Expansion of the Universe

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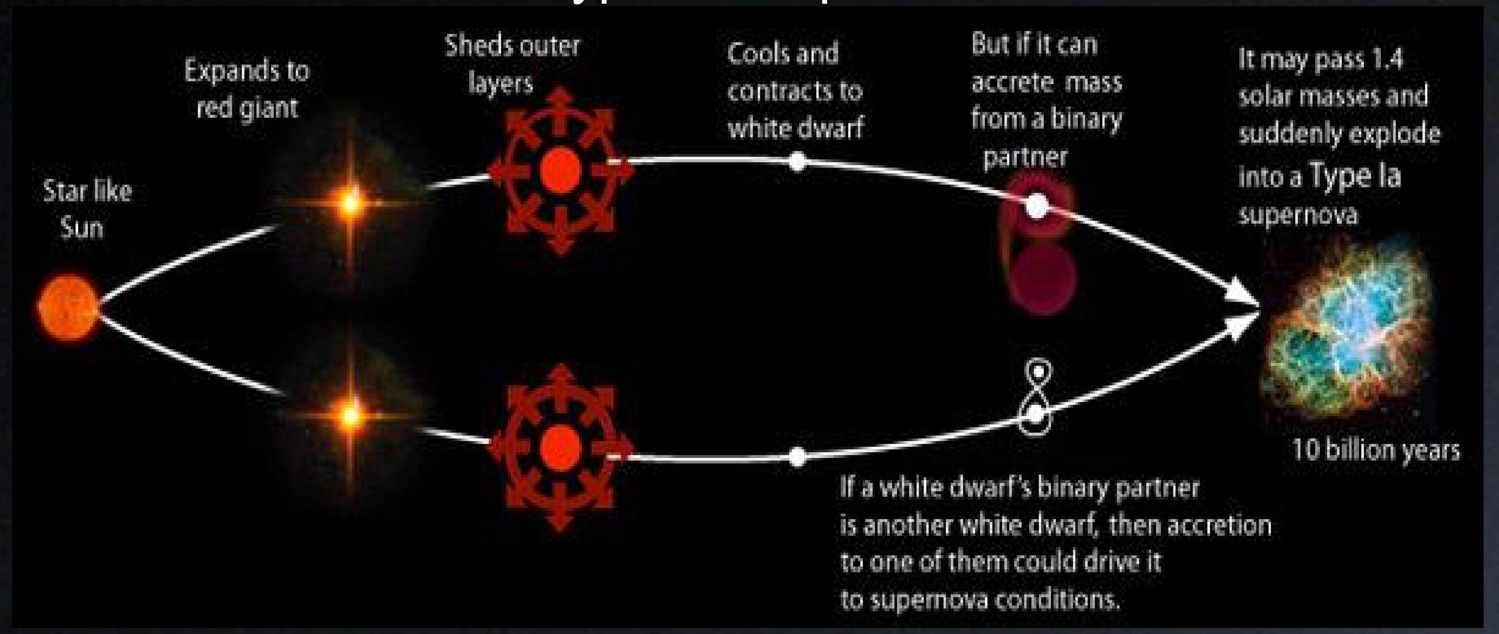
Abstract

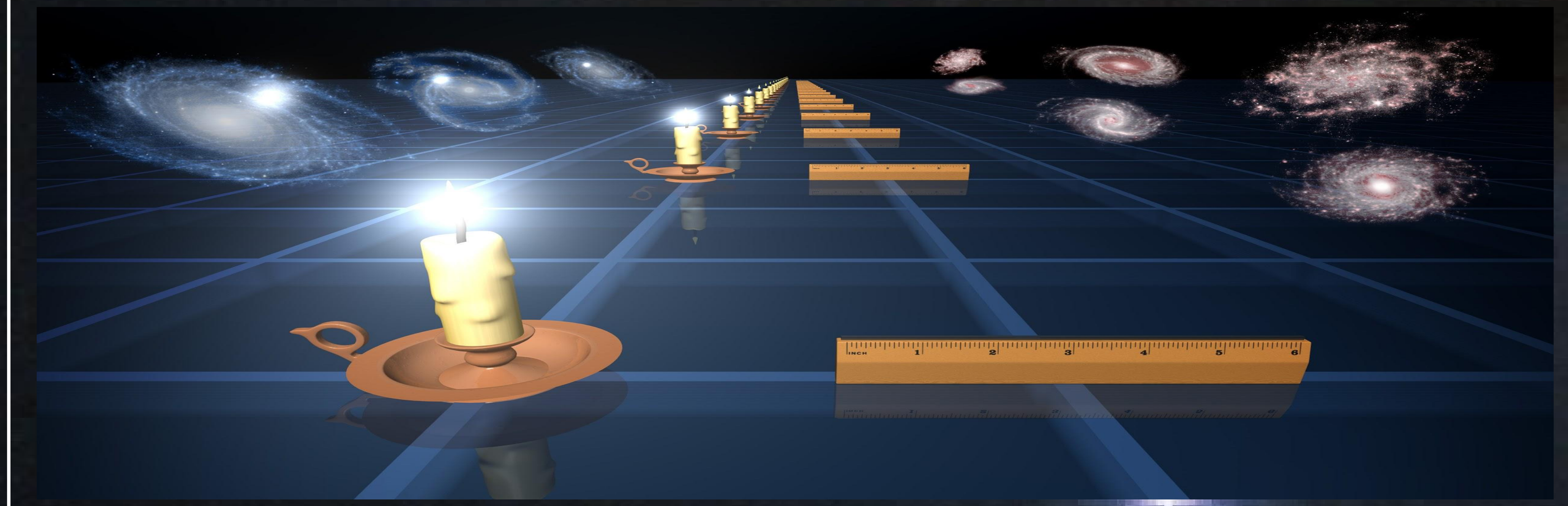
My research focused on examining our evidence for accelerating expansion of the universe. Edwin Hubble found other galaxies were moving away from us (except for ones very close) so, the universe was expanding because everything was moving away from us. We also think the universe's rate of expansion is increasing due to the brightness of distant supernovae. These discoveries are important in determining the fate of the universe and understanding how it works.

Type 1a Supernovae



[1]

- Supernova produce similar light curves since they all start around the Chandrasekhar limit (about 1.4 solar masses)[1]
- Light curves vary with peak brightness being inversely proportional to rate of decay, so the higher the peak brightness the faster the decay[1]
- Supernovae are incredibly rare the last one seen in our galaxy was in 1006 and should have been easily visible during the day[2]
- By looking at how much the object fades in the 15 days after its peak brightness researchers can calculate distance with incredible accuracy[2]
- Often referred to as standard candles



[3]

Supernovae work as standard candles because they have a consistent brightness so the fainter they appear the further away they are.

Another distance measurement technique, the standard ruler, utilizes galax to compare the distance between pairs of galaxies and their relative angle in order to calculate the their distance.

Redshift (z)

The wavelength of light is stretched by the expansion of light causing the light to be shifted towards the infrared end of the spectrum. This is similar to the well known doppler effect. Redshift is mathematically represented [4]

$$z = \frac{\lambda_{observed} - \lambda_{emitted}}{\lambda_{emitted}}$$

Where z represents redshift and λ represents wavelength

We can use redshift to calculate velocity and then use velocity to calculate distance using hubble's law.

$$z \approx \frac{v}{c}$$

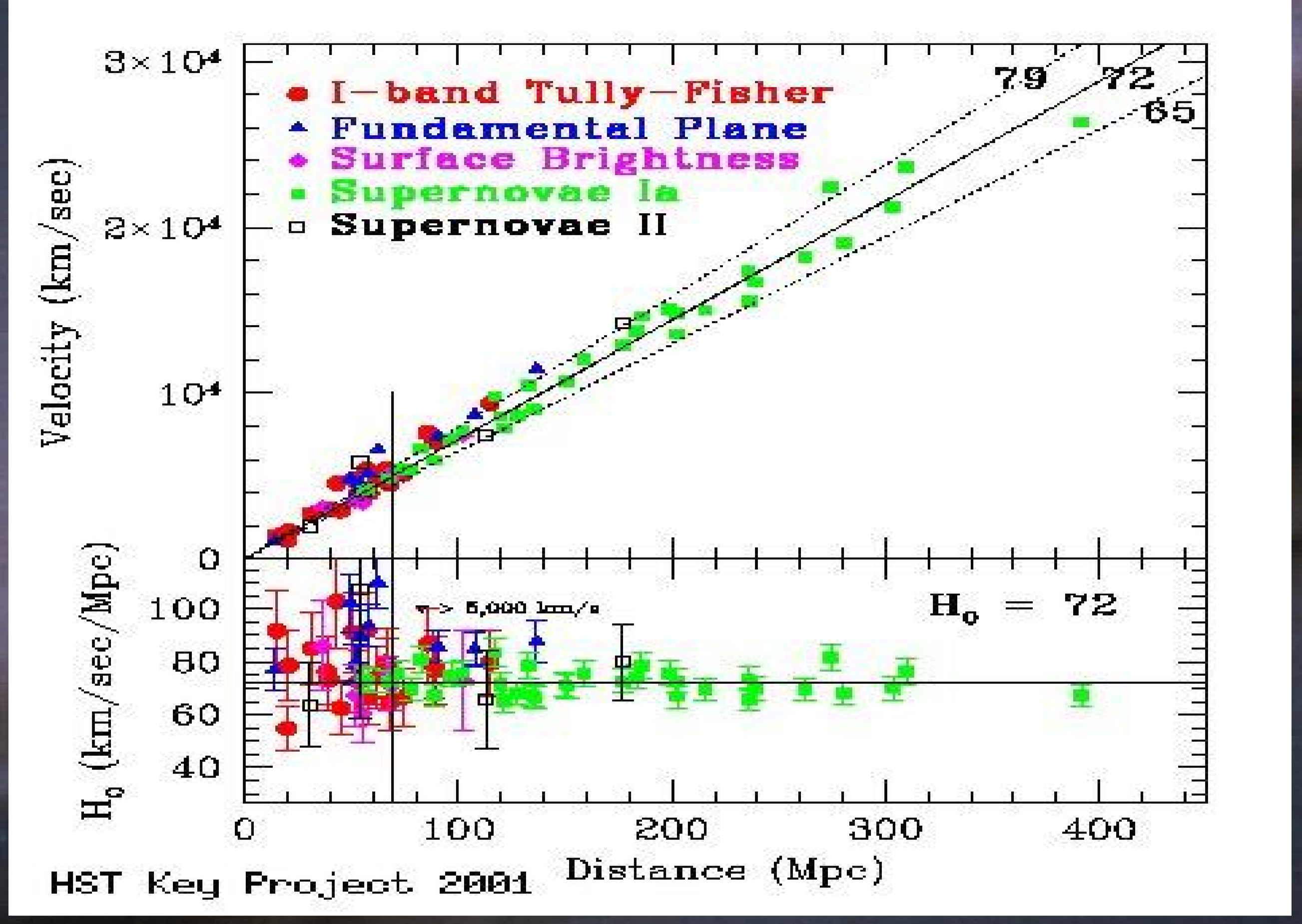
v = recession velocity
c = speed of light
z = redshift

$$v = H_0 D$$

v = recession velocity
H_0 = hubble's constant
D = distance

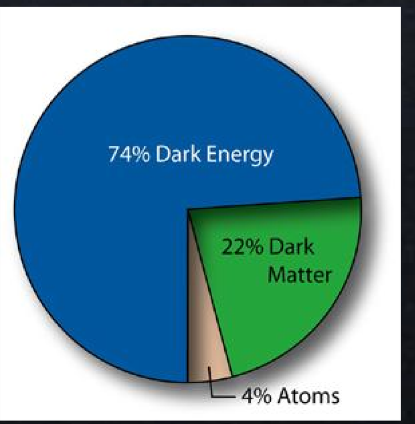
Hubble's constant is the slope of velocity over distance as shown below.[13]

[5]

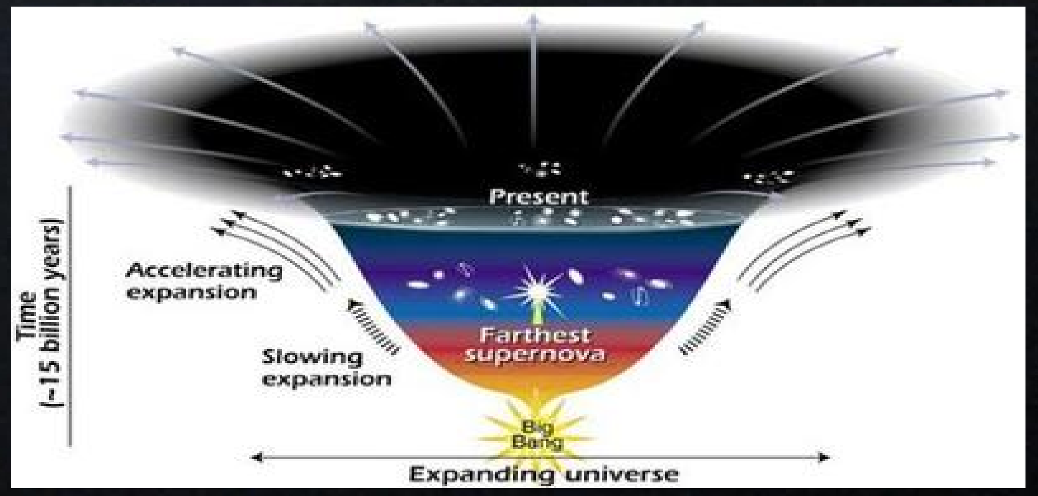


What is Causing Expansion

- Dark energy is a hypothetical form of energy suspected of causing the accelerating expansion of the universe[6]
- Three theories about what dark energy is:
- A property of space that does not change with time[11]
- Energy field that changes with space and time[12]
- Lastly some property of gravity we do not understand[6]
- The Supernova Acceleration probe(snap) aims to measure how dark energy changes with time if at all

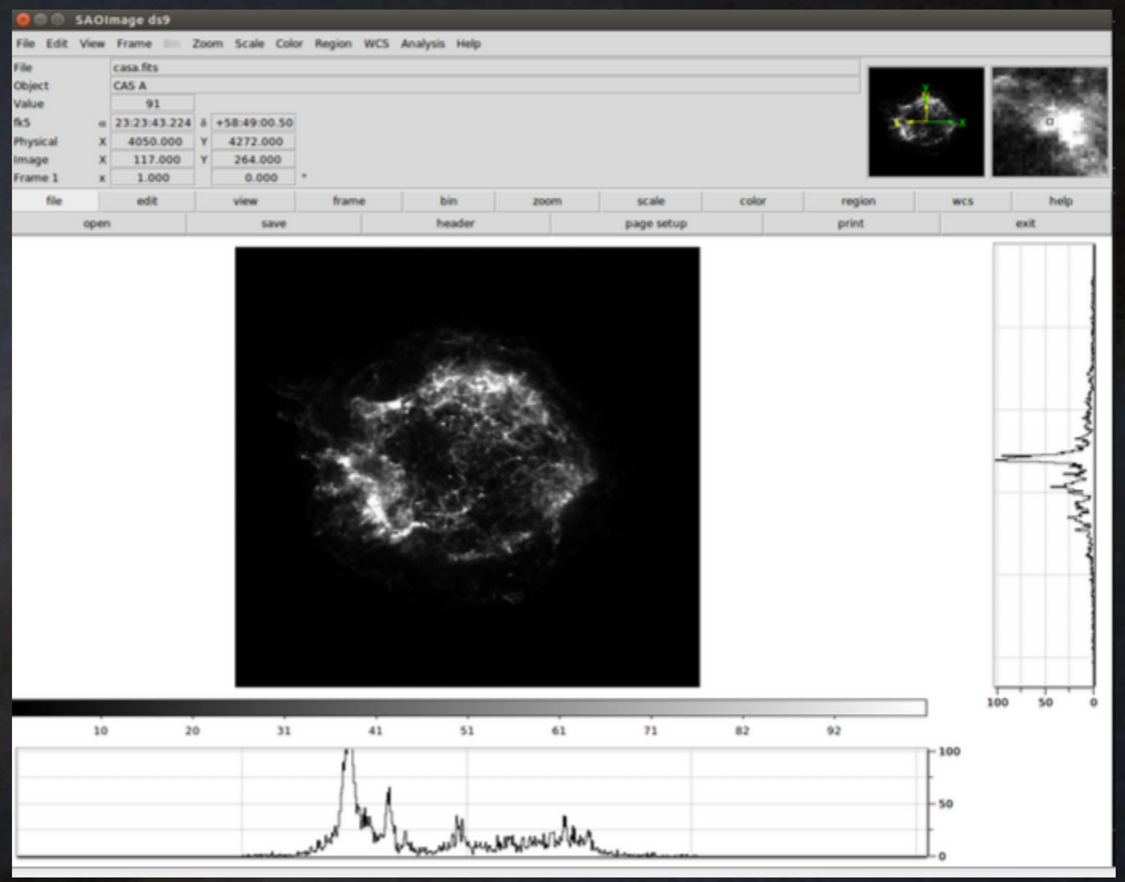


[7]



Analysing Data

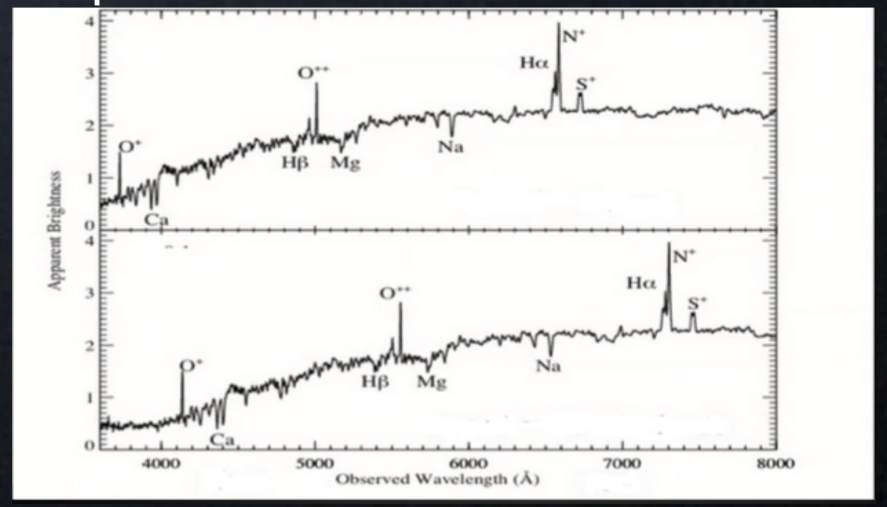
- FITS (Flexible Image Transport System) are the most common data type used for archiving and analysing astronomical data[8]
- The two most common programs for analysing fits files are iraf and ds9
- ds9 allows analysis of images



[9]

The plots to the right and below the above supernova remnant show the luminosity of the pixels along the horizontal and vertical axis of the location of your mouse.

- Iraf (image reduction analysis facility) provides tools image processing, graphical applications, reduction, and analysis of optical data.
- Iraf along with several other programs provide tools for plotting spectroscopy that when compared to what we would expect can be used to calculate redshift.



[10]

The spectrograph above shows two plots of flux vs. wavelength. The top plot represents what we would expect to see, while the bottom plot is a galaxy far away by calculating the shift in peaks we are able to calculate the galaxy's redshift

Acknowledgements

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SOURCES

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