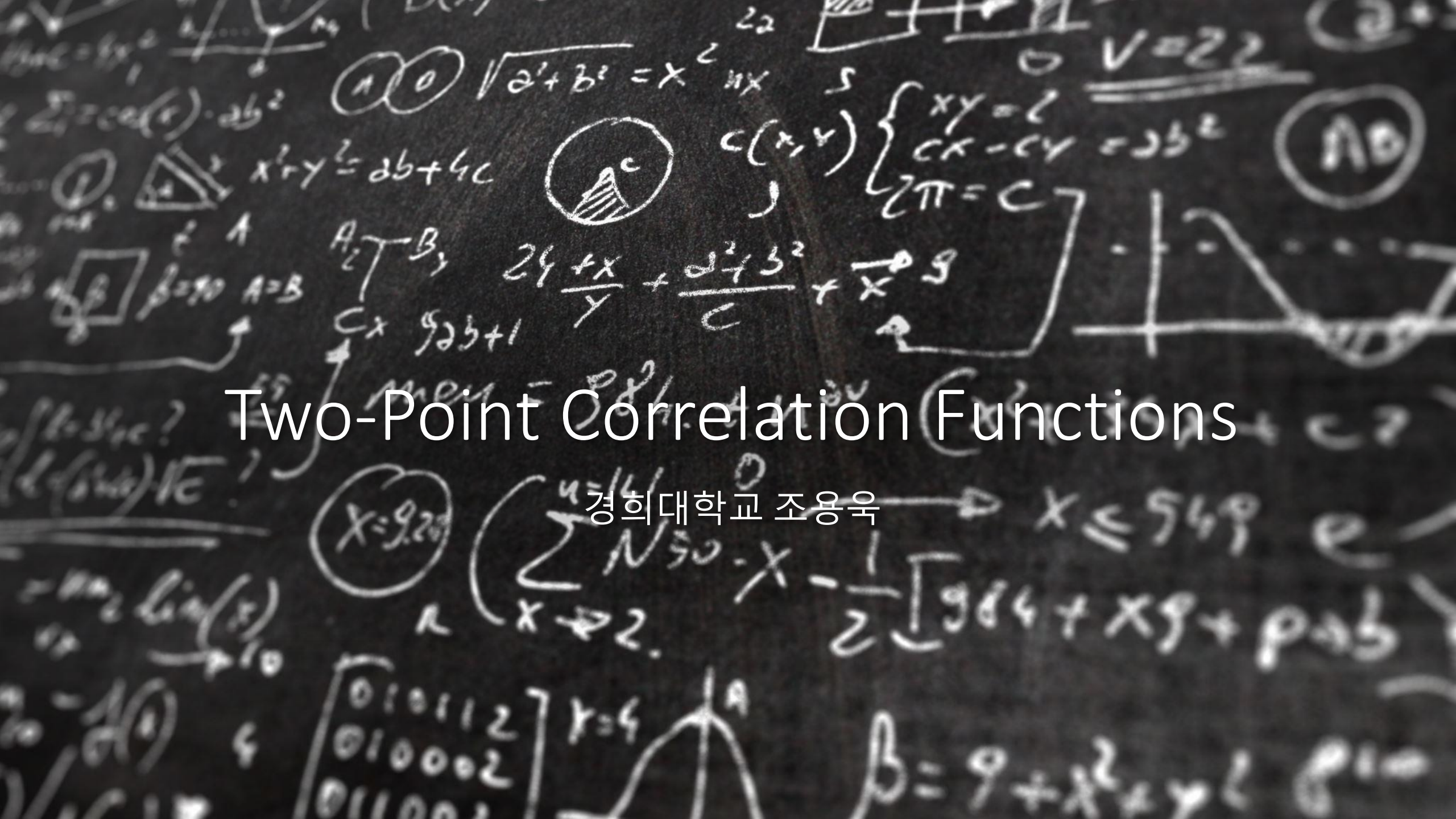


Two-Point Correlation Functions

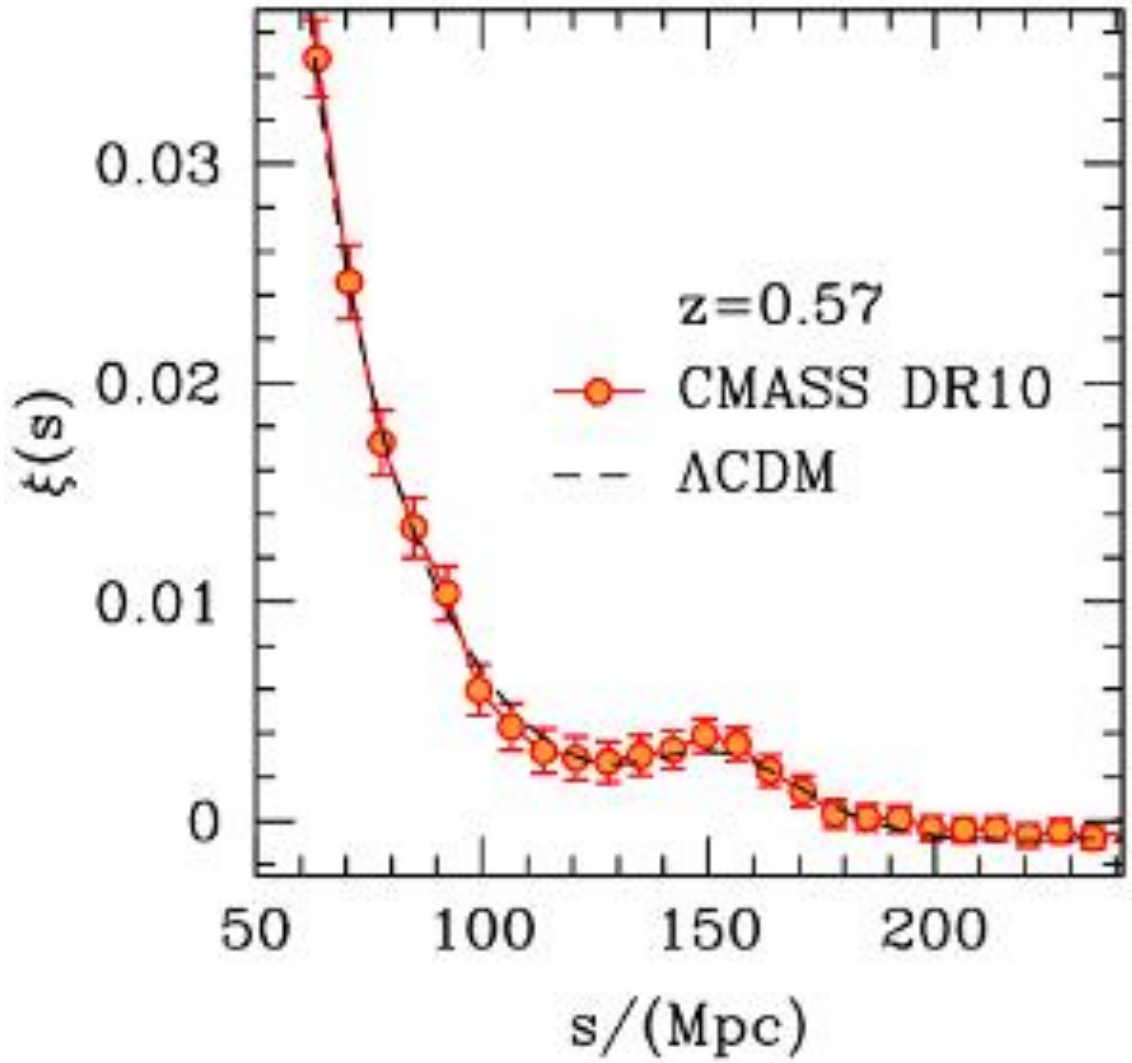
경희대학교 조용욱

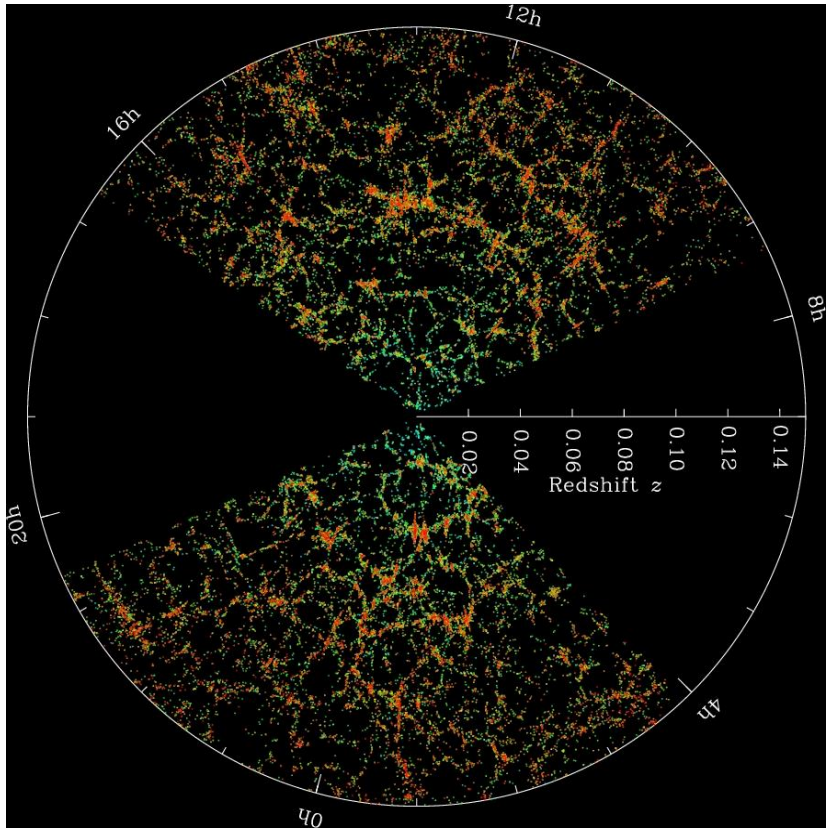
Reference

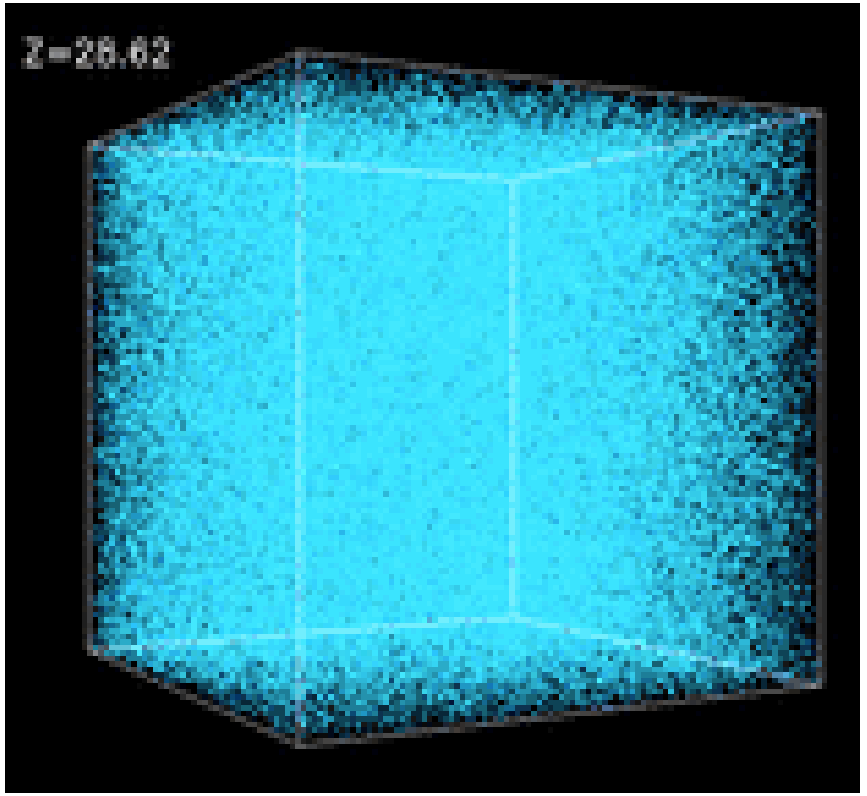
- Caltech, Galaxies & Cosmology 9-3 Large Scale Structure Power Spectrum https://www.youtube.com/watch?v=fYQnGyE1c64
- Caltech, Galaxies & Cosmology 9-2 **Galaxy Clustering The Two Point Correlation Function** https://www.youtube.com/watch?v=cTUVzoYDztU
- Donghui Jeong, **KIAS 여름학교 2022 외부은하와 우주론 I. 이점 상관함수 (two-point correlation function) https://www.youtube.com/watch?v=sT7FAvI1XTs**

What is Two-Point Correlation Functions?

- 은하들의 분포를 수치화하기 위한 함수
- 한 은하의 위치에서 특정 거리만큼 떨어졌을 때 다른 은하를 발견할 확률
- ->은하들이 무작위로 있지 않고 뭉쳐(clustered)있는 정도를 나타내는 함수




12h
16h
8h
20h
4h
0h
0.02
0.04
0.06
0.08
0.10
0.12
0.14
Redshift z


Z=26.62

Functional Forms

$$\xi(r) = \frac{P_2(x, x+r)}{P_1(x)P_1(x+r)} - 1$$

$P_1(x) \propto n(x)[1+\delta(x)]$: x에서 은하 하나를 찾을 확률

$P_2(x_1, x_2) \propto n(x_1)n(x_2)[1+\delta(x_1)][1+\delta(x_2)]$

: 좌표 1,2에서 모두 은하가 있을 확률

여러 부분에서 계산하여 평균을 내면 δ^2 항만 남음

$$\therefore \xi(r) = \langle \delta(x)\delta(x+r) \rangle$$

관측방법

- D : 관측된 은하목록
- R : 관측의 효과를 포함한 무작위 목록

1. David & Peebles (1983) $\xi(r) = \frac{DD}{DR} - 1$
2. Hamilton (1993) $\xi(r) = \frac{(DD)(RR)}{(DR)^2}$
3. Landy-Szalay (1993) $\xi(r) = \frac{DD - 2DR + RR}{RR}$

Power Spectrum

$$\xi(r) = \int \frac{d^3k}{(2\pi)^3} P(k) e^{i\vec{k}\cdot(x-x')}$$

$$\langle \delta(k)\delta(k') \rangle = (2\pi)^3 P_g(k) \delta^D(k+k')$$

->파워 스펙트럼은 correlation function의 푸리에 변환

-> 이론적으로 fluctuation을 나타내기 쉬움 (orthogonal function)

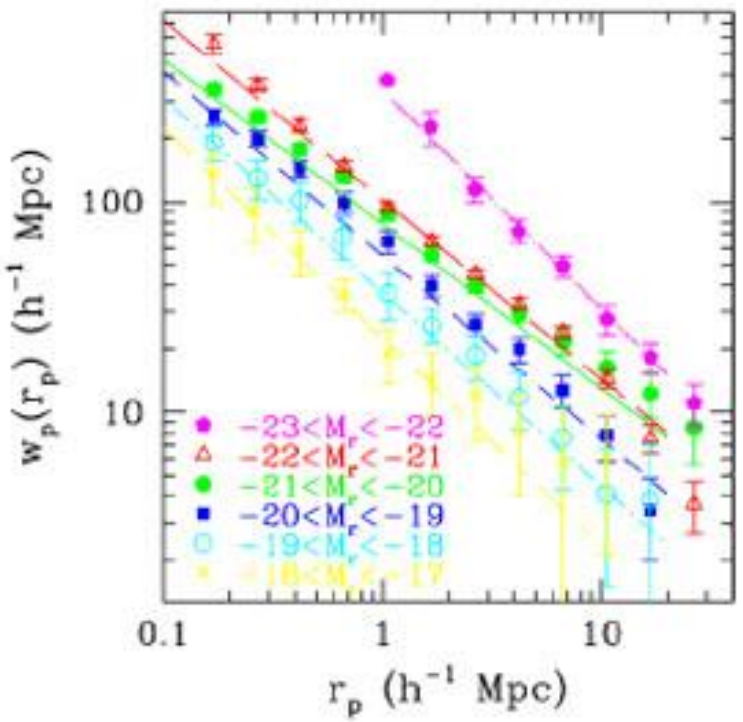
활용1 : Galaxy Clustering Analysis

$$\xi(r) = (\frac{r}{r_0})^{-1.77}, r < 10h^{-1}Mpc$$

$$r_0 \sim 5h^{-1}Mpc$$

1. Luminosity Dependence

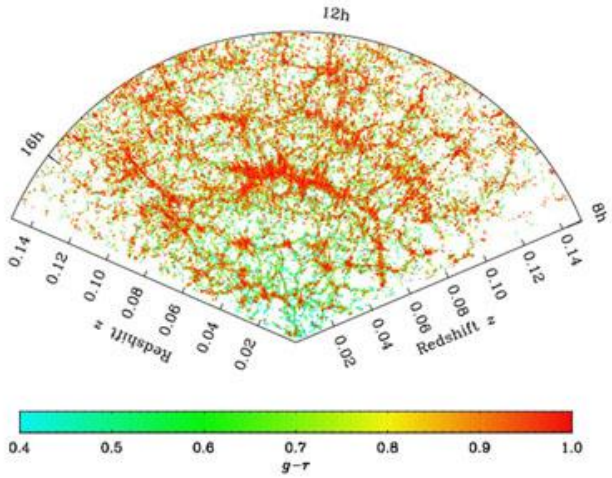
->The brighter, The more Clustered

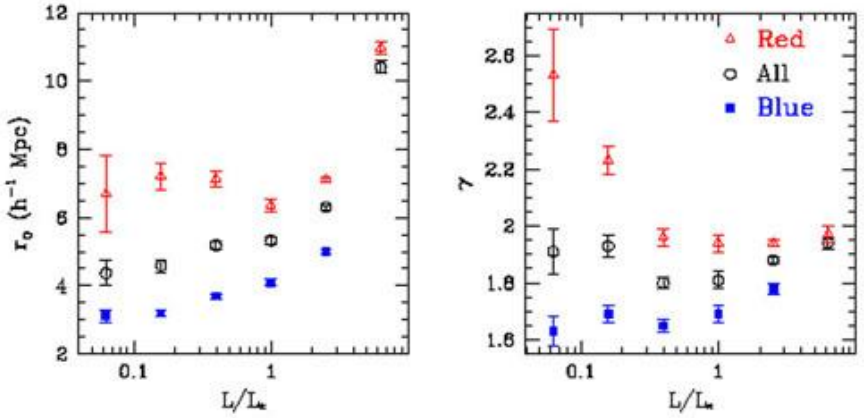


활용1 : Galaxy Clustering Analysis

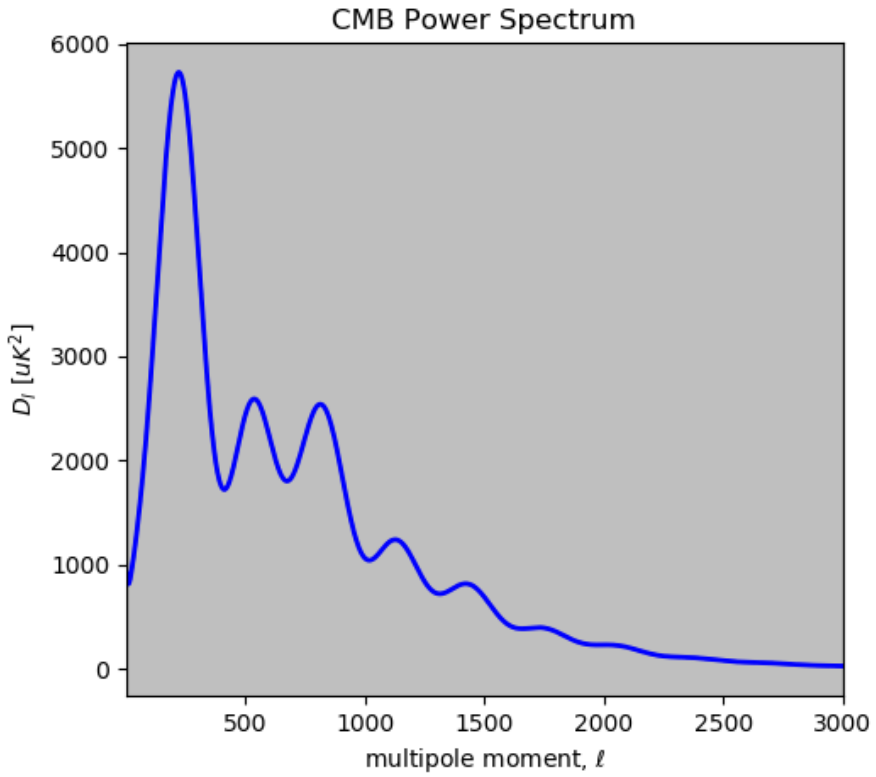
2. Color and Spectral Type Dependence

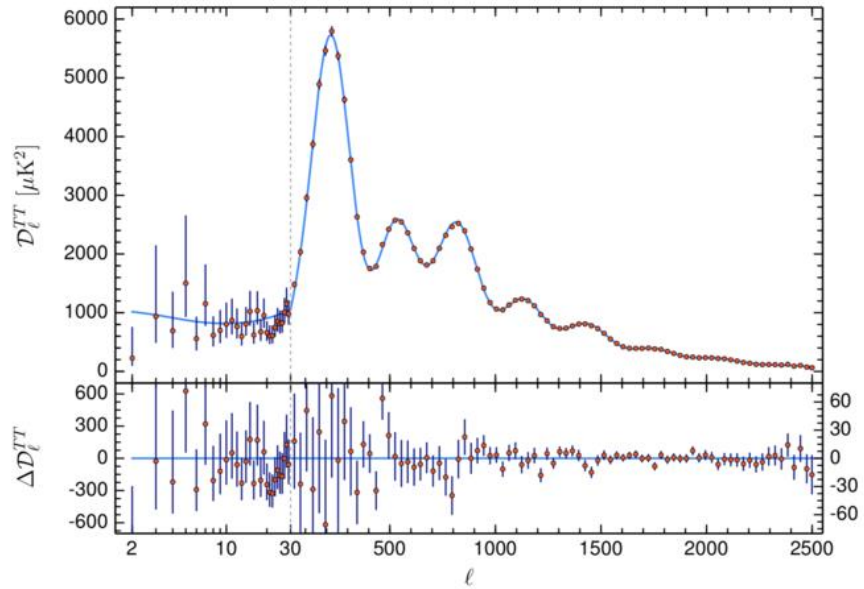
-> The redder, The more Clustered

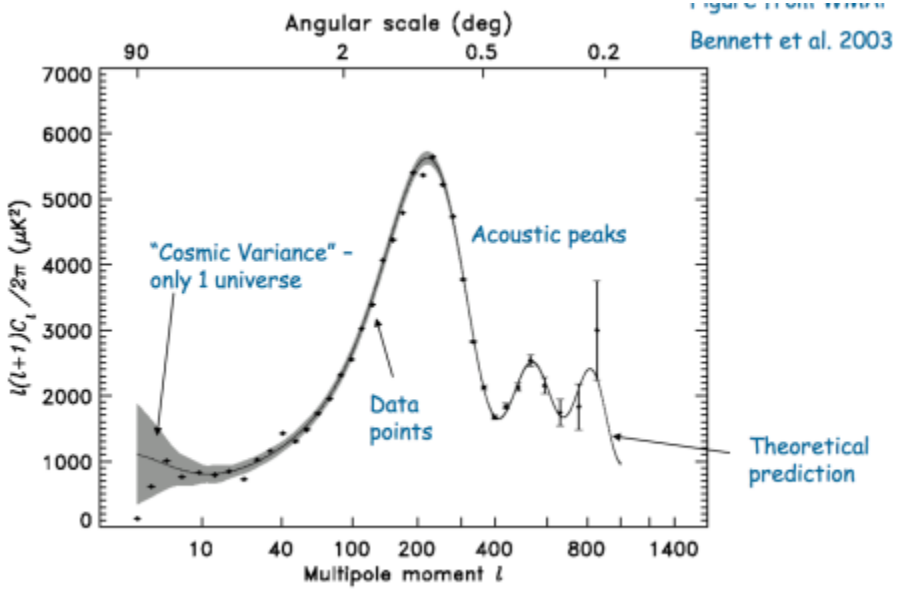




활용 2 : CMB Analysis

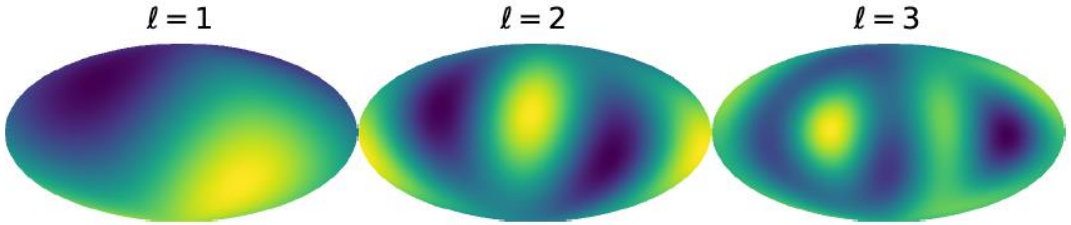


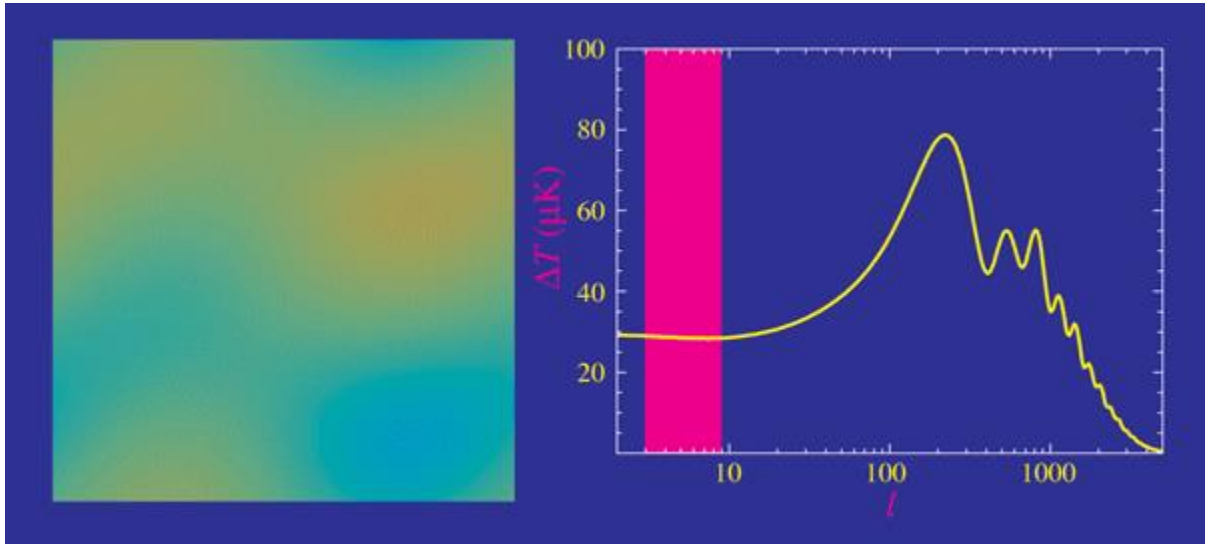




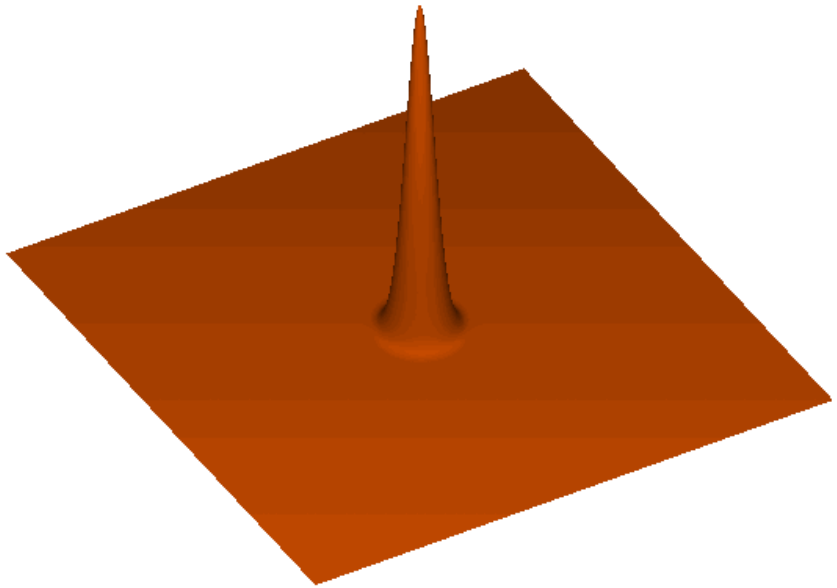
활용2 : CMB Analysis

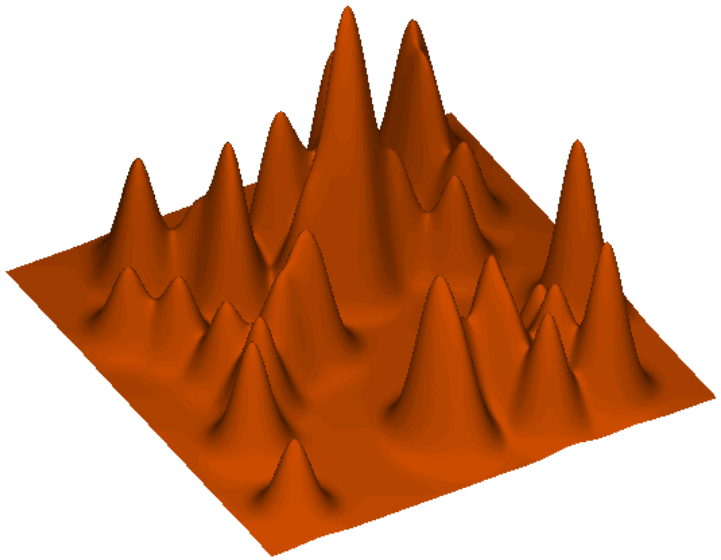
$$T(\theta,\phi) = \sum_{lm} a_{lm} Y_{lm}(\theta,\phi)$$
$$C_l = \langle a_{lm} a_{lm}^* \rangle$$

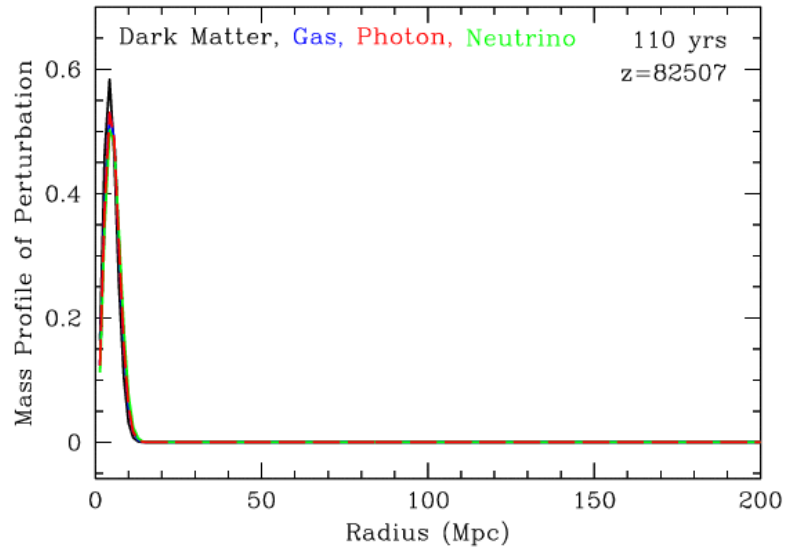




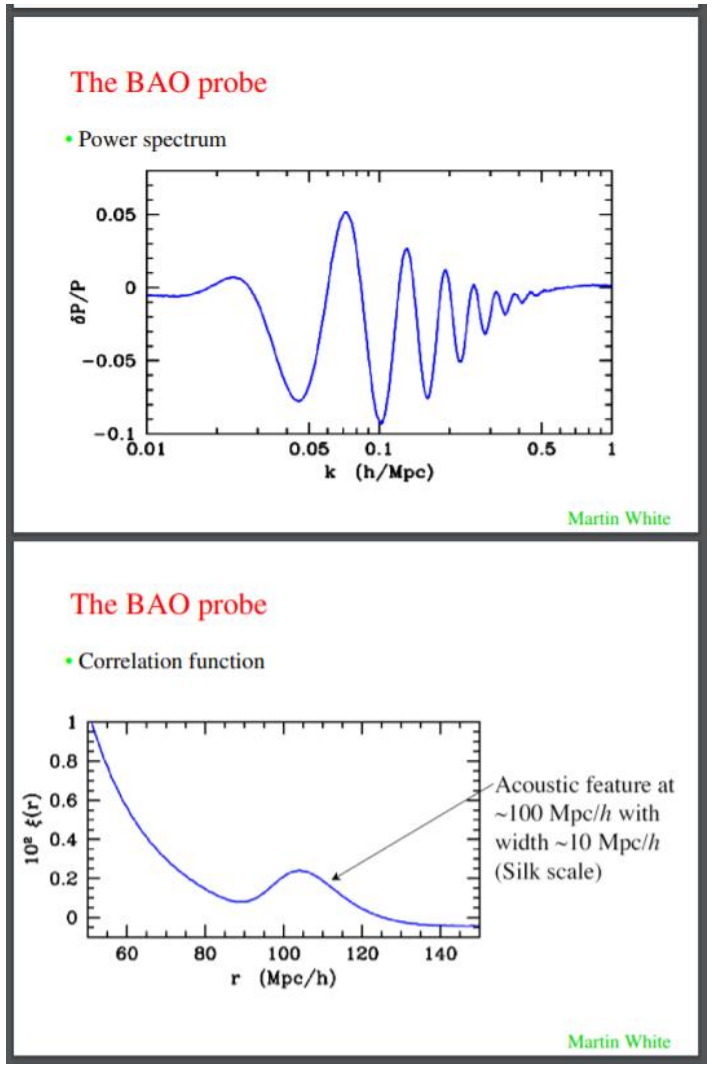
활용 3 : BAO Search

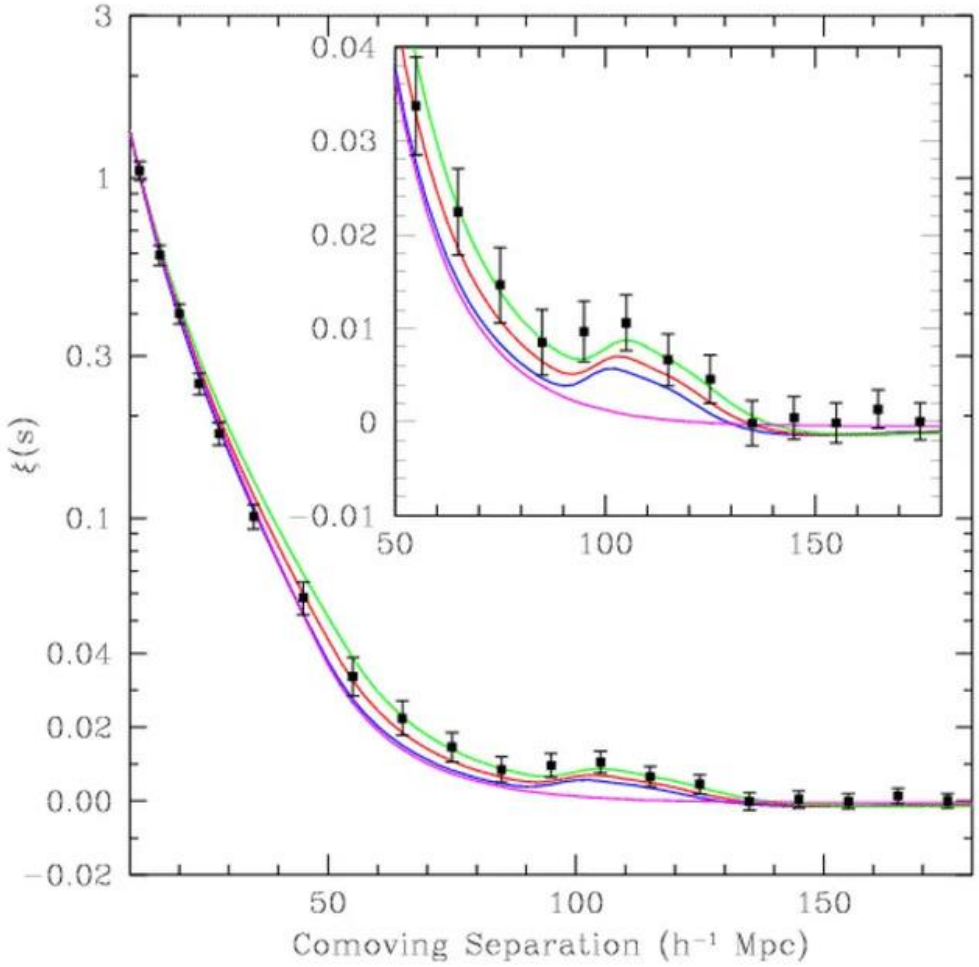




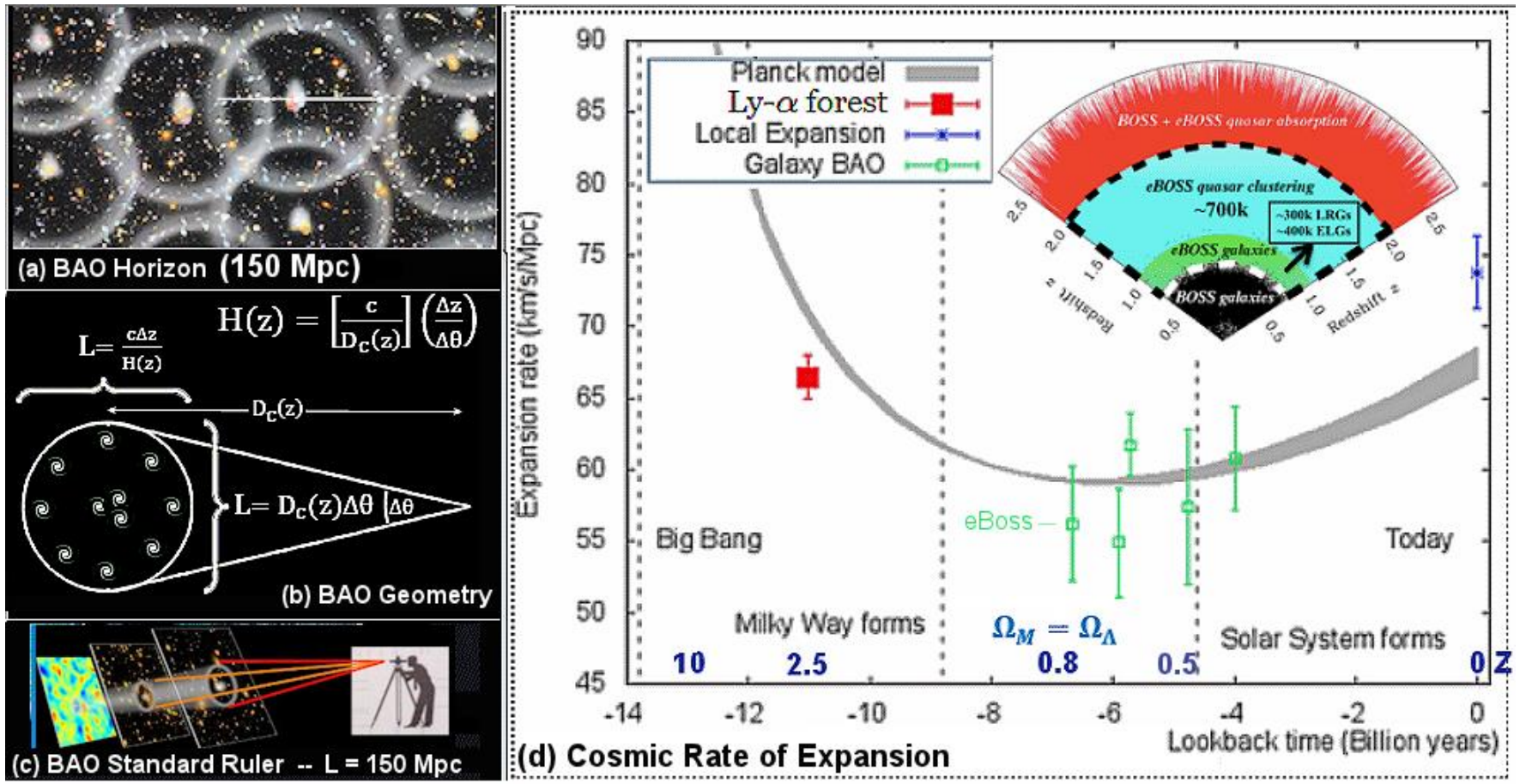


활용 3 : BAO Search





활용 3: BAO Search



THANK YOU!