Limits on the Luminosity Evolution of type Ia supernovae

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Abstract

Given an independently established cosmological model, the measurement of supernova Ia redshifts puts limits on their luminosity evolution. The Dark Energy Survey validates the standardizable candle for the last 8 Gyrs. This can be extended to earlier times in the evolution of the Universe in future surveys with the Rubin, Roman and Euclid telescopes, for example, and redshifts with telescopes such as the EELT, GMT, TMT and JWST.

1 Introduction

At the time of the award of the Nobel Prize for the discovery of dark energy, Roger Blandford, then at Caltech, said to the first author that he was surprised "that physicists are treating supernovae like electrons." Clearly, he was saying (succinctly) that in addition to the fundamental nature of the Chandrasekhar mass, the physics of supernova luminosities involved complex astrophysics. That caveat remains valid today.

2 OzDES and DES data

An assumption which tends to go unquestioned in supernova cosmology is the constancy of the SNIa maximum light luminosity. However, if the parameters of a flat ΛCDM cosmology are assumed as a prior, the Dark Energy Survey Hubble diagram of 1800 SNe from redshift 0 to 1.1 can be used to put an upper limit on $|dM/d\log z|$. To proceed with this we chose to assume the Planck ΛCDM cosmology (Ade et al 2020) and subtracted its luminosity distance moduli from the Hubble diagram data. We then did a linear regression on the m-M residuals versus $\log z$ weighted by the magnitude errors. The code used was that of Akritas & Bershady (1996). The result was $|dM/d\log z| \ < 0.014 \pm 0.009$ mag/dex. This means that monotonic variation of the SNIa standardized maximum luminosity has been less than 3% in the last 8 Gyr at a 2–3σ confidence level.

References

Ade, P. et al. , Planck collaboration 2020, A&A, 641, A6
Akritas, M. & Bershady, M. 1996, ApJ 470, 706
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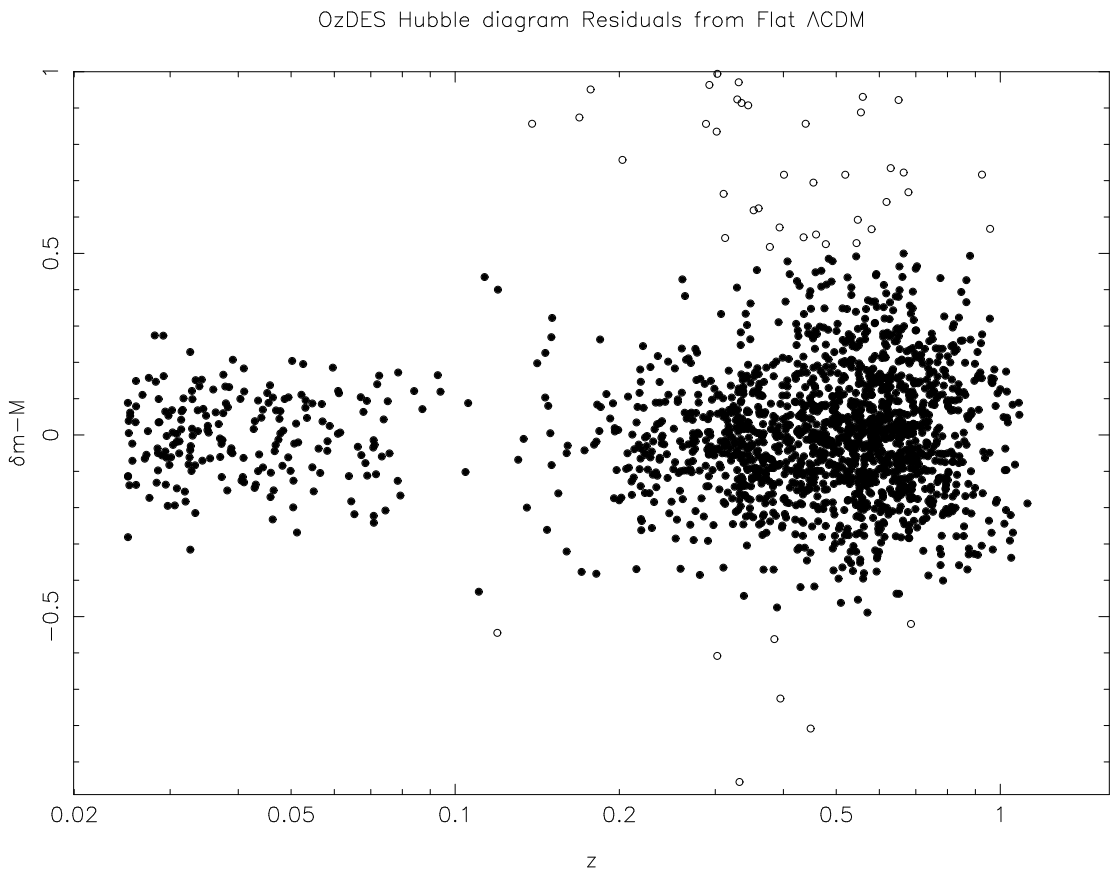

Figure 1: DES distance modulus residuals versus redshift from the Planck flat ΛCDM cosmology. Open circles are 2.5σ deviates.