The recent cosmological measurements vs $f(R)$ theory

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The simple description of Universe

- Ω_M how much matter there is in the Universe
- Ω_Λ how much dark energy there is in the Universe
- $\Omega_k = 1 - \Omega_M - \Omega_\Lambda$ what is the curvature of the Universe
- H_0 what is the speed of expansion of the Universe
- z „redshift”, parameter characterising the observed electro-magnetic spectrum

$$d(z) = d(z, H_0, \Omega_M, \Omega_\Lambda, \Omega_k)$$

Was Einstein right?

The simplest formulation

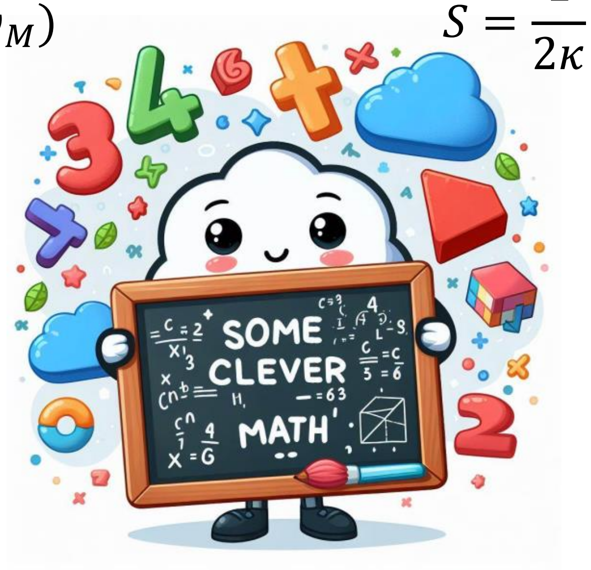
$$S = \frac{1}{2\kappa}\int d^4x\, R\sqrt{-g} + \int d^4x\, L_M(g_{\mu\nu}, \psi_M)$$

$$d = (1+z)\frac{c}{H_0}\int_0^z \frac{d\zeta}{\sqrt{\Omega_M(1+\zeta)^3 + (1-\Omega_M)}}$$

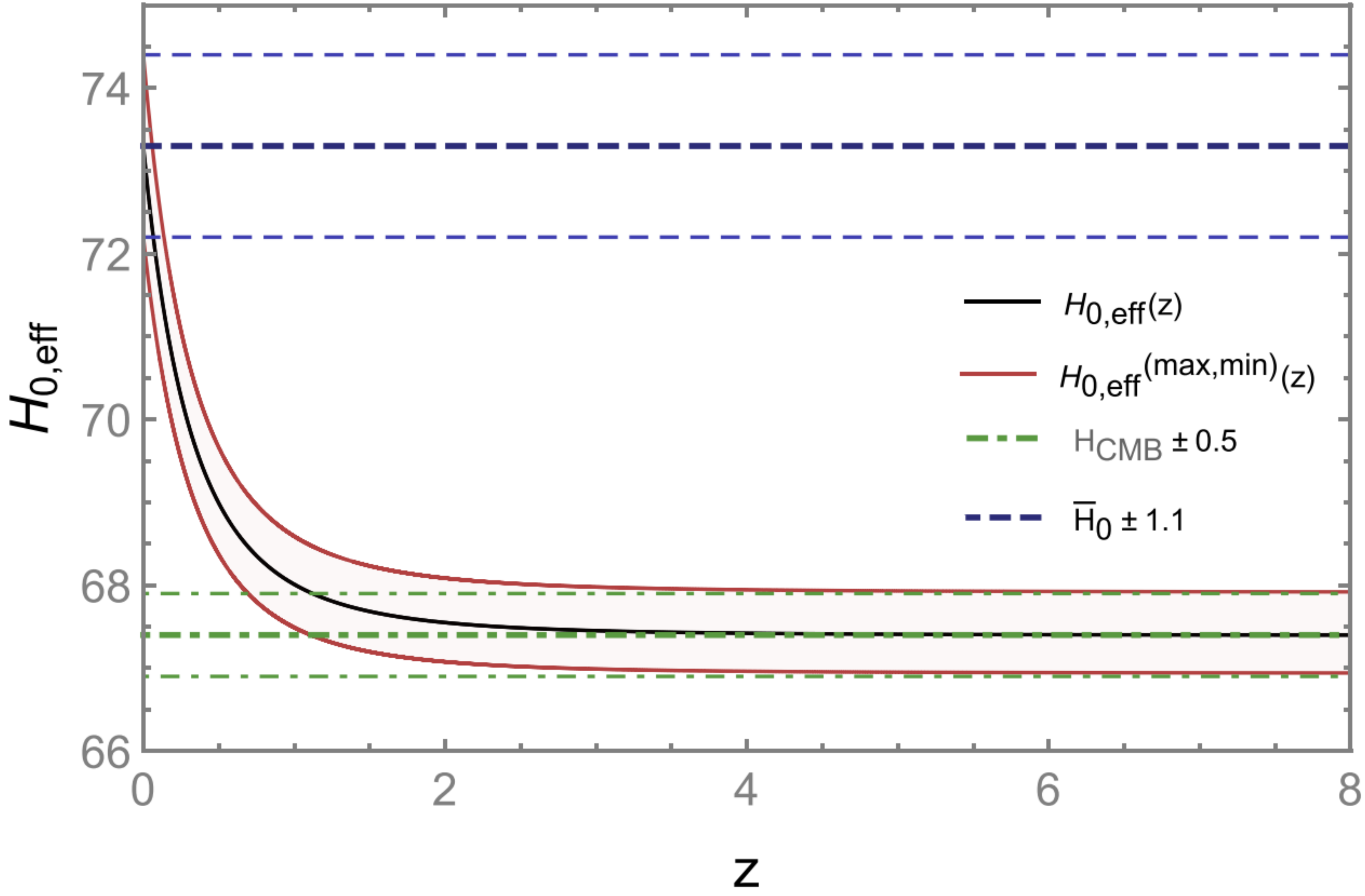
The *f(R)* formulation

$$S = \frac{1}{2\kappa}\int d^4x\, f(R)\sqrt{-g} + \int d^4x\, L_M(g_{\mu\nu}, \psi_M)$$

$$d = (1+z)\frac{c}{H_0}\int_0^z \frac{d\zeta}{\sqrt{\frac{\Omega_M}{\varphi(\zeta)}(1+\zeta)^3 + (1-\Omega_M)}}$$



Impact on the measurements of a speed of expansion

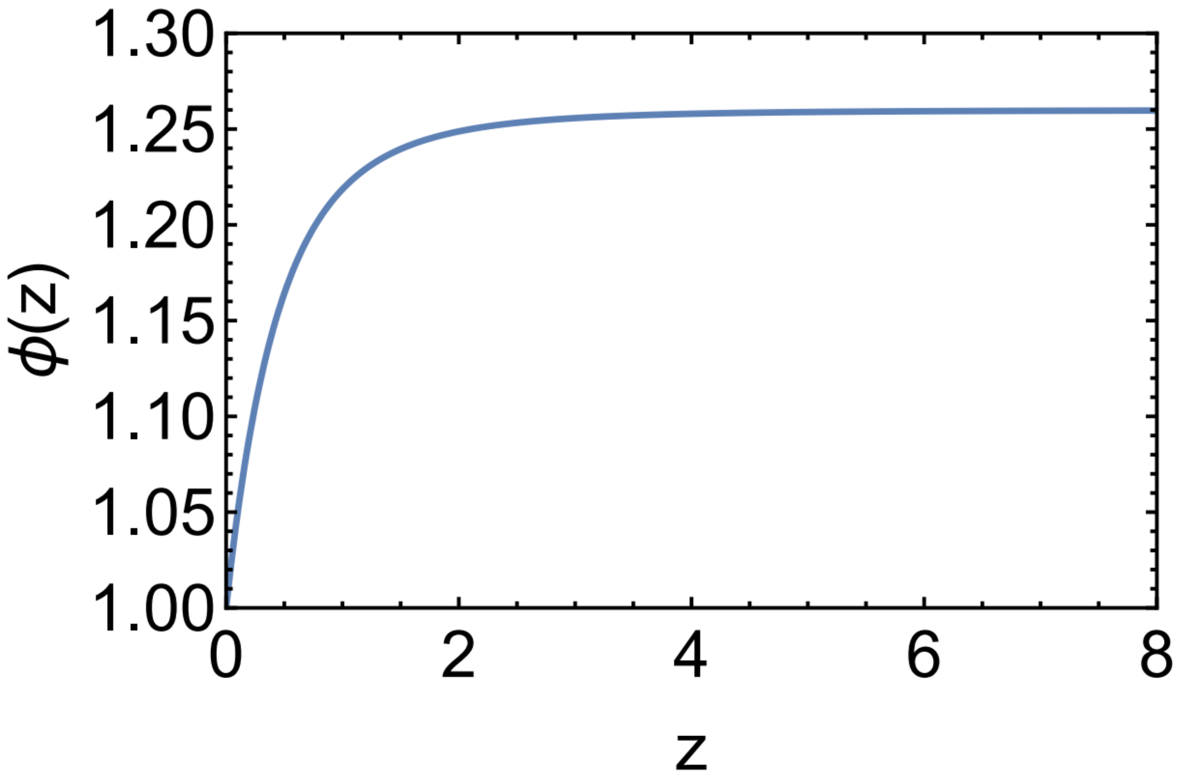


From equations of motion: $x \overset{\text{def}}{=} \ln(1+z)$

$$d = (1+z)\frac{c}{H_0}\int_0^z \frac{d\zeta}{\sqrt{\frac{\Omega_M}{\varphi(\zeta)}(1+\zeta)^3 + (1-\Omega_M)}}$$

$$2(\Omega_M - 1)\varphi(x)^2(\varphi'(x) + \varphi''(x)) + e^{3x}\Omega_M\left(\varphi'(x)^2 - \varphi(x)\big(7\varphi'(x) + 2\varphi''(x)\big)\right) = 0$$

Initial values: $\varphi(0) = 1, \qquad \varphi'(0) = w$



$\Omega_M = 0.30$

$\varphi'(x = 0) = -0.56$

But it should modify also Ω_M

$$d = (1+z)\frac{c}{H_0}\int_0^z \frac{d\zeta}{\sqrt{\Omega_M(1+\zeta)^3 + (1-\Omega_M)}}$$

$$d = (1+z)\frac{c}{H_0}\int_0^z \frac{d\zeta}{\sqrt{\frac{\Omega_M}{\varphi(\zeta)}(1+\zeta)^3 + (1-\Omega_M)}}$$

If we fit the simple model at high z, we expect smaller Ω_M, than at small z

Do we actually observe it?

Quasars (z<7.5) best fit

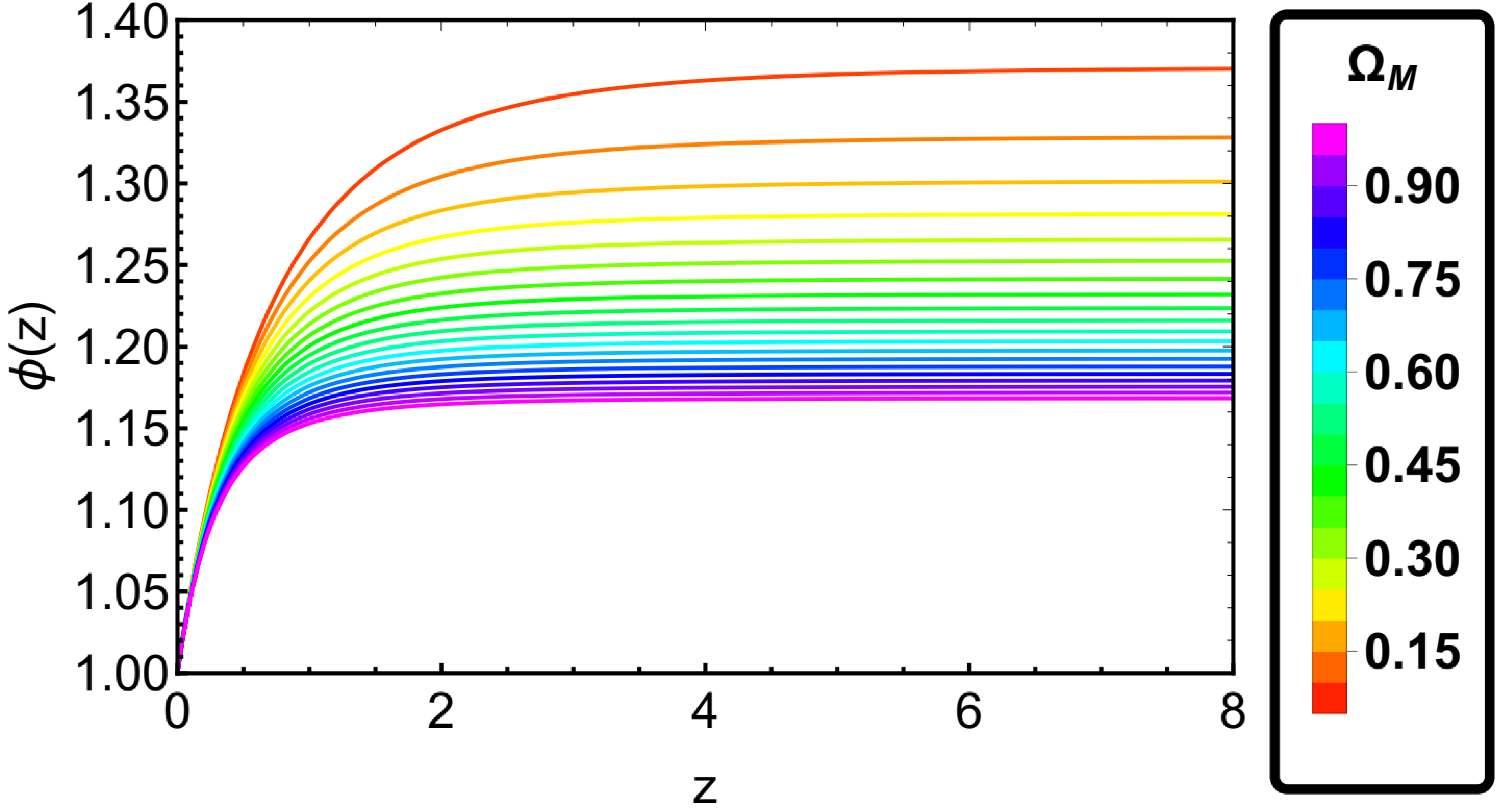
$$\Omega_M = 0.24 \pm 0.06$$

γ-ray attenuation (z<6) best fit

$$\Omega_M = 0.19 \pm 0.08$$

SNe Ia (z<2.1) best fit

$$\Omega_M = 0.334 \pm 0.018$$



1.40
1.35
1.30
1.25
1.20
1.15
1.10
1.05
1.00
0
2
4
6
8
z
ϕ(z)
Ω_M
0.90
0.75
0.60
0.45
0.30
0.15

Thank You For Attention

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Sources

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