The Accelerating Universe

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ABSTRACT

The purpose of our research was to provide evidence for the acceleration of the expansion of the universe. We researched the work of Dr. Adam Riess, Dr. Saul Perlmutter, and Dr. Brian Schmidt, and attempted to replicate their investigation of the accelerated expansion of the universe by the examination of redshifted Type Ia supernovae. Evidence of a disconnect between the observed and predicted luminosities of these supernovae supports the accelerating universe theory. The theory of the accelerating expansion of the universe necessitates the existence of dark energy, a hypothetical form of energy believed to account for this negative vacuum pressure and make up roughly seventy percent of the universe. Researching the accelerating expansion of the universe allows us to better understand the fate of the universe.

TYPE 1A SUPERNOVAE

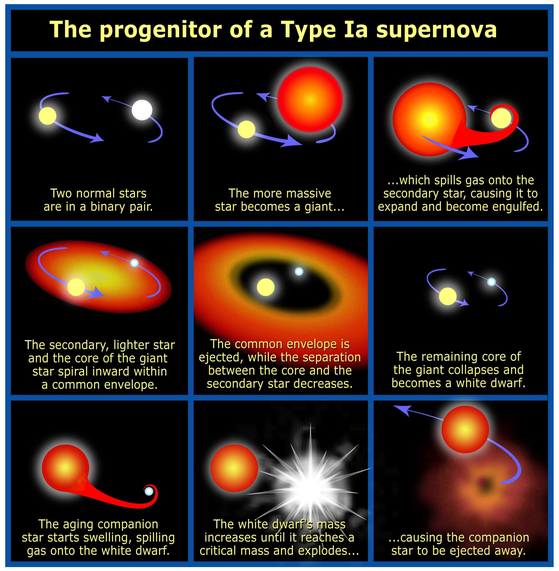

Figure 1 [10] – An explanation of Type Ia Supernovae formation

- Consistent peak luminosity due to the uniform mass of white dwarfs that explode at the Chandrasekhar limit
- Allows Type Ia supernovae to be used as standard candles for measuring the distance to host galaxies
- The average visual magnitude of Type Ia supernovae is −19.3 (about five billion times brighter than the sun) [8]
- An average galaxy has one or two Type Ia supernovae per century

REDSHIFT

- $z = \frac{observed\ wavelength - rest\ wavelength}{rest\ wavelength}$
- Wavelength of light increases as it traverses the expanding universe by the same amount that space has expanded during the travel time

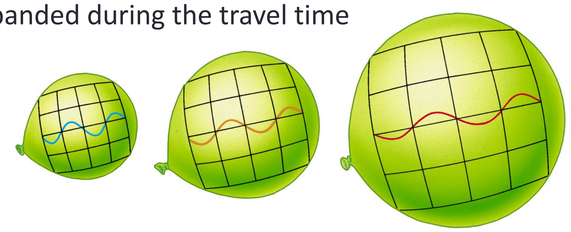

Figure 2 [1] – Using balloons to demonstrate cosmological redshift

- Hubble's Law: $v = H_0 D$
- Redshift Velocity: $v_{r\,s} = cz$
- $D = \frac{c}{H_0} z$

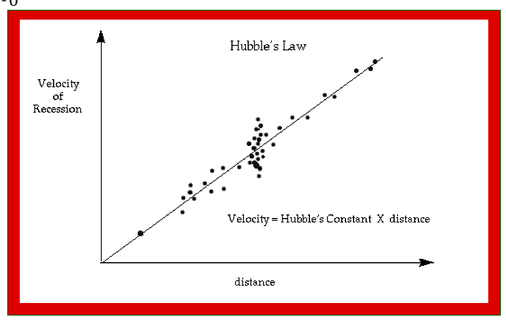

Figure 3 [3] – A graphical version of Hubble's Law

DARK ENERGY

- Hypothetical form of energy which permeates all of space
- Responsible for the accelerated expansion of the universe
- Constant energy density everywhere ($1.67x10^{-27}\ \frac{kg}{m^3}$) [4]
- The universe is about 70% dark energy based on observations from the WMAP and the Planck Spacecraft [13]

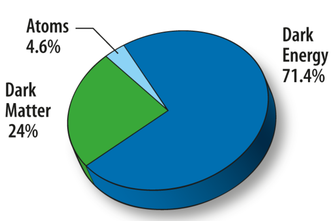

Figure 4 [13] – Today's Universe

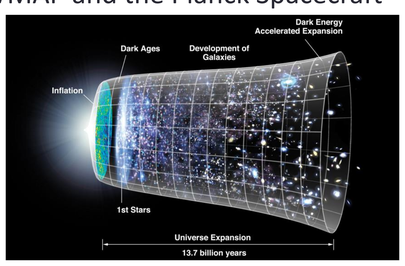

Figure 5 [11] – Universe Expansion

EVIDENCE FROM IMAGE PROCESSING

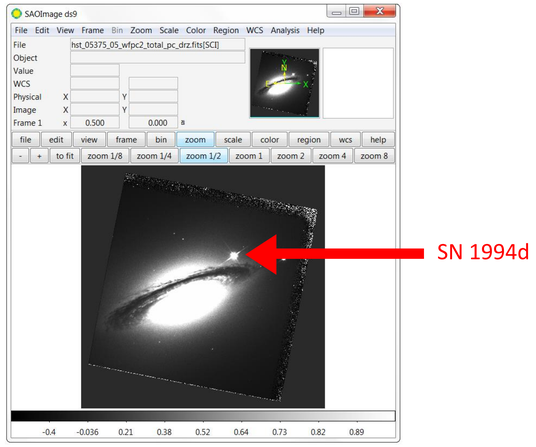

Figure 6 - ds9

- Astronomy images typically come in FITS files, which can be viewed and analyzed with SAOImage ds9
- Type Ia supernovae can be as luminous as the galaxy in which they reside (see Figure 6)
- To continue our research, we will determine the redshift using the spectral data from IRAF
- Distance can be found using redshift
- Expected luminosity can be solved for using distance
- An observed luminosity that is less than the expected luminosity is evidence for the existence of dark energy [6]

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