

Producing light curves for supernova explosions and their usage in determining a value for Hubble's Constant

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We have measured the magnitude of supernova explosions over an extended period of 47 days using 0.5 m and 1.0 m telescopes situated in Durham and La Palma. We have plotted several light curves and identified Type Ia, Type II, and II supernovae. Our fittings have had χ^2 analysis has performed, and it has produced values of χ^2 , χ^2 , χ^2 . We expect our biggest source of uncertainty arose due to the conditions and data analysis that we performed. Using a Type Ia supernova of brightness 00.00 mag, we have managed to produce a value for Hubble's Constant, $H_0 = 74 \text{ kms}^{-1} \text{ Mpc}^{-1}$. We attempted to calculate Einstein's coefficient, Λ , but this was unsuccessful due to redshift of something.

I. INTRODUCTION

In astronomy, one of the most violent and luminous events which can take place is a supernova explosion. At the end of a massive star's lifetime, there is a possibility that the equilibrium configurations for a star will cease to exist after it has ran out of nuclear fuel to burn. This eventually leads to the final explosion, the luminosity of which when at its peak can be as bright as a small galaxy [2].

Observing these events and measuring their magnitude over a period of time allows us to then plot light curves (magnitude is displayed as a function of time). From visualising this evolution we can draw the conclusion that there is some order in the explosions - they can be grouped together into multiple types as their light curves have similar shapes and features.

Once we have our different groups we can then use them in cosmology for example. One type of supernova explosion called Type Ia's can be used in calculations which leads to a value for Hubble's Constant. The methodology of which will be discussed later in section Ic.

In studying and using supernovae as a tool, we must understand the underlying physics which creates these awesome cosmic events. (??)

a. Supernovae Classification

The two basic classifications for supernovae are Type I and Type II explosions. The main distinction between them both is that the Type I supernova explosion (SNe) has an absence of the Balmer series of hydrogen in their optical spectrum (at maximum light), and Type II does have this hydrogen feature [1, 2]. (??)

In the following sections we will discuss the stages which led to the different types of supernovae. (??)=

With these two groups there are further possible sub-classifications. This is possible as there are visible differences their light curves and also in their spectral features [2]. In Table I, I have highlighted the subtypes which we will explore through experimentation and analysis. (??)

1. Type I Supernovae

With the case of Type I supernovae, the general consensus is that presupernova, a white dwarf within a binary system accretes matter from a donor star. The white dwarf then increases in mass until it reaches a critical point [2, 4]. This limit is thought to be the Chandrasekhar mass, $1.4M_\odot$, after accreting this much matter, the object will be gravitationally unstable [2]. As the

Type	Characteristic
Type Ia	Si II line at 616.0 nm <i>Type Ib and Type Ic also exist</i>
Type IIP	Reaches a plateau in it's light curve
Type IIL	Displays a linear decrease in it's light curve <i>Type IIn and Type Iib also exist</i>

TABLE I: Some of the subclassifications of supernova [2].

material is continually compressed and heated to a temperature of $T \geq 10^9 \text{ K}$, the fusion of carbon and oxygen begins in the core which releases thermonuclear energy. This energy that is produced disrupts the star at high velocity and prevents a collapse into a neutron star, thus we have a supernova explosion [4].

One of the subgroups of Type I which are especially important for cosmology are Type Ia SNe. When plotting their magnitudes against time passed we see that their light curves are generally homogeneous. These objects are the most luminous supernovae known, their absolute magnitudes in the B band are typically $M_B = -19.5 \pm 0.1$ [4]. Using light curve relationships and models we can determine precisely the magnitudes of very distant SNe, this has allowed astronomers to determine the redshift-distance relation for redshifts high redshift objects ($z > 1$). Then, with these calculated values it is then possible to estimate the cosmological parameters Ω_0 and Ω_Λ . In doing so, it has been found that using Type Ia SNe has produced agreement with the literature value. so and so (cite paper) have done this and produced values of.

2. Type II Supernovae

For a star to end its life as a Type II supernova explosion, its core must collapse to produce the enormous amounts of energy that we associate with a SNe. For stars more massive than $8M_\odot$, their post-main-sequence evolution relies on the continual burning of carbon, oxygen, and silicon burning. As this process continues to heat up the core to larger temperatures, photodisintegration will start to occur. Photons have enough energy to breakup heavier elements such as iron (^{56}Fe) and helium (^4He), this process is endothermic so energy is removed from the gas that would have created the pressure required to support the core of the star [1].

The free electrons which had been supporting the star through degeneracy pressure are now captured by heavy nuclei and by the protons that were produced through photodisintegration. Through the photodisintegration of

iron, and combined with electron capture by other elements, most of the core's support disappears and then the core begins to collapse extremely rapidly.

b. Supernova Discovery

All sky camera? [find source for this]

c. Application to Cosmology

Type Ia supernovae are useful to us as they can be classed as standard candles [cite]. With this we can use them to calculate a value for Hubble's Constant, H_0 , and thus calculate the expansion rate of the Universe.

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d. Project Aims

Studying the evolution of the magnitudes of different supernovae will allow us to produce a light curve which can be fitted with known models. Through this we can then discover the type of supernova that we are observing.

The main focus in our experimentation is attempting to collect the data which would form our light curves.

Could we confirm the expansion rate of the universe through our observations of supernovae?

II. OBSERVATIONS

a. Data Collection

Observing supernova explosions requires instruments which are sensitive enough to receive the photons which have travelled for vast distances before being recorded. In performing such observations (?) our main equipment are telescopes - they come in a wide variety of configurations and each can produce different results.

In collecting the data for our supernova we used three different types of telescopes. Two of them based in Durham on the Department of Physics's Roof, and one in La Palma.

As we were observing objects which were faint we required that we either have a large telescope to collect as much light as possible, or have good seeing conditions which allowed us to collect as much light as possible over a large observation time.

b. Observations Made

Over a period of (?) days we took images of SNe, however this also depended on the conditions and whether it was worth observing if the seeing was bad e.g. obscured by bad weather.

c. Data Analysis

As we collected our supernova day by day we performed various photometry techniques to try and calculate the magnitudes of the explosions.

d. Data Uncertainties

There are uncertainties which are prevalent within our experiment which required to be quantified.

e. Final Data

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III. ANALYSIS

a. Supernovae Models

The fitting of the templates/models to our observations.

b. Results

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IV. DISCUSSION

It is highly unlikely that we will see supernova remnants for the supernova that we have been studying, in the shape of the Crab Nebula. Much longer time periods would be required for this.

[neutrino studying]?

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V. CONCLUSIONS

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Acknowledgements

I would like to thank Carl Sagan for producing his Cosmos series and inspiring a generation to become astronomers.

References

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Appendix A - Observation Logs