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Query on Accelerating Expansion of the Universe by Error Analysis of Ia Supernova

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Abstract. Some serious faults in error analysis of observations for SNIa have been found. Redoing the same error analysis of SNIa, by our idea, it is found that the average total observational error of SNIa is obviously greater than 0.55m, so we cannot decide whether the universe is accelerating expansion or not.

1. Observation Analysis onto Accelerating Expansion of the Universe

A phenomenon of “Accelerating Expansion of the Universe” is detected by observations of type Ia supernova (SNIa). These analytical methods are based on two assumptions which came from a group of series of experience relations all of them are named as “Advanced Phillips experience relations”: a) Luminosity is related with the width of the light curve of SNIa; b) Luminosity is related with the color index (B-V) in the course of explosion of SNIa.

In the group a), use of type Ia supernovae (SNIa) as lighthouses or “standard candles” for cosmological studies became feasible upon the realization of an empirical correlation of peak luminosity with light-curve shape. The discovery of the relationship between light-curve shape and brightness led to a parameterization by the decline rate, $\Delta m_{15}$, in B-band brightness over 15 days after the maximum light [1]. The “multi-color light curve shape” method [2,3] is based on $\Delta$, the difference in peak luminosity between an observed SN and a fiducial template. The ”stretch” method [4,5] parameterizes light curves with a factor s which broadens or narrows the rest-frame timescale of a single standard template to match with observed light curves. The stretch factor s can be translated to a corresponding $\Delta m_{15}$ via the best-fit line $\Delta m_{15} = (1.96 \pm 0.17)(s^{-1} - 1) + 1.7$. It was found that stretch describes the observed B and V band light curves well over a month around maximum [5]. Afterwards, most related work in this field are based on the stretch factor parameter, s, including on determining both K-correction and extinction correction of SNeIa [6]. The “Bayesian adapted template match” method introduced by [7] estimates distances by comparing with a large set of well-observed nearby SNeIa rather than a parameterized template. These methods are fundamentally equivalent by making use of light-curve shapes.

In the group b), another distance measurement technique is the CMAGIC method [8], which uses the relationship between light-curve shape and brightness in a more indirect way than the above procedures. It is based on an observed linear relationship in color-magnitude space for a certain period after the maximum light to infer distances. Besides, In a paper the authors address...
that they have revealed clear evidence for a tight linear correlation between peak luminosities of SNeIa and their B - V colors $\sim 12$ days after the B maximum denoted by $\Delta C_{12}$ [9].

Based on the advanced Philips' experience relations above, SALT2 (Spectral Adaptive Light-curve Template) is a package of the software for Type Ia Supernovae light curve fitting [10]. Following the SALT2, UNION2 [11] deals with the data of 685 SNIa. The system error of the absolute magnitudes of SNIa is found by minimizing $\chi^2$ which is the normalized quadratic sum of distance modulus residual $[10,11]$, with the average total observational error, $\sigma_{tot} = 0.31^m$, including intrinsic error $\sigma_{int} = 0.18^m$. As a result, they come to a conclusion that universe is accelerating expanding. And Saul Perlmutter, Brian Schmidt and Adam Reiss share the 2011 Nobel Prize in Physics for their observations that type Ia supernovae indicate that the expansion of the universe is accelerating.

Due to advanced progress of researches on SNIa in recent years, all advanced Philips' experience relations have lost their physical basis [12,13]. However, the authors of all related statistical works declare that their statistic errors are rather small. The transferred errors which are caused by transferring from the statistical errors in their cited papers, however, did not be taken in to account. Indeed, they put the transferred errors into an intrinsic error (or system error) which is determined by $\chi^2$-method, $\chi^2 = \sum_{SN} \frac{(m_B - m_{mod})^2}{\sigma_{tot}^2}$, $\sigma_{tot}^2 = \sigma_{ext}^2 + \sigma_{int}^2$ ($\sigma_{ext}$ are the errors by the observational method including interstellar extinction, correction by gravitational lens etc., $\sigma_{ln}$ are errors by fitting both the light curve and color index of SNIa.)

$$m_{mod} = 5 \log_{10} D_L(z_{hel}, z_{cmb}, w, \Omega_m, \Omega_{DE}) - \alpha(s - 1) + \beta C + M$$

2. Some serious faults in error analysis

2.1. Error in absolute magnitude

The absolute bolometric magnitudes errors at maximum luminosity of SNIa consist of as follows: a)The intrinsic error ($\Delta M_{int}$) of the absolute magnitude at maximum luminance, in our idea, is just the half width at half-maximum (HWHM) of the statistic distribution curve of the number of SNIa with the maximum luminance, rather than the systematic error founding by using the $\chi^2$ check way [10,11]. b)Some errors of $M$ originates from delivered errors caused by statistical errors of the parameters $a$ and $b$ in original Phillips’ relation [11] or $\alpha_{phillips}$, $\beta$ in the advanced Philips’ Relations [2,3]. We call it as the delivered error, $\Delta M(a, b)$. c) Some errors of $M$, $\Delta M_{obs}$ is caused by the errors of some observational quantities of both light-curve and color index in advanced Phillips’s way. The total error of absolute bolometric magnitudes at maximum luminosity ($\Delta M_{total}$) is $(\Delta M_{total})^2 = (\Delta M_{int})^2 + (\Delta M_{max}^{(phillips)})^2$, $(\Delta M_{max}^{(phillips)})^2 = (\Delta M(a, b))^2 + (\Delta M_{obs})^2$. SALT2 [10] and UNION2 [11] didn’t give the aforementioned errors separately. In fact, they broadly merged them into the system error caused by $\chi^2$ -minimization. Advanced Philips Relation is very complex, but it is sure that the minimum of $\Delta M_{max}^{(phillips)}$ is at least larger than observational apparent magnitude error, $|\Delta M_{max}^{(phillips)}| > |\delta m|$ (the observational error of apparent magnitude. Furthermore, high $\zeta$ SNIa is faint when observed, so its $|\delta m|$ is much larger than nearby SNIa.

2.2. The systematic error by using $\chi^2$ check test is incorrect

However, premise of $\chi^2$ check test is the errors of distance modulus for the set of SNIa obeying a Gaussian distribution. But the set of modeling SNIa in UNION2 [11] including 685 SNeIa is really no Gaussian distribution. Although the average error of UNION2 which contains 685 SNeIa, is $0.16^m$, over 10% of total SNeIa are outline of $10\sigma$. If we take a subsample including 217 SNIa with very small observational average error to do the same statistics, it is found that over 10% of total SNeIa are outline of $5\sigma$. Really, the critical permitted outline value for outline of $2.6\sigma$ in the standardized normal distribution is $0.805\%$. Using the $\chi^2$ check test following
SALT2 [10], we find that 3.796% of the data are outline of 2.6σ based on the average total observational error of the distance modulus of SNIa, 0.31m. Obviously, the distance modulus error deviate Gaussian distribution seriously, and it is not suitable to calculate the systematic error $\sigma_{sys}$ of SNeIa by $\chi^2$ check test method. In our idea the real intrinsic error of a SNIa compilation should base on statistical distribution diagram of the number of SNIa for their absolute bolometric magnitudes(see Fig. 1). As we don’t know the exact luminosity of high z SNeIa, it is the only way to use SALT2 to get the absolute bolometric magnitudes of ”modelling SNIa”. The intrinsic error (or proper error) of the absolute magnitude at maximum luminosity is just the HMHW of a statistic distribution curve of the number of SNIa with the maximum luminosity. It is $\Delta M_{int} = 0.38m$, and it is much larger than the systematic error given by $\chi^2$ check test.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{figure1.png}
\caption{The count of SNIa vs. absolute magnitude.}
\end{figure}

3. Summary and conclusions

The average total observational errors of distance modulus is $\langle \Delta \mu \rangle^2 = \langle \Delta M_{total}^2 + (\delta m)^2 \rangle$. Using the data of SNIa and observational apparent magnitude error in UNION2, and divided intervals per $\Delta z = 0.1$, we repeat the statistics (by the same $\chi^2$ check test method) to calculate this ”modelling SNIa” sample’s average total observational errors of distance modulus. It is found that the average total observational error of SNIa is obviously greater than 0.55m (this is much larger than 0.4m). So we can’t decide whether the universe is accelerating expansion or not (see Fig. 2). And the direct observational evidence of the idea of ”dark energy” is also lost by the observational error analysis of SNeIa.
Figure 2. Residual distance modulus as a function of redshift.

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