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ON SUPERNOVA LOW LUMINOSITY PROBLEM

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Abstract

A modification of the Einstein-Friedmann (EF) cosmological model allows to propose a new solution of several fundamental cosmological problems, in particular the supernovae low luminosity problem at redshift z > 1.The proposal excludes in principle some non-monotone (for example, accelerating) Universe expansion.

1. Introduction

As it is known, the real supernovae luminosity is lower than this one predicted by the EF-model *without* the non-zero cosmological constant. The standard approach consists in fitting of a model by choice of the corresponding constant value. The author of the publication proposed in 1997th a new cosmological model (the Spherical Expanding Universe Theory – SEUT). It is systematically described in details in **[Shulman, 2006, 2007]**. Time currency is there connected with the single global process. This process is the Universe expansion, it is external one relative to its features. In the frame of this model any non-linear Universe radius dependence on its age has not any meaning. This new concept, as the author believes, allows us to solve a number of fundamental cosmological problems **[Shulman, 2007]** including the famous one – the remote supernova low brightness problem.

In the recent works (particularly, see **[Benoit-Levy and Chardin, 2009]**) the new types of cosmology were proposed, where the *linear* Universe age dependence on its radius appears. The authors show that such linear dependence explains quantitatively the low luminosity of SN type Ia without usage of the cosmological term and allows us to resolve a number of the paradoxes of the modern cosmology.

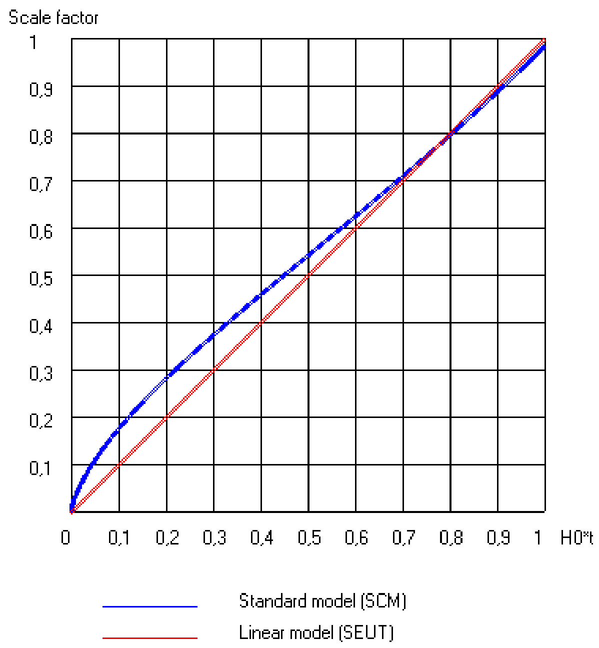

Figure 1.
Scale factor vs Universe age dependence in SCM and SEUT

The comparative dependences of the Universe scale factor evolution in the standard cosmological model (SCM) at $\mathbf{\Omega_m} = 0{,}25$, $\mathbf{\Omega_\Lambda} = 0{,}75$, $\mathbf{\Omega_k} = 0$ (blue curve) and in the SEUT (red curve) are shown in the Fig. 1. One can see that in our epoch (at small z) these curves are very close one to another.

2. Scale factor dependence on redshift

In the standard cosmology the coordinate dimensionless distance $\boldsymbol{r(z)}$ and the photometric one (or "luminosity distance") $\boldsymbol{\ell(z)}$ between $\boldsymbol{a}$ modern observer and some emitter of the light signal at redshift $\boldsymbol{z}$ are connected (at $c = 1$) by relationship:

$$\boldsymbol{\ell(z)} = \boldsymbol{H_0\, a_0\, r(z)}\,(1 + \boldsymbol{z})$$

where $\boldsymbol{H_0}$ is the Hubble constant, $\boldsymbol{a_0}$ is the Universe scale factor (at the present epoch). The factor $(1 + \boldsymbol{z})$ in a static universe is absent, but in the expanding Universe it accounts *an evolution* of the space scale during a light propagation time. On the other hand, the factor $\boldsymbol{r(z)}$ gives through $\boldsymbol{z}$ *the distance himself*, that the light signal had to move between emitter and receiver without account of the Universe expansion as such (as it is clear, it is equal to zero at $\boldsymbol{z} = 0$). The production $\boldsymbol{H_0 a_0 r(z)}$ is equal in the EF-model (**[Palash, 1999]**):

$$H_0 a_0 r(z) = \frac{1}{\sqrt{|\Omega_k|}}\,\mathrm{sinn}\left[\sqrt{|\Omega_k|}\int_0^z \frac{dz'}{\sqrt{(1+z')^2(1+\Omega_m z') - z'(2+z')\Omega_\Lambda}}\right],$$

where "sinn" means the hyperbolic sine function if $\mathbf{\Omega_k} > 0$, and sine function if $\mathbf{\Omega_k} < 0$. If $\mathbf{\Omega_k}=0$, the sinn and the $\mathbf{\Omega_k}$ disappear from the expression and we are left only with the integral. Here we use the dimensionless density components due to the matter ($\mathbf{\Omega_m}$), to the curvature ($\mathbf{\Omega_k}$), and to the cosmological constant ($\mathbf{\Omega_\Lambda}$), where $\mathbf{\Omega_m} + \mathbf{\Omega_k} + \mathbf{\Omega_\Lambda} = 1$.

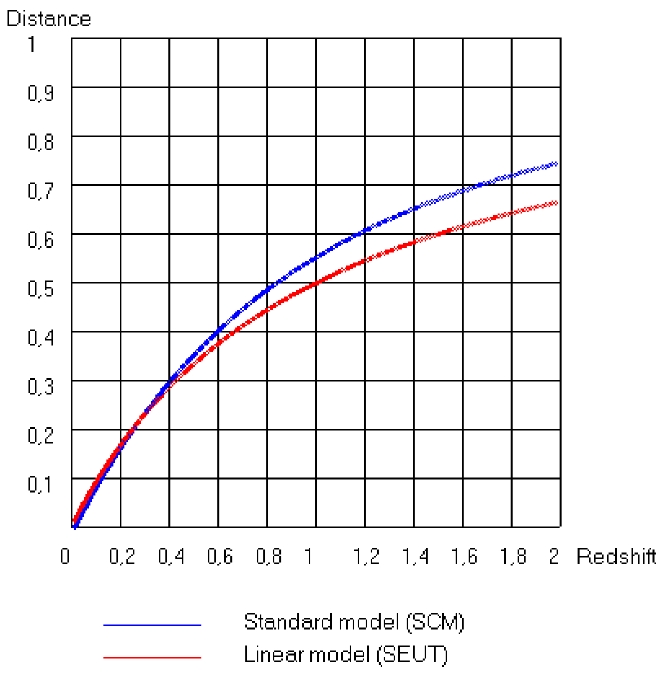

Figure 2.
Dependence $\boldsymbol{H_0\, a_0\, r(z)}$ vs redshift in SCM and SEUT

The numerically calculated plot $\boldsymbol{H_0 a_0 r(z)}$ for the SCM at $\boldsymbol{\Omega_m}$ = 0,25, $\boldsymbol{\Omega_\Lambda}$= 0,75, $\boldsymbol{\Omega_k}$ = 0 (blue curve) is shown in Fig. 2. In the same figure I show the dependence $\boldsymbol{H_0 a_0 r(z)}$ for the above model (SEUT), for it the distance between an observer and an object at a redshift z is equal to [1 – 1/(1+z)] = z/(z+1).

3. Luminosity dependence on redshift in different models

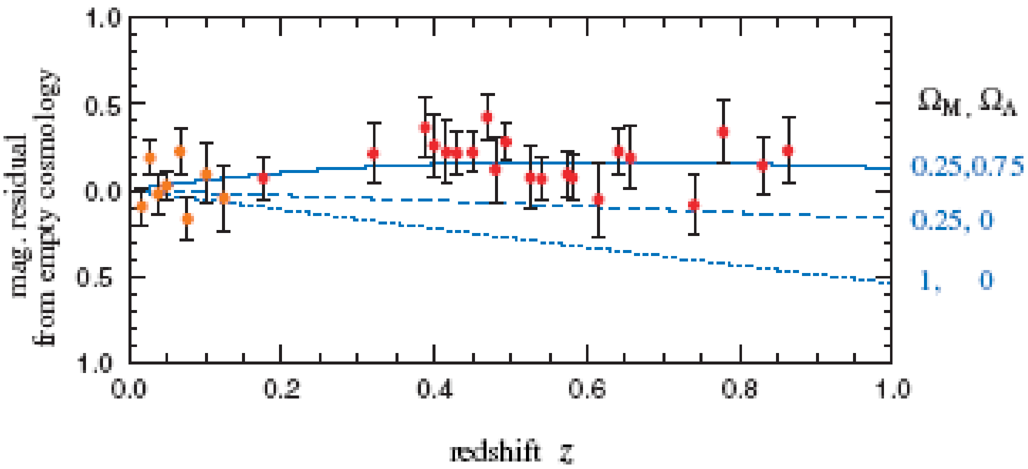

Figure 3. Luminosity dependence on redshift in EF-models
for different values of $\boldsymbol{\Omega_m}$ and $\boldsymbol{\Omega_\Lambda}$ (at $\boldsymbol{\Omega_k}$ = 0)

The residual luminosity dependence on redshift for EF-models with different values of $\boldsymbol{\Omega_m}$ and $\boldsymbol{\Omega_\Lambda}$ (at $\boldsymbol{\Omega_k}$ = 0) is shown on the Figure 2 **[Perlmutter, 1999]**. The magnitude difference Δm at given ***z*** for different models “A” and “B” can be found from the simple expression

$$\Delta m = 5 \cdot \lg\left(r_A(z) / r_B(z)\right)$$

(here 5 is the historically appeared factor, see for example **[Klapdor-Kleingrothaus, Zuber, 1997]**).

Table 1

Z	1,0	1,5	2,0
$r(\Omega_\Lambda = 0,75)$	0,55	0,66	0,74
$r_{тшрв}$	0,5	0,6	0,67
$r(\Omega_\Lambda = 0,75) / r_{тшрв}$	1,1	1,1	1.1
$\Delta m = 5 \lg [(\Omega_\Lambda = 0,75) / r_{тшрв}]$	0,2	0,2	0,2

On can see (in Fig. 2 and Tab. 1) that the difference between SCM and SEUT (at z<2) is not more than 10%. So, the difference between their luminosity magnitudes is not more than 0,2 and is practically equal to the measurement error. Because of that the SCM and SEUT predictions are the same.

4. Conclusion

Thus, the supernovae low brightness problem at high redshift in the standard EF-model is due to the *non-linear* Universe size dependence on its age. One of traditional way to eliminate this dificulty consists in usage of the cosmological constant and in fitting a relation between dimensionless density components ($\boldsymbol{\Omega_m}$ = 0,25, $\boldsymbol{\Omega_\Lambda}$ = 0,75, $\boldsymbol{\Omega_k}$ = 0).

But the SEUT does not in general provide any cosmological constant usage nor model parameters fitting. However, it can explicate the SN low brightness phenomena. The needed result is only due to the basic postulate of the Universe *linear* expansion. Therefore, contrary to the common opinion, I reject the fact of the Universe accelerated expansion in the modern epoch.

References:

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