Cosmology from quantum fluctuations of space-time (CMaDE model)

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The CMaDE model

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The Compton mass

Tonatiuh Matos and Laura L-Parrilla. Rev. Mex.Fis., (2021), 67, 040703. arXiv:2108.05206

Energy of a photon of frequency ν

$$E = h\nu = mc^2$$

Compton wavelength

$$\lambda = \frac{h}{mc}$$

Graviton

$$m_g = 0$$

$$E = h\nu = mc^2 \quad \Rightarrow \quad \lambda = \frac{h}{mc}$$

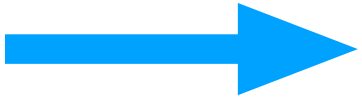
Everything gravitates

Compton mass

Tonatiuh Matos and Laura L-Parrilla. Rev. Mex.Fis., (2021), 67, 040703. arXiv:2108.05206

Weak field

$$g_{\mu\nu} = \eta_{\mu\nu} + h_{\mu\nu}$$



$$R_{\mu\nu} \sim \frac{1}{2}\Box h_{\mu\nu} = \frac{1}{2}\Box g_{\mu\nu}$$

Scalar Field

$$\Box\Phi = \frac{m^2c^2}{\hbar^2}\Phi = 0$$

Electromagnetic Field

$$\Box A_\mu = \frac{m^2c^2}{\hbar^2}A_\mu = 0$$

Gravitational Field

$$\Box g_{\mu\nu} = \frac{m^2c^2}{\hbar^2}g_{\mu\nu} = 0$$

Einstein Equations

Tonatiuh Matos and Laura L-Parrilla. Rev. Mex.Fis., (2021), 67, 040703. arXiv:2108.05206

$$R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R = \kappa^2 T_{\mu\nu} \qquad R_{\mu\nu} = \kappa^2\left(T_{\mu\nu} - \frac{1}{2}g_{\mu\nu}T\right)$$

Einstein Equations

Tonatiuh Matos and Laura L-Parrilla. Rev. Mex.Fis., (2021), 67, 040703. arXiv:2108.05206

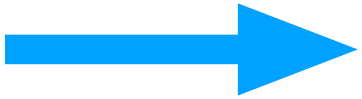
$$R_{\mu\nu} - \mathcal{M} g_{\mu\nu} = 0$$

Weak field $\Box g_{\mu\nu} - \frac{m^2 c^2}{\hbar^2} g_{\mu\nu} = 0$

$$R_{\mu\nu} \sim \frac{1}{2}\Box h_{\mu\nu} = \frac{1}{2}\Box g_{\mu\nu}$$

$$2R_{\mu\nu} - 2\mathcal{M} g_{\mu\nu} = 0$$

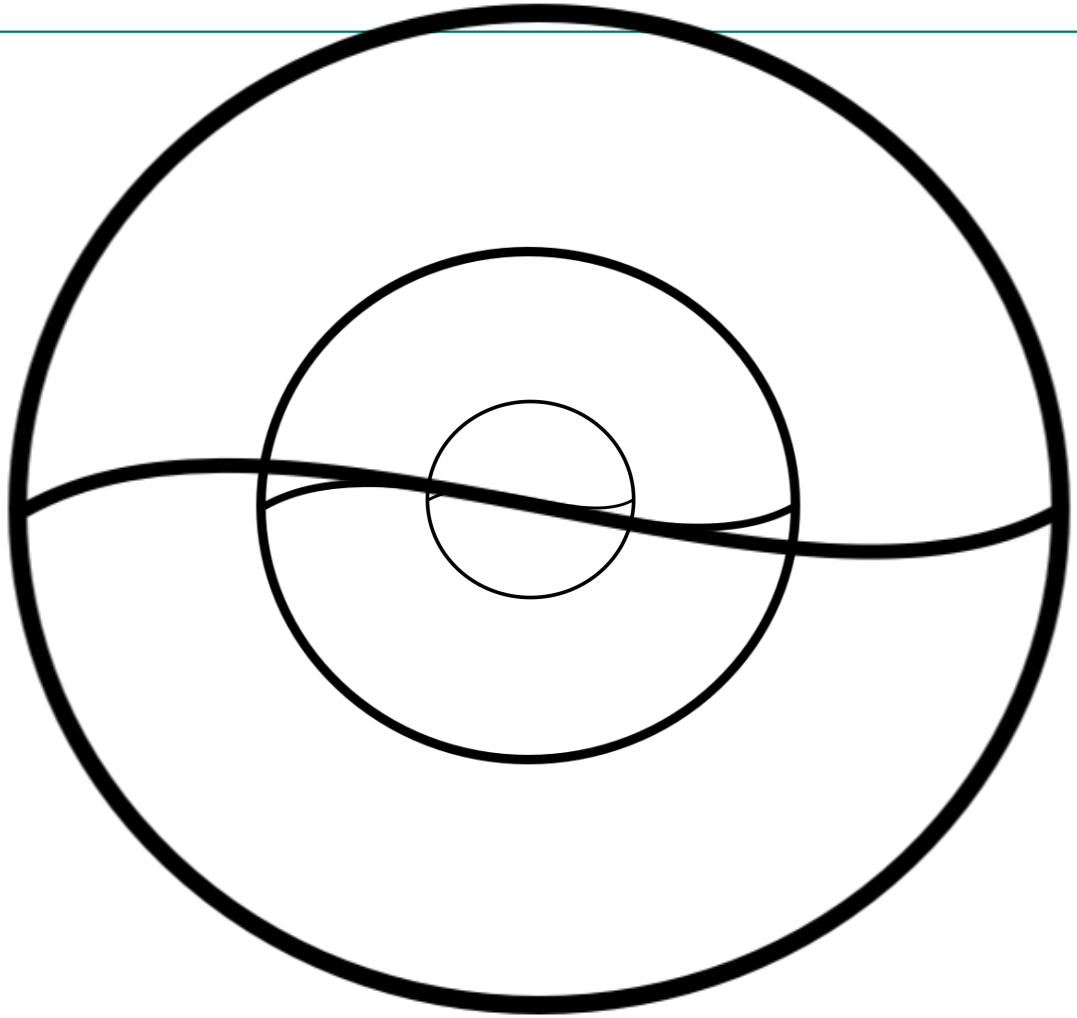
$$2\mathcal{M} = \frac{m^2 c^2}{\hbar^2} = \frac{4\pi^2}{\lambda^2}$$



Compton mass

$$m = \frac{h}{\lambda c}$$

The Universe is finite



$$ds^2 = -c^2 dt^2 + a d\mathbf{x}^2 = 0$$

The CMaDE model

Tonatiuh Matos and Laura L-Parrilla. Rev. Mex.Fis., (2021), 67, 040703. arXiv:2108.05206

$$R_H = H_0 \int_0^{today} \frac{dt}{a} = H_0 \int_{-\infty}^{0} \frac{dN}{H} e^{-N}$$

$$N = \ln(a) \qquad \dot{N} = H$$

$$\lambda = \frac{c}{H_0} R_H$$

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R + \mathcal{M} g_{\mu\nu} = \kappa^2 T_{\mu\nu}$$

$$\mathcal{M} = \frac{2\pi^2}{\lambda^2} = \frac{2\pi^2}{R_H^2} \frac{H_0^2}{c^2}$$

The Freedman equation

T.M., Luis Escamilla, Alberto Vázquez and Maribel Hernandéz-Márquez. In preparation.

$$H^2 = \frac{\kappa^2}{3}\left(\rho_m + \rho_r + \rho_\Lambda\right)$$

The Freedman equation

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$$H^2 + \frac{k}{a^2} - \frac{\mathcal{M}c^2}{3} = \frac{\kappa^2\rho}{3}$$

$$\Omega_{\mathcal{M}} = \frac{1}{3}\frac{c^2}{H_0^2}\frac{2\pi^2}{\lambda^2} = \frac{2}{3}\frac{\pi^2}{R_H^2}$$

$$\begin{aligned}
\mathcal{H}^2 &= \Omega_b^0 + \Omega_{DM}^0 + \Omega_r^0 + \Omega_{0k}^0 e^{-2N} + \Omega_{\mathcal{M}}^0 \\
\Omega_{DM}^{0\prime} &= -3\Omega_{DM}^0 - \mathsf{k_c}\Omega_{\mathcal{M}}^{0\prime} \\
\Omega_b^{0\prime} &= -3\Omega_b^0 \\
\Omega_r^{0\prime} &= -4\Omega_r^0 \\
\Omega_{\mathcal{M}}^{0\prime} &= \mathsf{Q}\frac{\sqrt{6}}{\pi}{\Omega_{\mathcal{M}}^0}^{3/2}\frac{e^{-N}}{\mathcal{H}}
\end{aligned}$$

The Freedman equation

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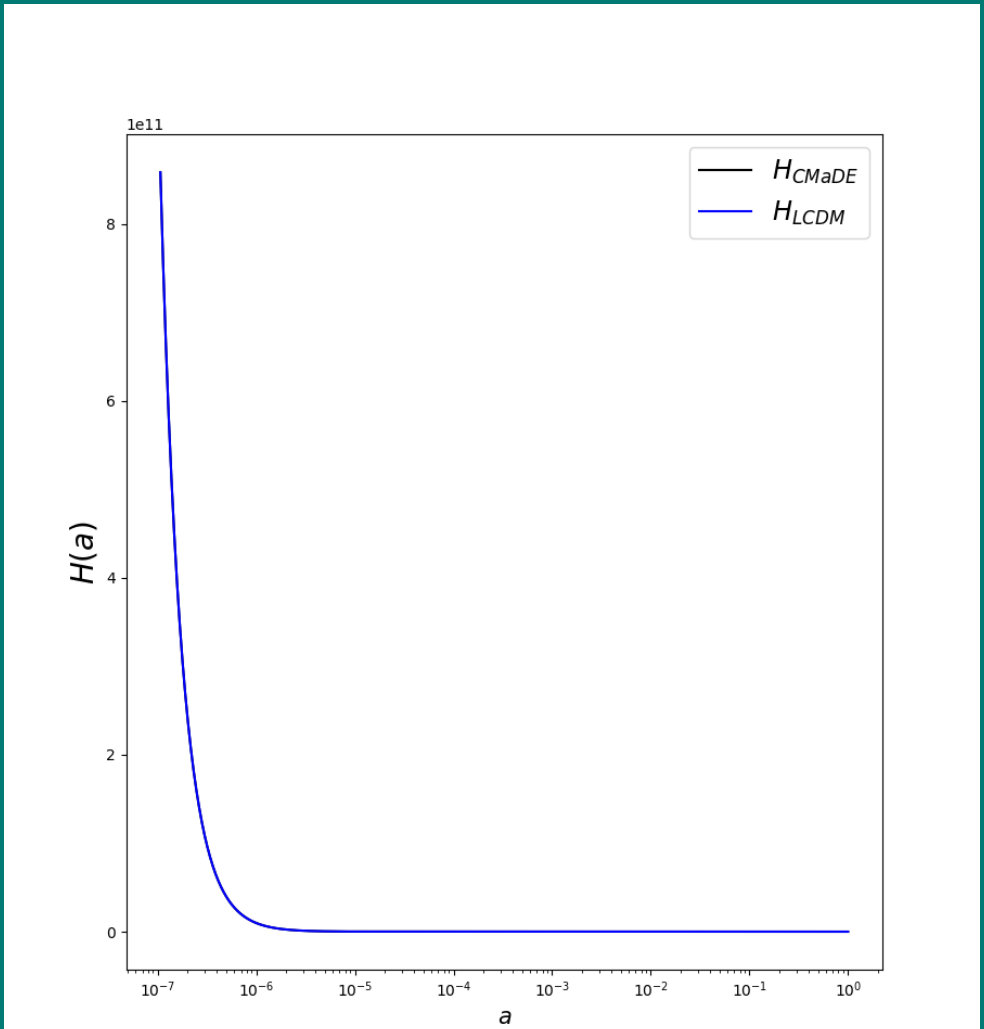

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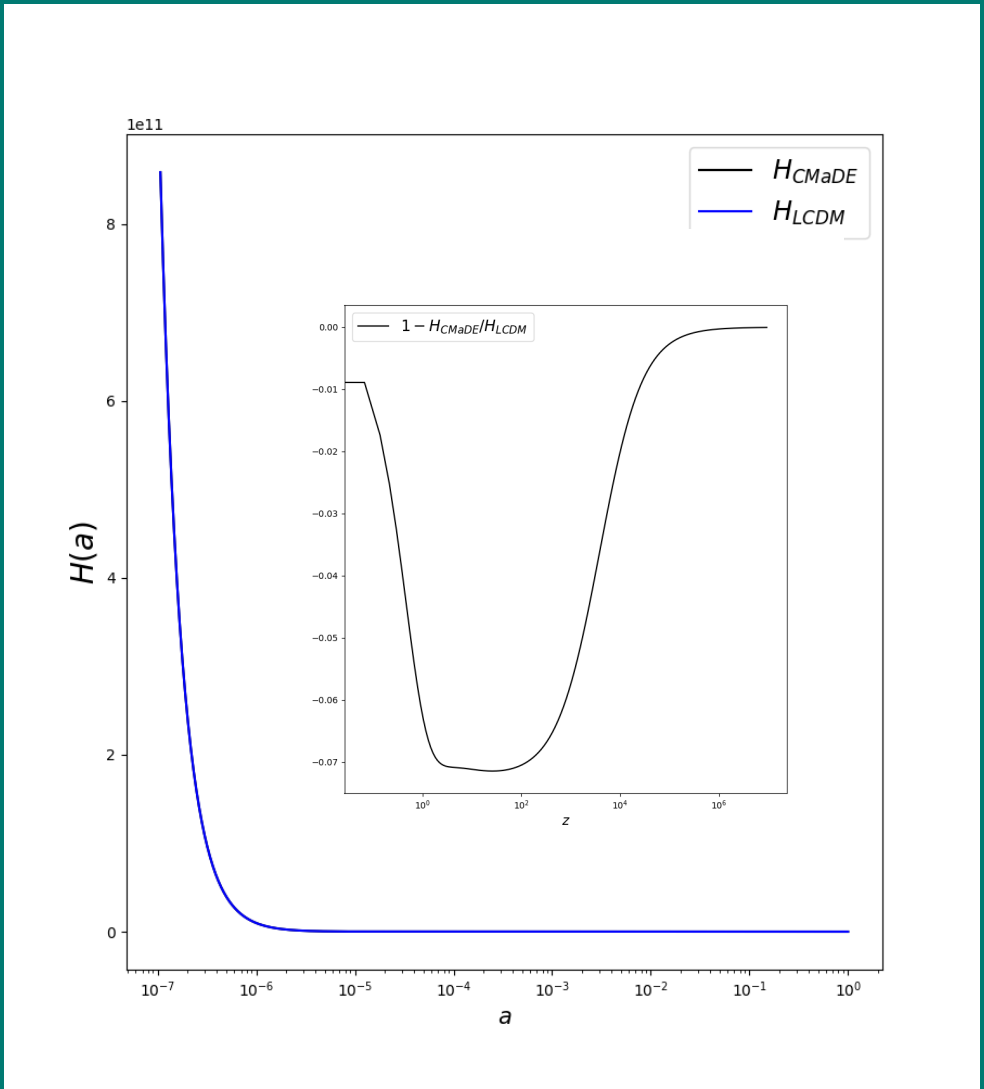

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$$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} + \frac{2\pi^2}{\lambda^2}g_{\mu\nu} = \kappa^2 T_{\mu\nu}$$

$\lambda =$ The Compton wavelength of the graviton

$$\mathcal{M} = \frac{2\pi^2}{\lambda^2}$$

The Friedman equations

$$\begin{aligned}
\mathcal{H}^2 &= \Omega_b^0 + \Omega_{DM}^0 + \Omega_r^0 + \Omega_{0k}^0 e^{-2N} + \Omega_{\mathcal{M}}^0 \\
\Omega_{DM}^{0'} &= -3\Omega_{DM}^0 - k_c\Omega_{\mathcal{M}}^{0'} \\
\Omega_b^{0'} &= -3\Omega_b^0 \\
\Omega_r^{0'} &= -4\Omega_r^0 \\
\Omega_{\mathcal{M}}^{0'} &= Q\frac{\sqrt{6}}{\pi}{\Omega_{\mathcal{M}}^0}^{3/2}\frac{e^{-N}}{\mathcal{H}}
\end{aligned}$$

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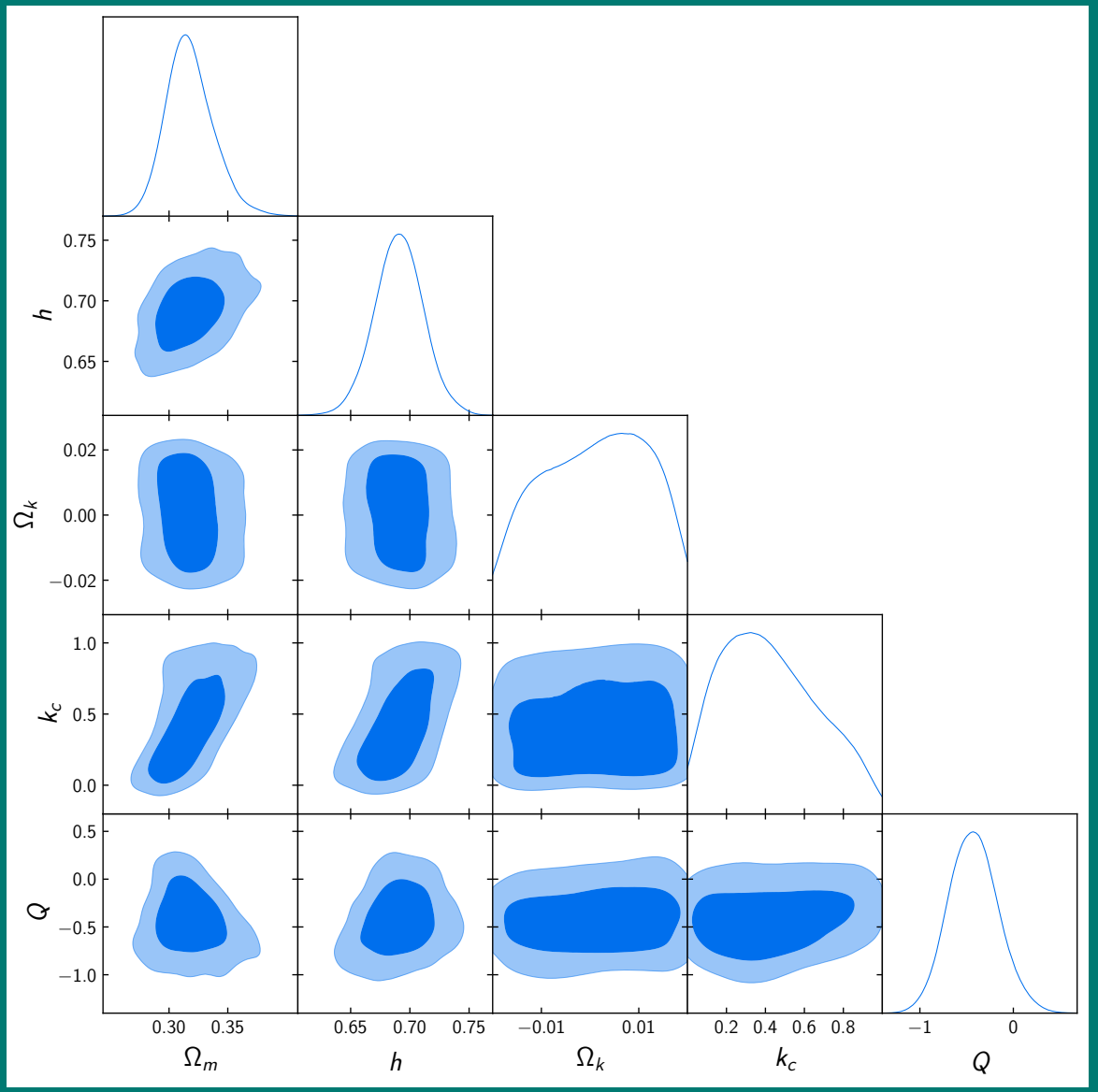
CC+BAO+ Pantheon

$$\Delta\chi^2 = 3.25$$

in favor of CMaDE against ΛCDM

$$h = 0.69, \;\; \Omega_m = 0.31, \;\; \Omega_k = 0.08$$



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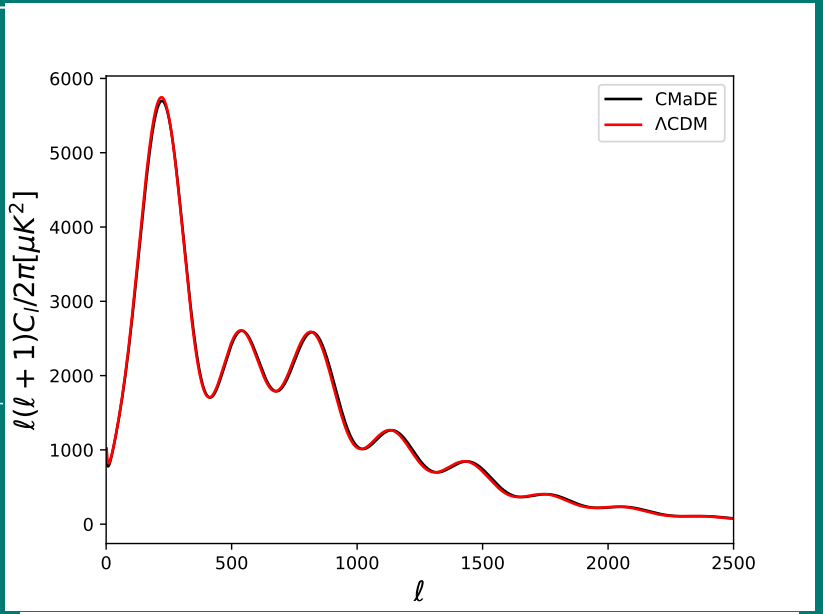
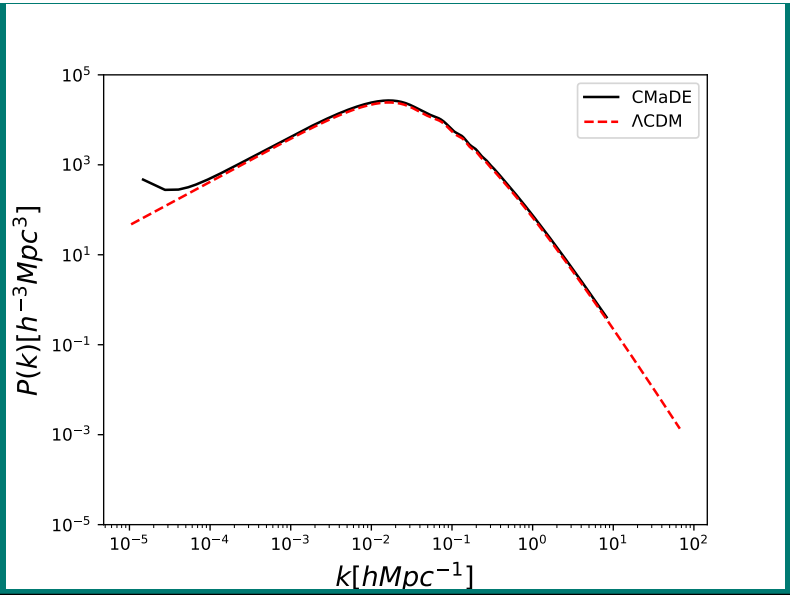
CMB

CMB and MPS

$h = 0.68, \quad \Omega_b = 0.048 \quad \Omega_{DM} = 0.23, \quad \Omega_k = 0.001$



MPS



by Tonatiuh Matos (tonatiuh.matos@cinvestav.mx)

- Conclusions: Quantum fluctuations in space-time seem to be able to explain very well the accelerating expansion of the universe, without the need for a cosmological constant, exotic extra matter, or modifications to Einstein's equations.

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Friedman equations

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\end{aligned}$$

CC+BAO+Pantheon

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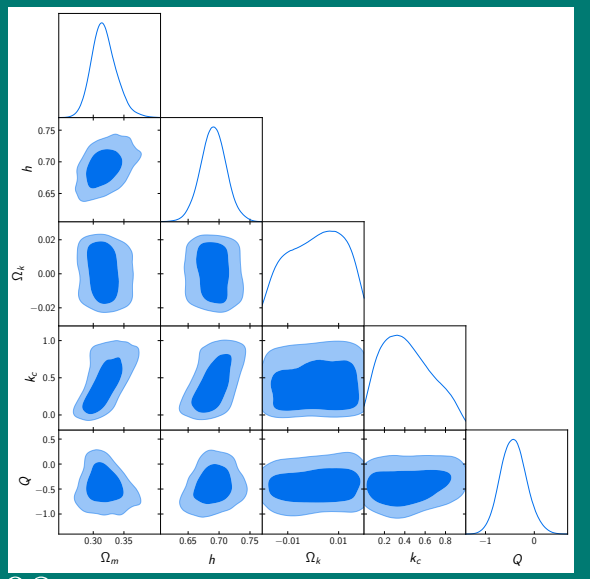

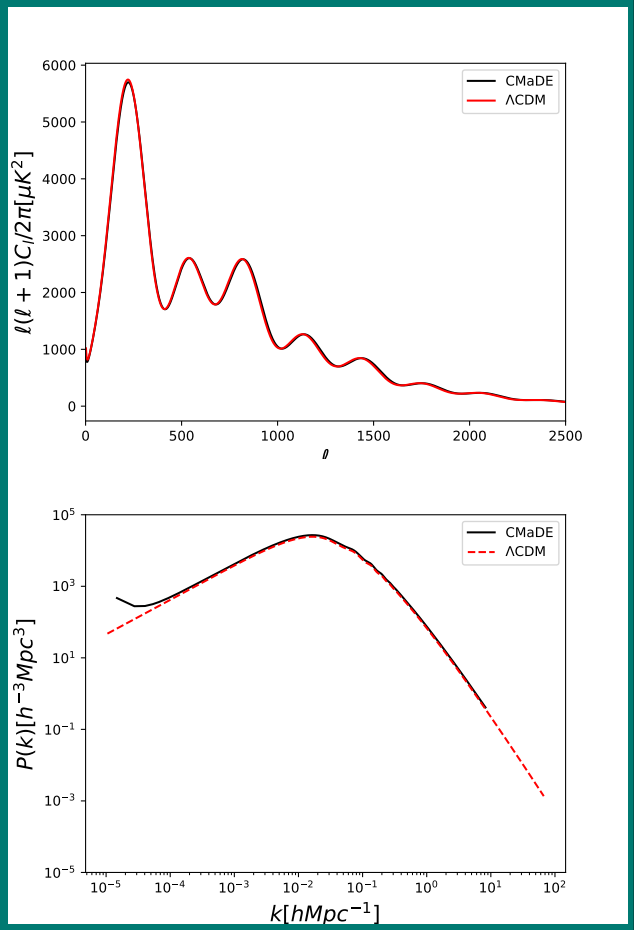

CMB, MPS $h = 0.68, \quad \Omega_b = 0.048 \quad \Omega_{DM} = 0.23, \quad \Omega_k = 0.001$