Failure of the hypothesis of accelerated expansion of the universe

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Abstract

Our estimates of the cosmological parameters within the ΛCDM model and the model with zero cosmological constant are very different from other studies. The purpose of this report is to draw attention to the difference between our approach and the approaches of other authors and to evaluate the correctness of these approaches.

Keywords: *cosmological models - supernovae - dark energy - acceleration: general*

1. Introduction

We analyze the Hubble diagram in order to find the best fit between the observational data of type 1a supernovae and cosmological models.

For better fit between theory and observation, Pearson's Chi^2 (Chi-squared) goodness-of-fit test was used. Results are obtained for the ΛCDM model and, for comparison, the model with a zero cosmological constant. In order to improve the fit between the observed data and theory, the optimization is also carried out assuming that the absolute magnitude of supernovae is not constant, but evolves with time. It is assumed that the dependence of the absolute magnitude on the redshift is linear: $M = M_0 + \epsilon_c z$, where ϵ_c is the evolution coefficient of the absolute magnitude of type 1a supernovae and $M_0 = M(z = 0)$. In the case of the flat universe ($\Omega_M + \Omega_\Lambda = 1$), the best fit between theory and observation is $\epsilon_c = 0.304$. In this case, for the cosmological parameters we obtain $\Omega_\Lambda = 0.000$, $\Omega_M = 1.000$. And for the absolute magnitude M_0 of supernovae 1a, we obtain the value -18.875. Naturally, this result exactly coincides with the simulation result for the model with zero cosmological constant ($\epsilon_c = 0.304$, $q_0 = 0.500$, $M_0 = -18.875$). Within the framework of the Friedmann-Robertson-Walker model, without restriction on space curvature ($\Omega_M + \Omega_\Lambda + \Omega_K = 1$), we obtain the following values: $\epsilon_c = 0.304$, $\Omega_\Lambda = 0$, $\Omega_M = 1.000$, $\Omega_K = 0.000$, $M_0 = -18.875$. Therefore, the general case also leads to a flat Universe model ($\Omega_K = 0.000$). Within the framework of this work, the critical impact of the absolute magnitude M of type 1a supernovae on the cosmological parameters is also shown. In particular, it was found that a change in this value by only 0.4m (from -19.11 to -18.71) leads to a change in the parameters from $\Omega_\Lambda = 0.7$ and $\Omega_M = 0.3$ to $\Omega_\Lambda = 0$ and $\Omega_M = 1$.

More details about these results can be found in Mahtessian et al. (2020) and Mahtessian et al. (2022).

2. Discussion

Such a critical difference between the results of ours and other authors must be explained. What is the difference between our approaches and those of other authors? Who is right?

First, about the differences.

First difference. This is due to the rather large width of the distribution of the absolute magnitudes of type Ia supernovae. This issue was studied in the article by Ashall et al. (2016). The average absolute magnitude of 115 studied stars was obtained $\overline{MB} = -19.04 \pm 0.07$, standard deviation $\sigma_{MB} = 0.70$, 89 of

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them have late host galaxies ($Sa - Irr$ or star-forming galaxies, $S - F$), for which $\overline{MB} = -19.20 \pm 0.05$, $\sigma_{MB} = 0.49$, and 26 have early host galaxies ($E-SO$ or passive galaxies), respectively $\overline{MB} = -18.48 \pm 0.19$, $\sigma_{MB} = 0.98$.

Such large standard deviations in the absolute magnitude distributions of type Ia supernovae allow us to conclude that when estimating the values of cosmological parameters, it is wrong to take as a basis the absolute magnitude determined by few stars. In Mahtessian et al. (2020) showed that in this case the obtained cosmological parameters lead to a violation of the initial assumption that the absolute magnitudes of type Ia supernovae do not change with distance. This violation disappears when the absolute magnitude of supernovae is estimated while estimating the cosmological parameters.

Thus, when estimating cosmological parameters, the absolute magnitude of supernovae should also be an estimated parameter. The absence of such an approach can be considered a shortcoming in the works of other authors related to this topic. Note that this approach also improves the fit between the observational data and the theory. Assuming that the absolute magnitude of supernovae is constant with distance, we get that the share of dark energy in a flat universe does not exceed 50%. **In Mahtessian et al. (2020) also obtained another important result that the cosmological model with a zero cosmological parameter describes the universe no worse than the Friedmann-Robertson-Walker model**.

Second difference. The correlation between the absolute magnitude of supernovae and the age of the stellar population of host galaxies indicates that there is an evolution in the absolute magnitude of supernovae (Kang & et al. (2020). It is known that the absolute magnitude of type 1a supernovae correlates with the characteristics of the host galaxy. For example, in Hicken & et al. (2009) found a systematic difference in the absolute magnitude of supernovae of ~ 0.14 magnitude between very early and very late galaxies. Sullivan et al. (2010) and Kelly et al. (2010) found that SNe Ia in less massive galaxies (by a factor of 10) are weaker by ~ 0.08 magnitudes than in more massive galaxies. Rigault et al. (2018) showed that SNe Ia in environments with local star formation (higher local SFR) is about 0.16 magnitudes weaker than in locally passive environments (lower local SFR).

Kang & et al. (2020), converted the features of the host galaxies (morphology, mass and local SFR) to age differences with methods known in the literature. Table 1 is taken from Kang & et al. (2020). The table shows the correlation of the absolute magnitude of supernovae 1a with the properties of the parent galaxies. The last column of Table 1 shows the estimated absolute magnitude evolution over 5.3 Gyr, which corresponds to the difference in age at z=0 and z=1 (see Kang & et al. (2020), for each of the four different studies. The average of these values is ~ 0.25 mag/5.3 Gyr. In this range of redshifts, the observed decrease in supernova brightness in the Hubble diagram is approximately comparable to this value (see, for example, Riess & et al. (998)). And so, this effect may be associated with the evolution of the luminosity of supernovae and has nothing to do with the accelerated expansion of the universe.

We estimate the absolute magnitude of the supernova from simulations, whether we accept its evolution or not.

In order to assess who is right, in a previous work (Mahtessian et al. (2020)) we proposed an absolute magnitude test.

The meaning of the test is that after finding the values of the cosmological parameters, the dependence of the absolute magnitudes of SNe 1a on the distance (on the redshift z) is plotted and its compliance with the initial assumption is checked. If initially it was assumed that the absolute magnitude was independent of the redshift, then the absolute magnitudes calculated from the obtained parameters Ω_Λ and Ω_M should be independent of the redshift.

That is, there must be consistency between the initial guesses and the simulation results.

3. The sample

For the study, we use a subsample from SNIa "Union2" (Amanullah & et al. (2010)). The sample consists of 719 supernovae identified in 17 papers. Following several principles, the authors cleared the sample and left 557 supernovae for further study. We also use the observational material of these 557 stars without making any changes.

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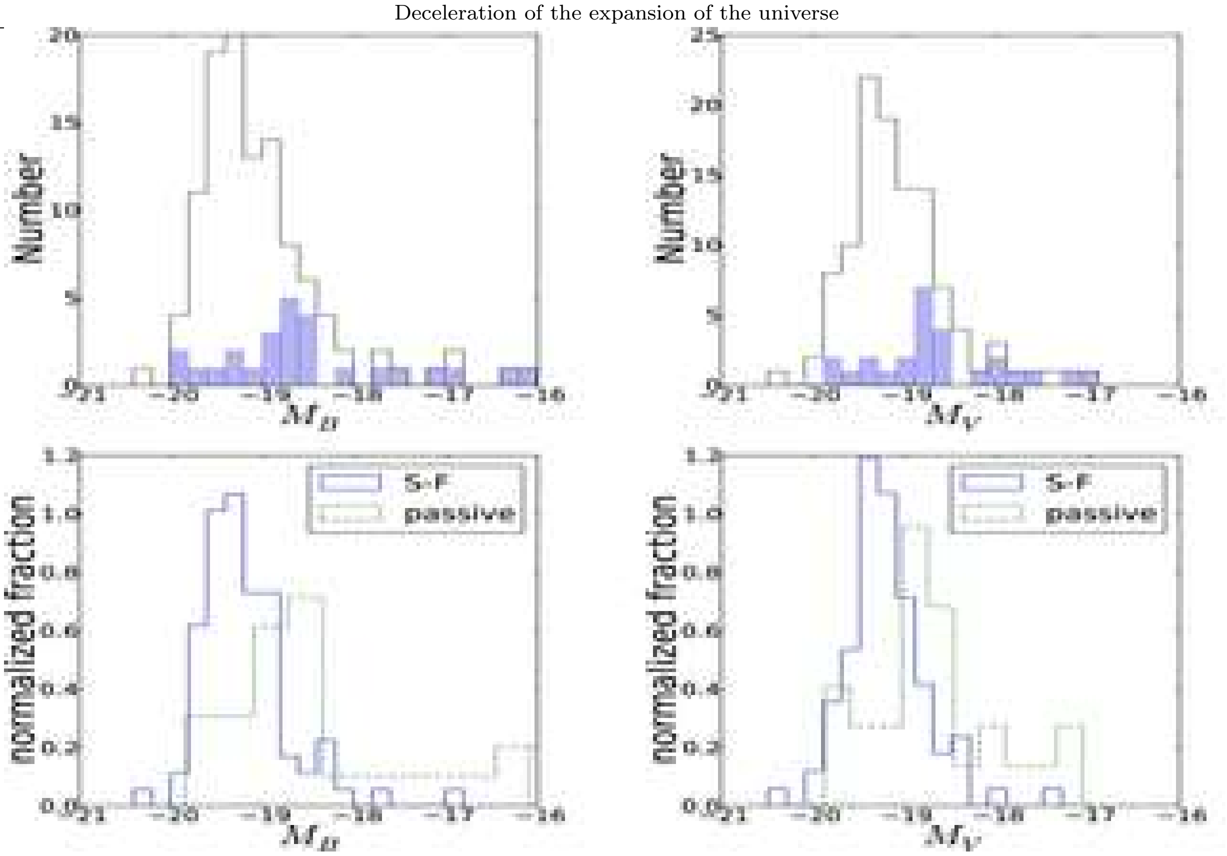

Figure 1. Distribution of absolute magnitudes of 115 type 1a supernovae. Graph copied from Ashall et al. (2016).

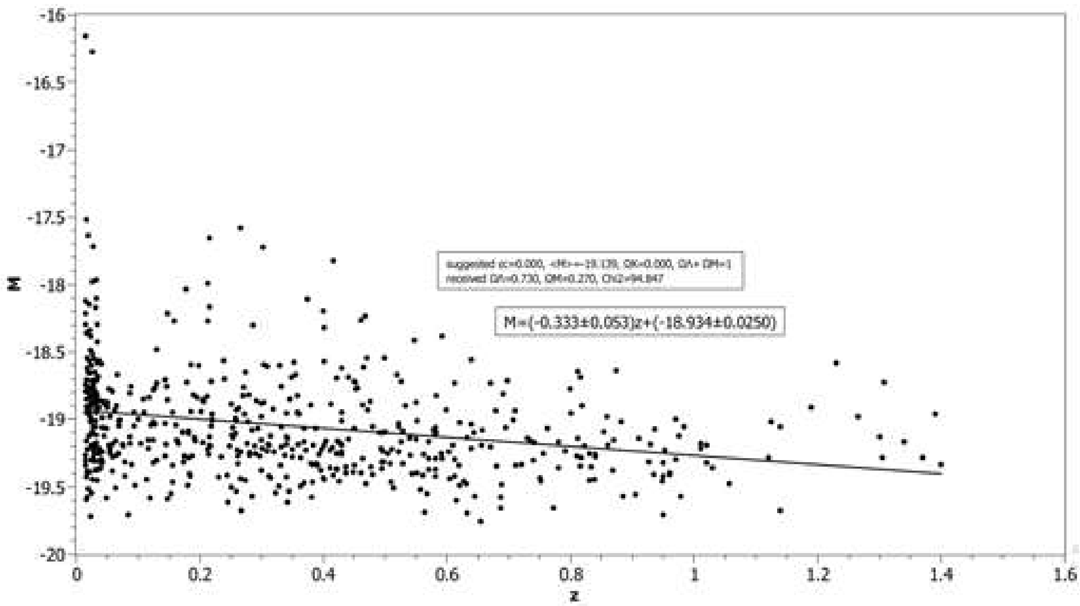

Figure 2. Dependence of the absolute magnitude of SNe1a on the redshift at $\Omega_\Lambda = 0.73$, $\Omega_M = 0.27$ for Amanullah & et al. (2010) sample.

4. Test

Amanullah & et al. (2010) investigate the case of a flat universe under the assumption that the absolute magnitudes of type 1a supernovae do not evolve.

That is, $\Omega_K = 0$, $\Omega_\Lambda + \Omega_M = 1$, $\epsilon_c = 0$.

With $M = -19.139$ ($H_0 = 72.305$) we get $\Omega_\Lambda = 0.73$, $\Omega_M = 0.27$, which were obtained in Amanullah & et al. (2010). Now let's do the "absolute magnitude test". The dependence of the absolute magnitude of M

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on the redshift is shown in fig. 2.

As can be seen, there is a clear relationship between the considered quantities. Thus, in this case, after the simulation, the assumption about the independence of the absolute magnitude of SNe Ia from the redshift is violated.

This gives grounds to believe that the authors found incorrect values of Ω_Λ and Ω_M.

Now let's run the simulation without fixing the absolute magnitude of the supernovae. The absolute magnitude will be obtained during the simulation. That is, we accept $\Omega_K = 0$, $\Omega_\Lambda + \Omega_M = 1$, $\epsilon_c = 0$ (as in Amanullah & et al. (2010) and we will evaluate Ω_Λ, Ω_M together with M.

The simulation gives $\Omega_\Lambda = 0.397$, $\Omega_M = 0.603$, $M = -18.903$.

Let's check the "absolute magnitude test" (Fig. 3).

As can be seen in this case, the original assumption about the independence of the absolute magnitudes of the redshift is not violated.

In addition to the "absolute magnitude test", the correctness of our result is indicated by the values of Chi^2. For the case of Amanullah & et al. (2010) obtained $Chi^2 = 94.85$, for our case $Chi^2 = 83.73$. The difference is quite big.

Thus, we can conclude that our approach is correct.

We will briefly show the results for different cases (Tables 1 and 2).

As can be seen from the tables, when the constancy of the absolute magnitudes of supernovae 1a is assumed, then the fraction of dark energy turns out to be 0.4, in contrast to 0.7, when the evolution of the absolute magnitudes of supernovae 1a is assumed, then Ω_Λ turns into 0.

When there are no restrictions on the curvature of space and the absolute magnitudes do not depend on the redshift, the Universe also consists only of gravitational matter ($\sim 40\%$ of the critical density), but has a negative curvature. This opinion reigned for approximately 50 years before 1998.

It was also found that the value of the cosmological parameters strongly depends on the absolute magnitude of supernovae.

Figure 4 shows a plot of , Ω_Λ, Ω_M versus M. This plot is built for the ΛCDM model for a flat universe ($\Omega_\Lambda + \Omega_M = 1$) and no evolution ($\epsilon_c = 0$). The graph shows the values of M corresponding to three combinations of cosmological parameters:

a) $\Omega_\Lambda = 0.7$, $\Omega_M = 0.3$ obtained at $M = -19.11$;

b) $\Omega_\Lambda = 0$, $\Omega_M = 1$ obtained at $M = -18.71$;

c) $\Omega_\Lambda = 0.397$, $\Omega_M = 0.603$ obtained at $M = -18.90$.

At the same time, as shown above, the best solution for a flat universe, without taking into account evolution, was obtained in the latter case (see Table 2).

The difference in the absolute magnitudes of supernovae 1a for combinations of a) and b) is: 19.11-18.71 = 0.4 magnitudes, while, as we saw above, the standard deviation of the distribution of absolute magnitudes of SNe Ia is 0.7 magnitudes. The magnitude difference between combinations a) and c) is only 0.2.

Thus, the dependence of the values of the parameters Ω_Λ and Ω_M on the accepted absolute value M SNe Ia is very strong, and therefore, when determining M, we must be extremely careful. As stated above, the determination of the absolute magnitude of supernovae must be simulated using the entire sample of type 1a supernovae.

5. Conclusion

The main results of this work are the following:

a. Under the assumption of the evolution of supernovae SNe 1a, the λCDM model describes the observational data better than under the assumption that the absolute magnitudes of SNe 1a are independent of redshift. In this case, a small evolution is obtained ($\Delta M = 0.304$ during the time of the corresponding z=1). Young supernovae are dimmer. Evolution is observed for both nearby and distant stars.

b. The universe turns out to be flat, even if this constraint is not initially introduced.

c. There is only gravitational matter in the universe.

d. he expansion of the universe is slowing down.

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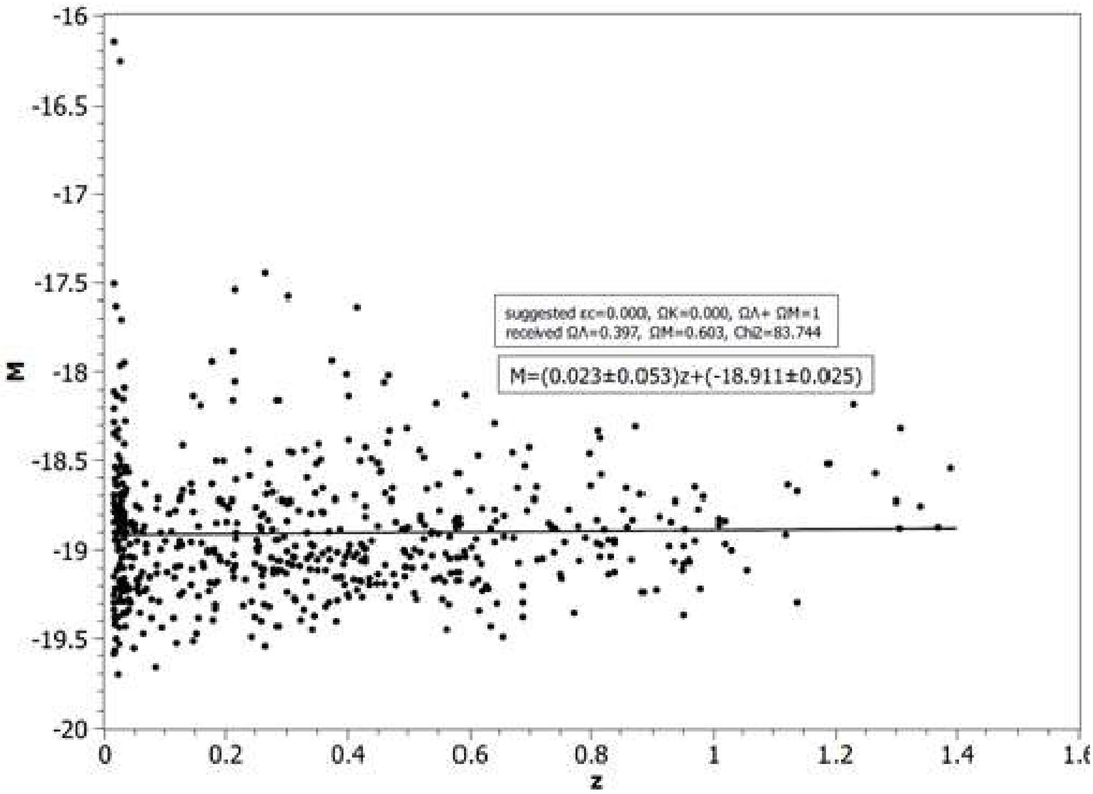

Figure 3. Absolute magnitude dependence on redshift for Amanullah & et al. (2010) sample for the case $\Omega_\Lambda = 0.397, \Omega_M = 0.603$.

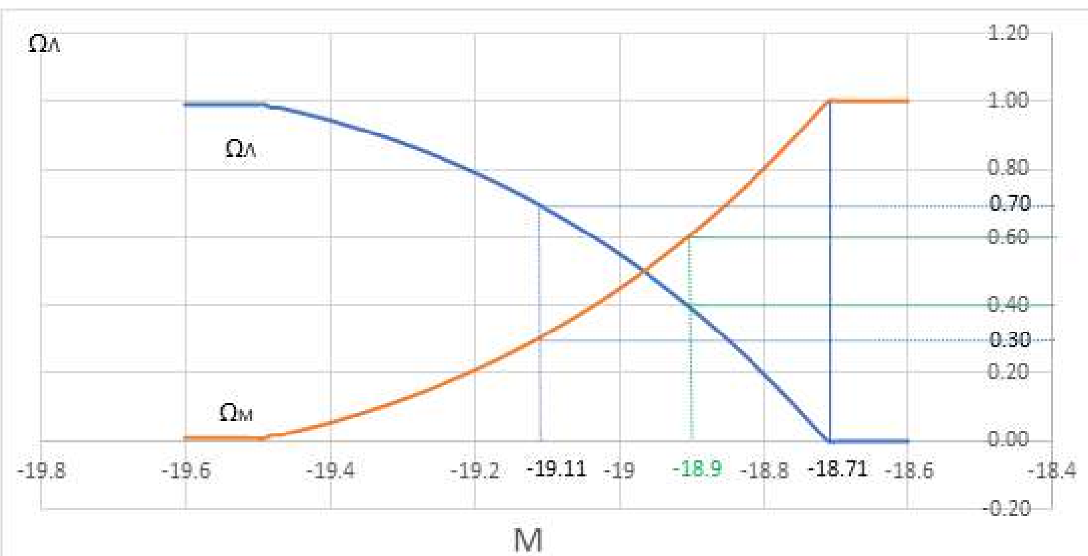

Figure 4. Plot, Ω_Λ, Ω_M versus M calculated for the ΛCDM model for a flat universe ($\Omega_\Lambda + \Omega_M = 1$). As can be seen from the figure, a change in M by only 0.4^m (from -19.11 to -18.71) leads to a change in parameters from $\Omega_\Lambda = 0.7$ and $\Omega_M = 0.3$ to $\Omega_\Lambda = 0$ and $\Omega_M = 1$.

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Table 1. Correlation of the absolute magnitude of supernovae 1a with the properties of host galaxies Kang & et al. (2020)

Host Property	References	Original Correlation	Direction	Converted to Age difference
Morphology	Hicken & et al. (2009)	ΔHR/Δmorph $\approx 0.14 mag/$ (Scd/Irr-E/S0)	Fainter in Later type galaxy	~0.19 mag/5.3Gyr Fainter in Younger galaxy
Mass	Sullivan et al. (2010)	ΔHR/Δmass ≈0.08 mag/ ($\Delta log M_* \sim 1$)	Fainter in Less massive galaxy	~0.21 mag/5.3Gyr Fainter in Younger galaxy
Local SFR	Rigault et al. (2018)	ΔHR/ΔlocalSFR ≈0.16 mag/ (Δ logLsSFRstep $\sim 2yr^{-1}kpc^{-2}$)	Fainter in Higher SFR environments	~0.34 mag/5.3Gyr Fainter in Younger galaxy
Population Age	Kang & et al. (2020)	ΔHR/Δage ≈0.051 mag/Gyr (YEPS)	Fainter in Younger galaxy	~0.27 mag/5.3Gyr Fainter in Younger galaxy

Table 2. The results for different cases of the Friedmann-Robertson-Walker Model

		Received					
Suggested	Evaluated	M_0	ϵ_c	Ω_Λ	Ω_M	Ω_K	Chi^2
$\epsilon_c = 0$, $\Omega_K = 0$, $\Omega_\Lambda + \Omega_M = 1$	M_0,Ω_Λ,Ω_M	-18.903	-	0.397	0.603	-	83.7439
$\Omega_K = 0$, $\Omega_\Lambda + \Omega_M = 1$	M_0,ϵ_c,Ω_Λ,Ω_M	-18.875	0.304	0.000	1.000	-	82.2258
$\epsilon_c = 0$, $\Omega_K + \Omega_\Lambda + \Omega_M = 1$	M_0,Ω_Λ,Ω_M,Ω_K	-18.881	-	0.000	0.368	0.632	83.2808
$\Omega_K + \Omega_\Lambda + \Omega_M = 1$	M_0,ϵ_c,Ω_Λ,Ω_M,Ω_K	-18.875	0.304	0.000	1.000	0.000	83.2258
$\Omega_K + \Omega_\Lambda + \Omega_M = 1$ $z = 0.0 \div 0.5$, $N = 403$	M_0,ϵ_c,Ω_Λ,Ω_M,Ω_K	-18.886	0.399	0.000	1.000	0.000	72.2283
$\Omega_K + \Omega_\Lambda + \Omega_M = 1$ $z = 0.5 \div 1.5$, $N = 154$	M_0,ϵ_c,Ω_Λ,Ω_M,Ω_K	-18.970	0.403	0.000	1.000	0.000	10.7607

Table 3. The results for the model with zero cosmological parameter ($\Lambda = 0$)

		Received			
Suggested	Evaluated	M_0	ϵ_c	q_0	Chi^2
$\epsilon_c = 0$, $\Lambda = 0$	M_0,q_0	-18.881	-	0.184	83.2808
$\Lambda = 0$	M_0,ϵ_c,q_0	-18.875	0.304	0.500	82.2258
$\Lambda = 0$, $z = 0.0 \div 0.5$, $N = 403$	M_0,ϵ_c,q_0	-18.886	0.399	0.500	72.2283
$\Lambda = 0$, $z = 0.5 \div 1.5$, $N = 154$	M_0,ϵ_c,q_0	-18.970	0.403	0.500	10.7607

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