Constraining the geometry of the Universe using Type Ia supernovae

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Date of report: 28/02/2018

Type Ia supernovae have the unique trait of being standard candles, their light curves can be used in cosmology to calculate and constrain cosmological parameters. In observing Type Ia supernovae and fitting model light curves to such data one can attempt to derive such values. We have monitored, collected, and analysed data for supernova explosions over a period of 34 days. A 16″ and a 0.5 m telescope situated in Durham and La Palma was used for this project. After calculating the magnitudes for a Type Ia (2017hhz) and Type Ia-91bg (2017hle) supernova object, we fitted template light curves with the Python program, *SNooPy*. The quality of fit for the program's `fit()` function was deemed to be acceptable in accordance to the average reduced χ^2 values calculated for the B and V photometric bands, $\chi^2_{\nu,B} \approx 1.38$ and $\chi^2_{V,\nu} \approx 2.95$ - a good fit requiring $\chi^2_\nu \approx 1$. The distance modulus to the supernova 2017hhz was calculated by SNooPy to be 36.121 ± 0.106 mag, using this value we were able to compute $H_0 = 70 \pm 20$ km s^{-1} Mpc^{-1}. However, the quoted error negates the meaning of H_0 as it is too large of an uncertainty. In improving the accuracy and uncertainties we suggest that more observations of the supernovae were required, and constraining values should be used for the parameters in SNooPy's templates.

I. INTRODUCTION

In cosmology, one can argue that one of the most important observable events are supernova explosions. As a massive main sequence star runs out of nuclear fuel to burn, the equilibrium configurations which initially provided structure will cease to exist. What follows is a cataclysmic supernova explosion [3].

We can generally class supernova explosions into two separate groups, Type I and Type II supernovae. The main distinction arises due to the fact that Type I's have an optical spectra which contains no Balmer hydrogen features, whilst Type II supernovae do contain this hydrogen feature [1].

Within these two subclasses there are further divisions which can be characterised through their spectra and through features as found in their light curves [2]. Light curves are a way to show the evolution of a supernova's magnitude as time passes.

a. Type Ia Supernovae

To probe the geometry of the Universe, Type Ia supernovae can be utilised. Known for their curious homogenous nature, they are used as standard candles, a feature which can be taken advantage of to calibrate cosmic distances.

Through measuring their magnitude as time evolves, a ?light-curve? can be plotted and a maximum B-band magnitude obtained. With this and a value for the supernova redshift, z, we can use Hubble?s Law and the Friedmann equation to find a value for the dark energy density, Ω_Λ. In our model, the following equation was utilised in the Friedmann equation as the Hubble Parameter,

b. Cosmological Parameters

sdfsdf

c. Cosmological Parameters from Type Ia Supernovae

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d. Project Aims

Through computational analysis it is possible to employ data sets of Type Ia supernovae to constrain values for cosmological parameters. In Section **??** we discuss the results from our entire experimental period, from our early work with Least-Square statistics to later experimentation with the Markov-Chain-Monte-Carlo method.

II. RESULTS AND DISCUSSION

From our experimentation we have therefore found results which ??

a. χ^2 Statistics

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b. Bayesian Statistics

asdasd

c. Further Investigation

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III. CONCLUSIONS

In conclusion, we have found that it is possible to constrain cosmological parameters of the universe using Type Ia supernova data.

References

[1] B. W. Carroll and D. A. Ostlie. *An Introduction to Modern Astrophysics.* Pearson, 2nd edition, 2007.

[2] A. Gal-Yam. *Handbook of Supernovae: Observational and Physical Classification of Supernovae.* Springer International Publishing AG, 2017.

[3] M. Longair. *High Energy Astrophysics.* Cambridge University Press, 3rd edition, 2011.

Appendix A: ??