July 10, 2023

Concerning the Time dilation of the Supernovae

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ABSTRACT

This brief analysis follows the one in [viXra:2207.0051]. The observations reported have the purpose of defending the reasons of an alternative model to the standard cosmological one. Named 4-Sphere [*], it is introduced in [viXra:2209.0098] (it works in the Special Relativity context).

Astronomers assert that type Ia Supernovae provide the equivalent of a cosmic clock. Their observations try to relate the Time dilation of this clock with the redshift z of the Supernova so as to identify the cosmological model that best fits the results.

The value of the Time Dilation is also used for calculating the distance of a supernova Ia. The results found here are used in our distance calculations: [viXra:2208.0152].

The Friedmann-Lemaître-Robertson-Walker *(FLRW)* metric that is part of ΛCDM, the currently most developed model with important successful predictions and scientific results, bases its superiority, over alternative models, above all on the results of the Time dilation analysis of the Supernovae: its prediction gives the value $1 + z$ where z is its Redshift.

In this brief discussion, we intend identify the key points of the problem, so to provide our position on it, and in order to compare the standard model and the alternative ones, we take as reference the Time dilation in Special Relativity *(SR).*

[*] – 4-Sphere is a proper name, but here we also mean the hypersphere embedded in four-dimensional space R4 (someone call it 4-ball too); its surface is named by topologists a S^3 sphere.

INTRODUCTION

To set the terms of the problem we need to clarify the concepts and quantities involved. In the first place, to compare a distant Supernova with a sample one, chosen near us, we need to speak of a Photometry Rest Frame [*].

To simplify, we refer to the Supernova Ia *(SN)*, as a monochromatic light source, and we will treat the absolute magnitude M_B in the color B band as the bolometric absolute magnitude M. Where necessary, however, we will refer to the brightness, and other quantities, in the various color bands: *U, B, V, I, ...* [1]

That simplification brings us back to the previous exposition [viXra:2207.0051], regarding the Apparent magnitude, to reach our synthesis on the *K* correction.

There we have emphasized the difference between *FLRW* and *SR* in the rest frame concept. While for SR a star can be stationary and far away from us, for *FLRW* the stationary star must be placed close to us, at a chosen conventional distance of 10 Parsec *(Pc)*. So, while with SR we can define the *K* correction, in my opinion clearly, as the difference between the observed and the "intrinsic" Apparent Magnitude, in *FLRW* the K_{corr} relationship concerns the Apparent magnitude, the Absolute one and the Luminosity distance.

But this passage does not define completely the concept and, even in *FLRW* one speaks of an intrinsic Spectral Energy Distribution *(SED)* [*].

[*] - [arXiv:astro-ph/0307149] - The Rest-Frame Optical Luminosity Density, Color, and Stellar Mass Density of the Universe from z=0 to z=3

HOW THE TIME DILATION OF THE SUPERNOVAE HAS BEEN VERIFIED

The evolution of the explosion of a Supernova is studied by astronomers with a regression analysis of the *SN* light curve on a sample given, to fit the shape of the decay following the explosion. From the resulting curve, quantities as t^B_{Max}, the time relative to the maximum of *B,* are derived.

Over time the procedures have refined becoming more and more sophisticated and complex but, to understand what the measurements are, underlying that regression analysis, we can refer to how the problem was addressed in [*]. The article highlights a very important relationship found between the absolute magnitude M_B of the *SN* and the quantity $\Delta m_{15}(B)$ that measure the amount of magnitude that the *B* light curve drops during the first *15* days following maximum:

$M_{band} = a + b\ \Delta m_{15}(B)$ where the parameters a and b, found by regression on the sample are given.

For the *B* color Band: $M_B = 2.698\ \Delta m_{15}(B) - 21.726$

Then, once a sample of *SN* has been classified for its Absolute magnitude M_B, it is sufficient to know the $\Delta m_{15}$of the *SN* to be analyzed to identify the matching Supernova sample and from it all the properties of the decay light curve. In the study [*], the Supernovae of the sample are all close to us, with their redshift in the range $0.0027 < z < 0.03$ and their Absolute magnitude calculation not significantly affected by *K* correction.

Hence, given the redshift z of the *SN* and with two measurements of the Apparent magnitude m_{Bo}, one at the peak and the other after 15 days, it is possible to deduce all the rest.

It is now a question of establishing the way to operate.

Seen from the *SR* context, a light source at rest and far away from us is a perfectly defined physical state to which it is possible to associate its Apparent magnitude m. Are given the relations:

$m - M = \mu$ and $m = m_o - K_{SR\ corr}$ where the relations are valid in a color Band too

The equipped procedures used by *FLRW* allow to recalculate K_{corr} at each point of the decay curve, managing in this way even strong deviations of the light spectrum after the bump. However when K_{corr} is constant, its value disappears in the differences in magnitude.

In the absence of known K_{corr}, being constant μ and with it $K_{SR\ corr}$, we can also refer to the moving light source with $\Delta m_{B0} = \Delta M_B$.

The problem, then, comes back to the measurement of some Apparent magnitudes observed at a distance of time that we know to be dilated by the γ Lorentz factor. By having more observations in the decay curve for the first *15-20* days, we can use a parabolic interpolation to estimate the second observation. Having some data before the explosion would be ideal!

[*] - Astrophysical Journal Letters v.413, p.L105 - The Absolute Magnitudes of Type IA Supernovae

SN CHECK IN THE SPECIAL RELATIVITY CONTEXT

Coming to the point, we choose [*] that studies the Time dilation for the distant ($z = 0.479$) Supernova *SN 1995K*. Its similarity with the sample *SN 1990N* and *SN 1991T* (close to us) has been studied for the Time dilation of this faraway *SN*.

To proceed, we now check the Time dilation recalculated, this time, with *SR* using the Absolute magnitudes of the two *SN* of the sample from [**]:

For *SN 1990N* $M_B = -18.74$ for *SN 1991T* $M_B = -18.96$

Our count is rough and adequate skills are lacking, so we will choose the simplest way. We will also clarify all the logical steps, using the data from [*], but without relying on its calculations.

To get Δm_{15}, the data are from Table 3 “PHOTOMETRIC DATA FOR SN 1995K” and the “bump” it is estimated [see *] on April 1 (our calculation agrees). Then:

$$m(B) = m_0(B45) - K_{corr}$$

where in this case the K_{corr} used are practically constant [see *] and we can ignore them in our following computations (instead, this $K_{SR\ corr}$ - in the B color - will be essential for the verification of the Luminosity distance to come from the Distance modulus).

For $z = 0.479$ we have $\gamma = 1.078$ and the Time dilation is given by $\delta t_o = \gamma \delta t_e$. This means that the observation of April 5 does not refer to a value $m_0(B45) = 22.23$ found after 4 days from the maximum, but after 3.71 days.

Following this schema, we used a fourth-degree polynomial regression [***] in which each point was weighted according to the inverse of its uncertainty intervals. For example:

to the day April 5	$m_0(B45) = 22.23\ (09)$	was assigned $weight = 1/9$.
$day\_t_e = 3.71$	$magnitude = 22.23$	$weight = 1/9$

Accepting the maximum on April 1 $day_{\_t_e} = 0$ $m_0(B45) = 22.19$ and extrapolating the value on $day\_t_e = 14$ $m_0(B45) = 23.30$ we get $\Delta m_{15} = 1.11$ with an Absolute magnitude:

$$M_B = 2.698\ \Delta m_{15} - 21.726 = -18.73$$

This makes *SN 1995K* similar to *SN 1990N.*

As already mentioned, the value of the Time Dilation is used for calculating the distance of a supernova Ia, and for their part, the distances of the stars are fundamental for verifying or falsifying a cosmological model. With these observations together with those in [viXra:2207.0051] and in [viXra:2208.0152] I believe we should not yet rule out a model based on *SR*.

This, whatever the results of *ΛCDM* are in other fields.

[*] - [ads: DOI 10.1086/306308] -The High-Z Supernova Search: Measuring Cosmic Deceleration and Global Curvature of the Universe Using Type Ia Supernovae

[**] - Astrophysical Journal Letters v.413, p.L105 - The Absolute Magnitudes of Type IA Supernovae

[***] – NumPy: The Polinomial class: Copyright (c) 2005-2022, NumPy Developers. All rights reserved.

References from Wikipedia:

[1] – Photometric system