

LARGE QUASAR GROUPS

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QUASARS

- Quasi-stellar Radio Sources
- Subset of Active Galactic Nuclei
 - AGNs are compact and extremely luminous regions at the center of galaxies
- Identified as strong EM radiation sources, especially radio and visible, similar to stars.
- Spectra contains broad emission lines, unlike stars.
- Luminosity 100 times greater than Milky Way Galaxy
- Size, not much larger than our Solar System
 - Extremely high energy density

SIGNIFICANCE OF QUASARS

- Show very high redshift (evidence of expansion of universe)
- Implied that Quasars are extremely distant and ancient entities.
- Some of the most luminous and energetic objects in the Universe.
- Gravitational lensing predicted by Einstein's General Theory of Relativity were confirmed by double images of some quasars

HISTORY

- First discovered in 1960s as radio sources, later found to have a corresponding visible light.
- Unsure of what they were, spectral lines were observed to be much different than stars.
 - They were actually spectral lines of hydrogen receding at 15.8%
 - Corresponds to the object receding at 47,000 km/s (15% of speed of light)
- Early theories were that quasars could be made of stable antimatter or could be the white hole end of a wormhole
- Luminosity possibly due to accretion disc of supermassive black holes
 - Converts 10% of objects mass into energy (nuclear fusion of sun is 0.7%)

LARGE QUASAR GROUPS

- Collection of quasars that form the largest structures in the known universe
- Universe seems to follow a hierarchal model of organization

Structure		Scale	
Stars	10 ⁶ km		10 ⁻⁸ pc
Galaxies		10 ⁵ ly	10 ⁴ pc
Galaxy Groups			10 ⁶ pc
Galaxy Clusters			10 ⁷ pc
Superclusters			10 ⁸ pc
Large Quasar Groups			10 ⁹ pc

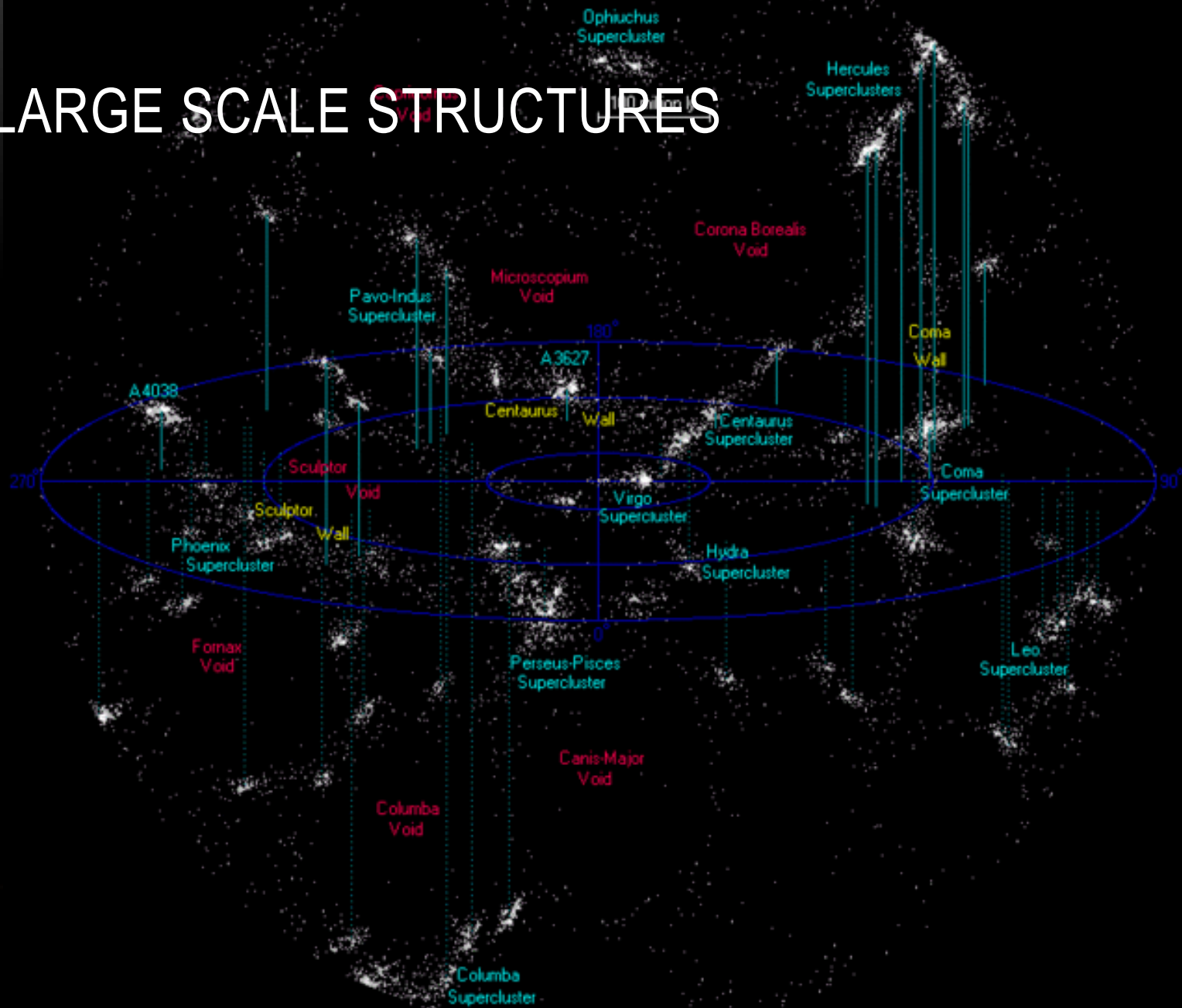
LARGE QUASAR GROUPS

- Large Quasar Groups form sheets, walls, and filaments that tend to follow web-like strings of dark-matter through the universe.
- These massive structures are separated by great voids
 - Voids are nearly empty spaces with diameter between 10-150 Mpc
- The combination of walls and filaments separated by voids is known as the cosmic web
- No known larger structures

MAPPING LARGE SCALE STRUCTURES

- Sloan Digital Sky Survey (SDSS-III)
- Began in 2000, started its 3rd phase in 2008
- Maps the 3D spatial positions of galaxies and quasars.
- Determining projected position is relatively easy, but determining objects' distance is much more difficult.
- Redshift is the change in frequency (specifically decrease of f) of radiation due to the relative motion of the object to the observer.
- SDSS-III uses linear red shift for “nearby” objects and relativistic redshift for much further objects.
- This technique, among others, is used to create a 3D map of our universe
 - See video at end of presentation

LARGE SCALE STRUCTURES

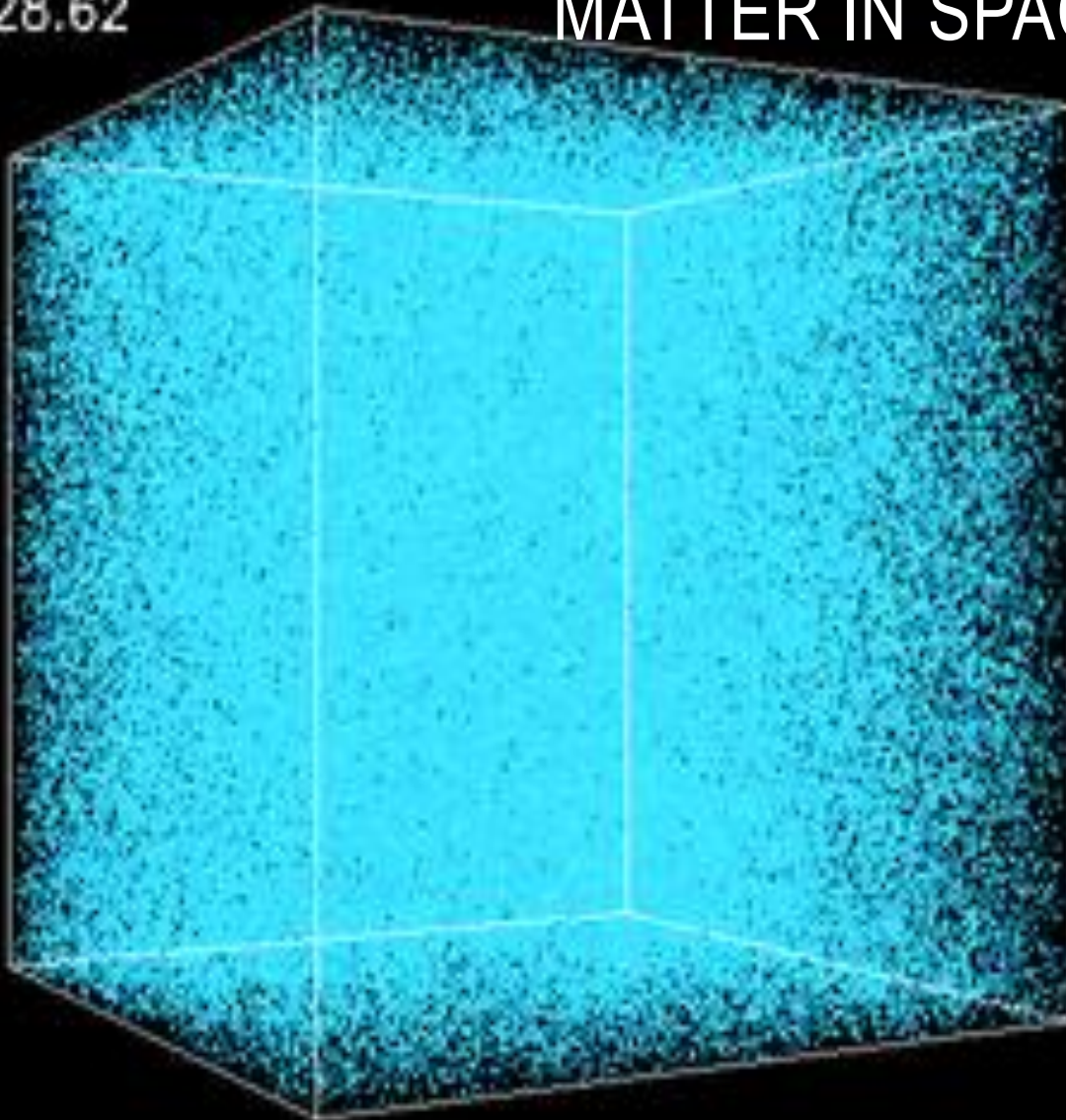


HOMOGENEITY OF THE UNIVERSE

- Cosmological principle is the idea that when viewed on a large enough scale, the universe would appear to uniform in structure with no irregularities
 - Universe looks the same whoever and wherever you are
 - Universe looks the same in whatever direction you look
 - “Looks the same” refers to consistency of physical constants and ratios
- The largest LQGs may challenge the principle of homogeneity of the universe.
- According to some calculations, for homogeneity to hold true, structures in the universe should be larger than ~ 350 Mpc
- However, the largest LQG found, the Huge-LQG, has an elongated shape whose largest dimension is ~ 700 Mpc

3D DISTRIBUTION OF MATTER IN SPACE

$z=28.62$

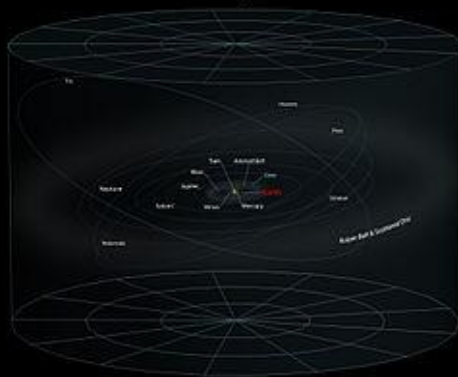


- This is not the whole universe, but just a cubic sample of it (which can represent any cubic area because theoretically the universe looks the same everywhere)
- <http://cosmicweb.uchicago.edu/filaments.html>

Earth



Solar System



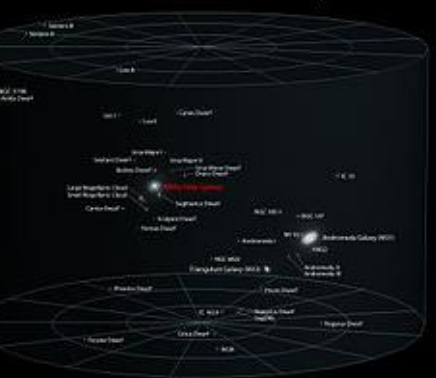
Solar Interstellar Neighborhood



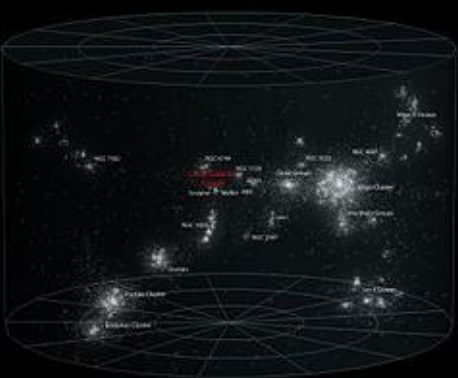
Milky Way Galaxy



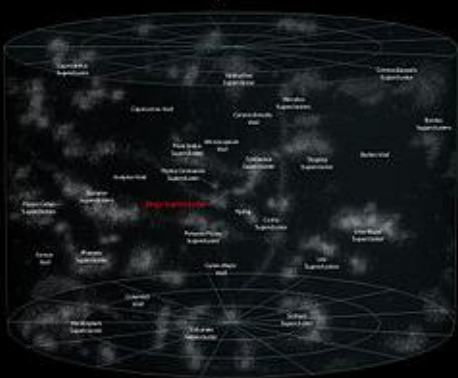
Local Galactic Group



Virgo Supercluster



Local Superclusters



Observable Universe



FRACTAL COSMOLOGY

- Fractals are mathematical objects that look the same regardless of the scale at which you view them.
- Russian Nesting Dolls are a physical example of a fractal
- The universe appears to be fractal-like in nature but it is believed that Large Quasar Groups are the “Largest Nesting Doll” and there are no larger structures.
- Astronomers counted number of galaxies in large random spheres, and compared those densities to that of a random homogenous distribution and observed an extreme similarity
- Even distribution of mass through universe confirms Einstein’s Theory of General Relativity. (Never Doubt Einstein!)

SDSS VIDEO

- <https://www.youtube.com/watch?v=08LBItPDZw>
- 3D version
- <https://www.youtube.com/watch?v=qZolE9t8lZc&feature=plcp>

REFERENCES

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- <http://mnras.oxfordjournals.org/content/282/3/713.full.pdf+html>
- <http://arxiv.org/pdf/1108.6221.pdf>
- <http://www.space.com/17234-universe-fractal-large-scale-theory.htm>



DISCUSSION QUESTIONS

- What is the nature of the universe? Finite, Looping, Infinite, Fractal?
- How do we observe such large scale structures?
 - Neutrinos: 10^{-24} m
 - Humans: 10^0 m
 - Largest LQG: 10^{26} m
- Why is dark matter distributed the way that it is?

