New Cosmological Model and Observational Data Interpretation

Branislav Vlahovic and Maxim Eingorn
Department of Physics, North Carolina Central University, Durham NC, vlahovic@nccu.edu

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The conventional ΛCDM cosmological model supplemented by the inflation concept explains the Universe evolution well. However, there are still a few concerns; the dark matter is not detected directly and the dark energy is not described theoretically on a satisfactory level. Within the FLRW formalism we consider a model of the closed Universe (with the spherical spatial topology), filled with additional perfect fluid with the constant parameter -1/3 in the linear equation of state (which may be called quintessence). We compare this model with the standard ΛCDM one and answer the following question: can this additional fluid lead to light traveling between the antipodal points during the current age of the Universe? This possibility strongly affects the inflation scenario that may completely lose its necessity. Because the observed CMB may originate from a single antipodal point or region and for that reason it must be the same regardless of direction of observation. Small observed fluctuation are due to the Integrated Sachs-Wolfe effect.

Closed Unoverse Model

GR does not specify topology of the space. We will consider spherical shell model, S^3xT. In this model light can propagate only along the arc of the shell, but not across the shell, since there is no space inside the shell.

Let us first consider question, is there a possibility from the mathematical point of view that the last scattering surface is approximately point-like in the closed FLRW Universe?

$$ds^2 = c^2dt^2 - a^2(t)\left[d\chi^2 + \sin^2\chi\left(d\theta^2 + \sin^2\theta d\psi^2\right)\right]$$

Hyperspherical coordinates: $\chi \in [0,\pi];\quad \theta \in [0,\pi];\quad \psi \in [0,2\pi)$

I. The pure ΛCDM model

$$H^2 = \left(\frac{\dot a}{a}\right)^2 = \frac{\kappa\bar\rho c^4}{3a^3} + \frac{\Lambda c^2}{3} - \frac{c^2}{a^2} = H_0^2\left(\Omega_M\frac{a_0^3}{a^3} + \Omega_\Lambda + \Omega_K\frac{a_0^2}{a^2}\right)$$

The approximate condition of light traveling between the antipodal points during the age of the Universe

$$\int_{-t_0}^{0}\frac{cdt}{a(t)} = \pi$$

$$\sqrt{-\Omega_K}\int_0^1\frac{d\tilde a}{\sqrt{\Omega_M\tilde a + \Omega_K\tilde a^2 + \Omega_\Lambda\tilde a^4}} \approx 0.1 \neq \pi$$

II. ΛCDM + Quintessence with w = -1/3

$$H^2 = \left(\frac{\dot a}{a}\right)^2 = H_0^2\left(\Omega_M\frac{a_0^3}{a^3} + \Omega_\Lambda + \Omega_Q\frac{a_0^2}{a^2} + \Omega_K\frac{a_0^2}{a^2}\right)$$

$$\begin{cases}\Omega_M + \Omega_\Lambda + \Omega_Q + \Omega_K = 1\\ -\dfrac{\Omega_M}{2} + \Omega_\Lambda = -q = 0.535\end{cases}$$

$$\underline{\Omega_M} = \frac{2}{3}\left(1 - \Omega_Q - \Omega_K + q\right)\qquad \underline{\Omega_\Lambda} = \frac{2}{3}\left(\frac{1}{2} - \frac{\Omega_Q}{2} - \frac{\Omega_K}{2} - q\right)$$

$$\sqrt{-\Omega_K}\int_0^1\frac{d\tilde a}{\sqrt{\Omega_M\tilde a + \Omega_Q\tilde a^2 + \Omega_K\tilde a^2 + \Omega_\Lambda\tilde a^4}} = \pi$$

Two examples

A) Exact compensation: $-\Omega_K = \Omega_Q = 0.93$

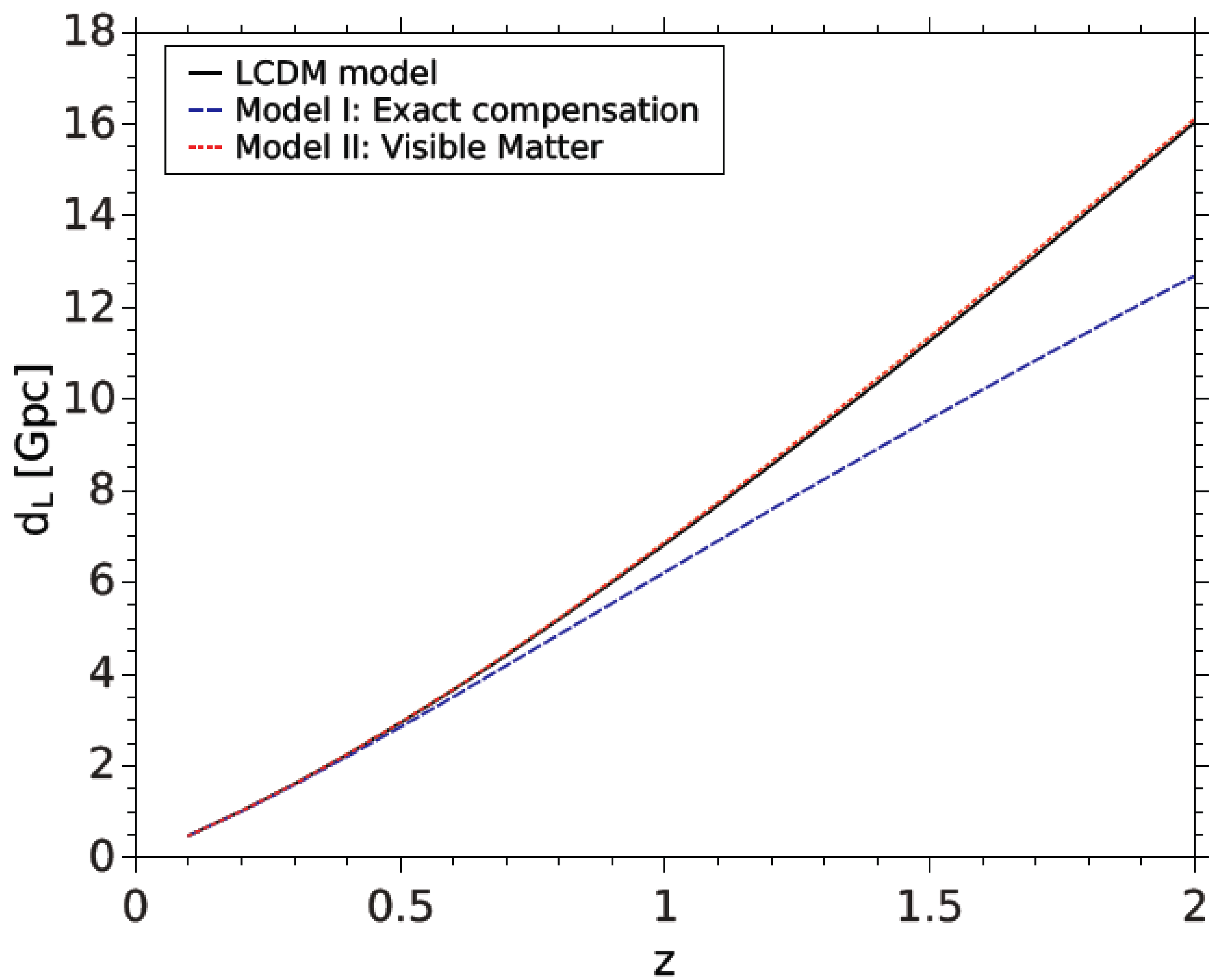
$\Omega_M = 0.31,\quad \Omega_\Lambda = 0.69$

B) Visible matter: $\Omega_M = 0.040,\quad \Omega_\Lambda = 0.555$

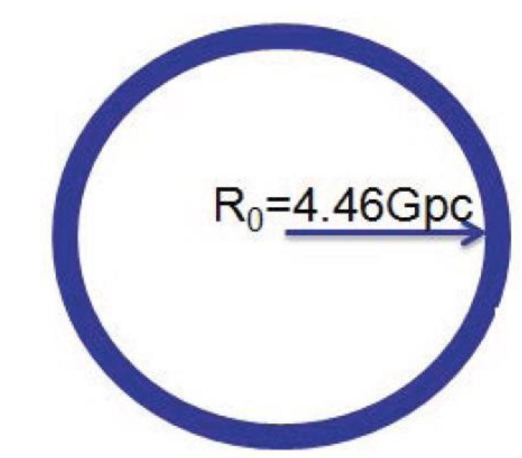
$\Omega_Q = 0.721,\quad \Omega_K = -0.316$

$$d_{L(\mathrm{I,II})}(z) = \frac{c}{H_0}(1+z)\sqrt{-1/\Omega_K}\,\sin\left[\sqrt{-\Omega_K}\int_{\frac{1}{1+z}}^{1}\frac{da}{\sqrt{a\Omega_M + a^4\Omega_\Lambda + a^2\left(\Omega_Q + \Omega_K\right)}}\right]$$

$$d_{L(\Lambda CDM)}(z) = \frac{c}{H_0}(1+z)\int_{\frac{1}{1+z}}^{1}\frac{da}{\sqrt{a\Omega_M + a^4\Omega_\Lambda + a^2\Omega_K}}$$



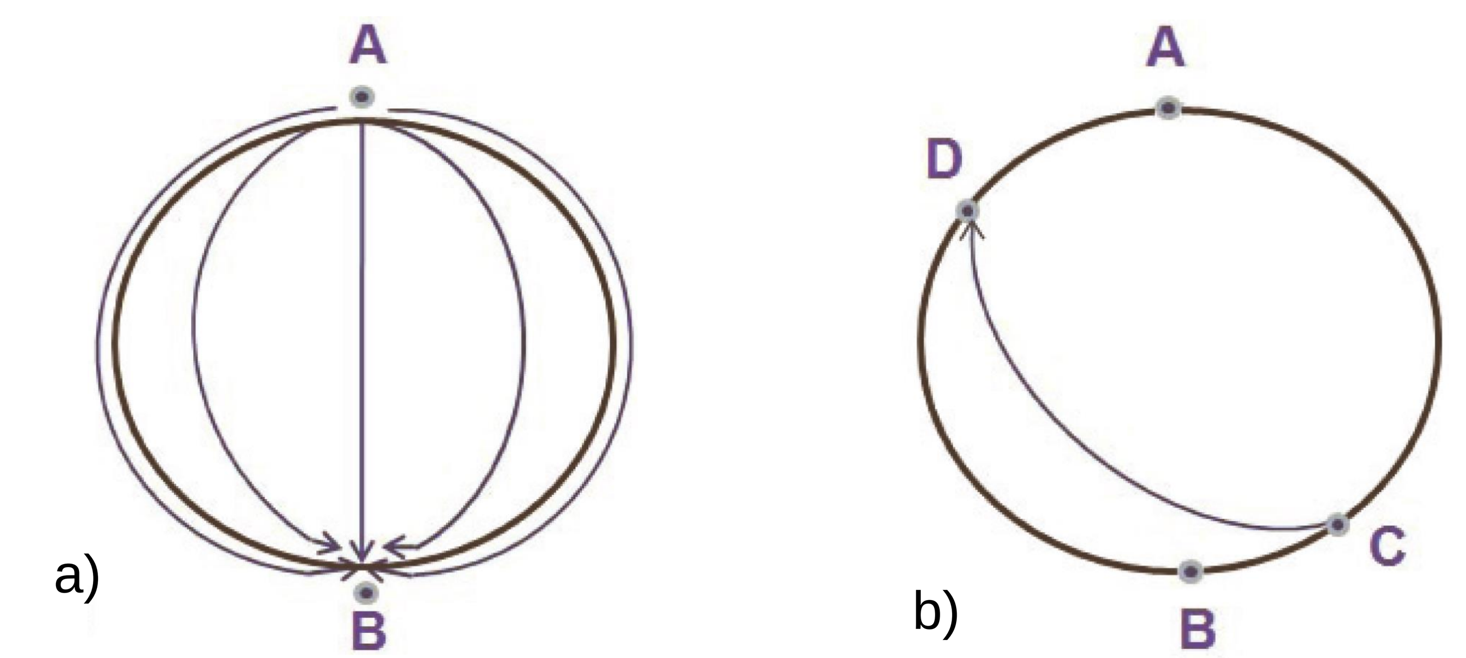
The visible universe as expanding thin shell



The visible universe as a spherical shell with radius R_0 = 4.46 Gpc and thickness much smaller than radius. Since light is traveling along the arc the particle horizon is the same as in the ΛCDM 14.0 ± 0.1 Gpc.

The model predicts uniformity of CMB

The CMB is uniform because it originates from one point or region. When we observe CMB we are always looking in that point or region.



a) CMB visible from Earth (by observer in point A) is originated in point B, b) CMB visible from another place in the universe (point C) is emitted at the point D.

To establish connection between the uniformity of the early universe at the time of decoupling and the CMB, measurement of the CMB must be done at two different points, which is not possible.

Conclusion

In the ΛCDM model supplemented by the quintessence with w = -1/3 in the spherical space there is an elegant solution of the horizon problem without inflation: under the proper choice of the parameters light travels between the antipodal points during the age of the Universe. We always measure the same CMB originated at the antipodal point or region regardless of direction of observation.

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