Sloan Digital Sky Survey:
SDSS_DR7

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Question to Explore

- What are the **significances** of the **farthest** luminous objects found in the 7th data release of the **Sloan Digital Sky Survey**?

Sloan Digital Sky Survey

- This project, using the SDSS telescope, has made the most detailed 3D map of the universe, by mapping various luminous objects such as galaxies, quasars and stars.
- Captured images and spectra of over 3 million stellar objects with SDSS -VI.
- Future phases to be enacted with SDSS-V.
- We will be looking at data from SDSS-II, due to accessibility. Specifically, at quasars and galaxies.

Background

- **Redshifts** (represented by **z**): the shift in wavelength of light from when it was emitted from its origin to when it was observed on Earth. This shift is the result of the light losing energy as it travels through space. Redshifts of objects are proportional to their distances relative to Earth (the larger the redshift, the larger the distance).
    - The farther something is from Earth in Space, the farther back in time astronomers are able to see. We see objects as they were; not as they are today.

Background

- **Quasars**: Quasi-stellar radio sources share identical spectra, which is what this project captured. The spectra are like fingerprints of the various wavelengths of light that emit from luminous objects. This is presented as a variety of emission and absorption lines throughout the electromagnetic spectrum.

- Galaxies are similar, especially from the earlier ages of the universe, where there were still only relatively light elements forming within stars.

Redshifts from sdss_dr7

- Note: z on vertical axis represents the redshift
- Very few luminous objects at higher redshifts → younger age of the universe
- Nearer objects at lower redshifts do seem bluer compared to farther objects at higher redshifts (exaggerated color scheme).
- Data pulled from dataset where sdss_dr7 page mentioned to find quasars and galaxies:
  - PLATE numbers between 673 and 714.

Objects v. Redshift (z)

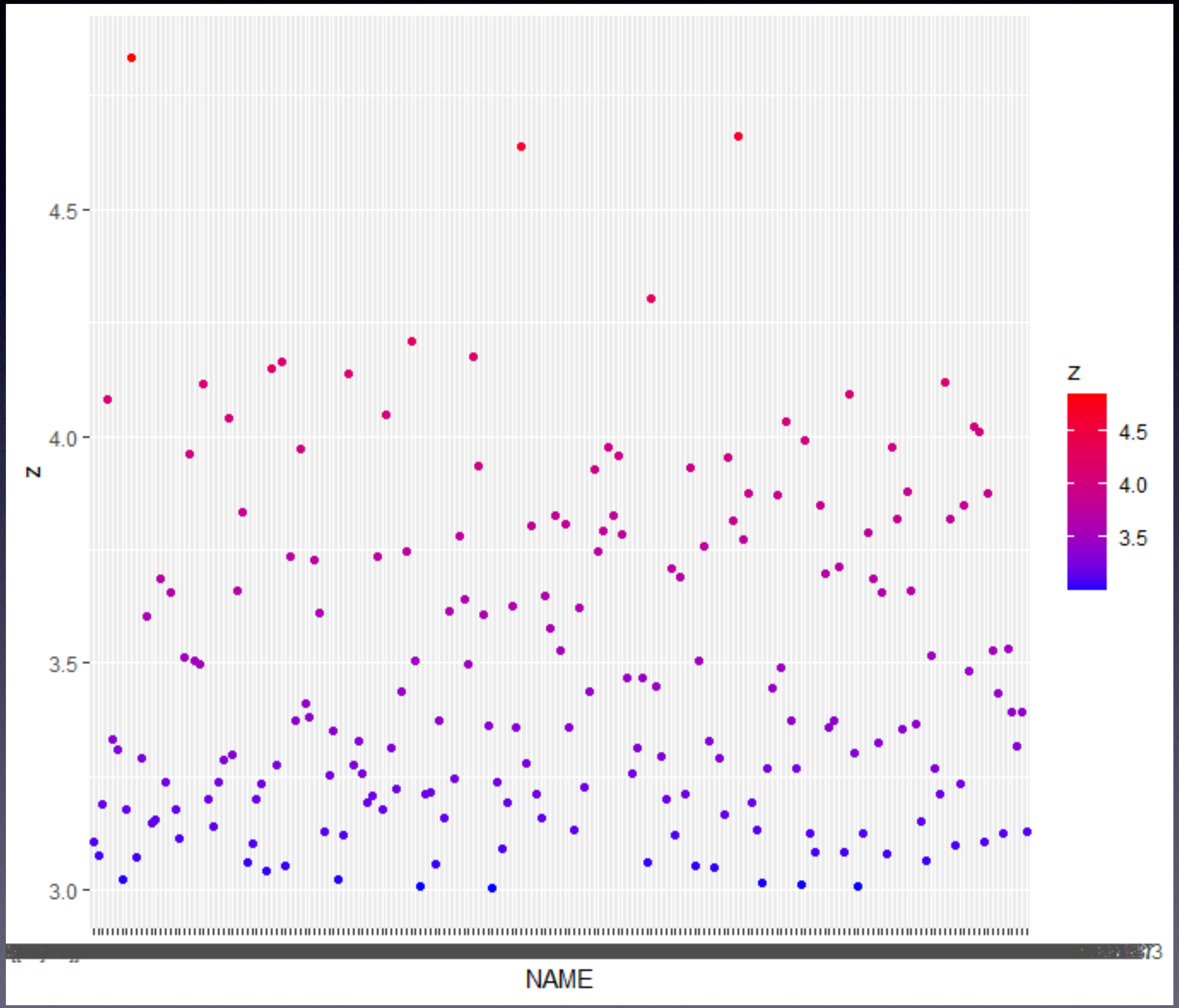

Figure: Displays the number of objects at redshifts in the interval $3 \leq z < \sim 4.9$.
sdss_dr7 data used to create visualization.

Useful Equations

Hubble's Law: $cz = H_0 d$, where $H_0 \approx \dfrac{1}{4.4x10^{17} seconds} \rightarrow 14$ billion years (this is the hubble constant is the inverse of the age of the universe), $c = 2.99x10^8 \dfrac{m}{s}$, and d is the distance from the origin of emitted light to Earth. This means, if we know the redshift, z, then we can solve for the distance, which gives

$$d = \frac{cz}{H_0},$$

and determine how far these farthest objects are from us!

If we use the following relation between the redshift and the scale factor of the universe,

$$a = \frac{1}{1+z},$$

we can even find the size the universe was relative to the size it is now at the time the light we received left its point of origin, back in time!!

Data Statistics and Calculations

	Redshift
Minimum	3.006700039
Maximum	4.832699776

Using these numbers, we can find the corresponding distances based on the equation mentioned: $d = \frac{cz}{H_0}$,

with our constants: $H_0 \approx \frac{1}{4.4x10^{17}seconds}$ and $c = 2.99x10^8\frac{m}{s}$.

So for the

- minimum redshift, $d = 3.96x10^{26}$ meters $\approx 4.2x10^{10}$ lightyears $\approx 1.3x10^4$ Mpc (Mega parsecs).
- maximum redshift, $d = 6.36x10^{26}$ meters $\approx 6.7x10^{10}$ lightyears $\approx 2.1x10^4$ Mpc.

This is what we would expect with the relationship discussed earlier: a larger redshift, z, corresponds to a larger distance, d. It is stated that at such large redshifts as our maximum, it is more logical to use the relation to the scale of the universe as Hubble's law becomes less exact (Carrol).

More Calculations

	Redshift
Minimum	3.006700039
Maximum	4.832699776

- If we wanted to find out the size of the universe at these corresponding redshifts, we look to use the second relationship mentioned previously:

$$a = \frac{1}{1+z}.$$

So for the

- minimum redshift, we get a result of $a \approx 0.25$. This means the universe was a quarter of the size it is today when this light was emitted from its origin, $1.3x10^4$ Mpc away.

- maximum redshift, we get a result of $a \approx 0.17$. This means the universe was about a fifth of its current size when this light was emitted form its origin, $2.1x10^4$ Mpc away

This is what we would expect with the relationship discussed earlier: a larger redshift, z, corresponds to a larger distance, d.

Conclusion

- The Sloan Digital Sky Survey has done a very well done and extensive deed by mapping the universe, allowing mankind to be able to distant stellar objects as they were billions of years ago.
- As it probes for such luminous objects, astronomers and cosmologists are able to assess what the universe may have been like at some obscure stages in its life, such as:
  - The Cosmic Dark Ages
  - The Cosmic Dawn
  - The Epoch of Reionization

These stages still hold a lot of mystery, but as technology progresses, only more information can be gained.

References

- Data from
  - big-query-public-data.blackhole_database.sdss_dr7.
- Research from

  - *Carroll, B. W., amp; Ostlie, D. A. (2007). An introduction to modern astrophysics. Pearson Addison Wesley.*
  - *SDSS Data Release 7, classic.sdss.org/dr7/.*