Dark Energy Report

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Scientific Importance and Motivation

Dark energy is a mysterious component of the universe which is believed to be responsible for the accelerated expansion of the universe and is primarily studied from type la supernovae. A type la supernova is a type of supernova that occurs when two stars are orbiting one another, where of the stars is a white dwarf. Supernovae observations provide significance evidence for the existence of dark energy. Data from these supernovae implies that the universe's expansion is accelerating, which cannot be explained by any known forms of matter.

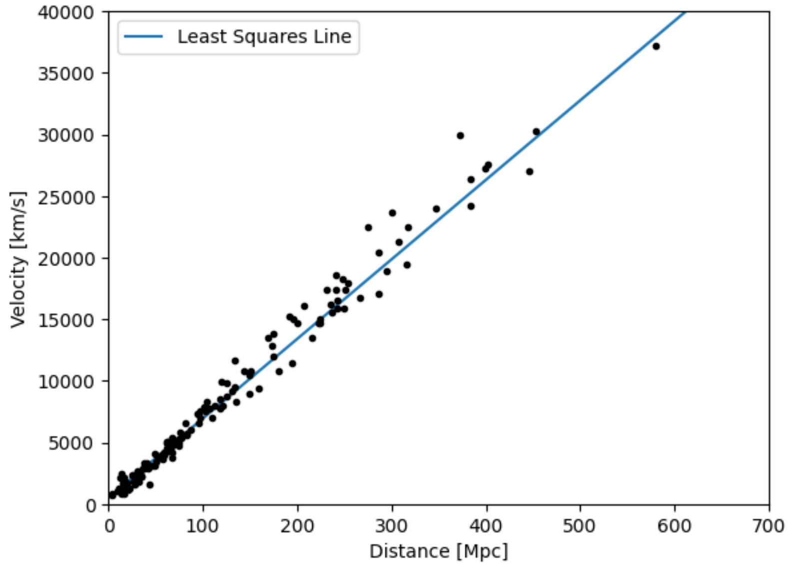
Math

Hubble's Law describes the relationship between the redshift of galaxies and their recession velocities. It states that the velocity of a distant galaxy moving away from an observer is directly proportional to its distance from the observer. Mathematically, it is expressed as $v = H_0 D$, where v is the recessional velocity, H_0 is the Hubble constant (a measure of the current expansion rate of the universe), and D is the distance to the galaxy. By knowing the distance to a type la supernova, we can apply Hubble's Law to calculate the recession velocity of the galaxy where the supernova is located. However, we need to first find the Hubble constant.

Method

In my work, data from well observed type la supernovae within 700 Mpc are studied. I plot a graph with distance on the x-axis and velocity on the y-axis to fit a least squares line of best fit. Using Hubble's Law, this allows us to calculate the value the slope of this line as an estimate for Hubble constant. This quantity is directly related to the age of the universe. The value of the Hubble constant, however, has not been constant throughout time as it has changed as the universe has evolved.

Results



The plot for type la supernovae in provided as Figure 1. The Hubble constant was calculated by comparing distances to their corresponding recessional velocities of the galaxies observed. The slope of the line, or Hubble's constant, is estimated to be 67.48 km/sec/Mpc with some uncertainty. This value represents the current rate of cosmic expansion and can estimate the speed of an object at any distance. The value of the Hubble constant, however, has not been constant throughout time as it has changed as the universe has evolved. The precise value of the Hubble constant at different epochs are subject to change due to ongoing research, as with our understanding of the universe's history.

As seen in Figure 1, we can see the relationship between redshift and distance for local (0 Mpc – 250 Mpc) and distant (250 Mpc – 700 Mpc) galaxies. The further away a galaxy is, we can see redshifts that increase. That is, the more distant a galaxy is, the faster it recedes from us. This shows that not only is the universe expanding, but it is expanding at an exponential rate.

Conclusion

The universe's acceleration has defied expectation throughout history. Hubble's Law and the derived Hubble constant has been crucial in revealing why the universe is expanding. The observed cosmic acceleration would be impossible without an additional force acting on the universe. This leads us to the existence of dark energy, and its presence has introduced us to a new understanding of the universe's evolution over time.

References

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