The cosmic microwave background and mass power spectrum profiles for a novel and efficient model of dark energy

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Quantum Mechanics can explain Dark Energy

The quantum energy $E=hf=m_g c^2$ (where f is the frequency of the particle and h is Planck's constant) of the quantum mediator of the gravitational interaction, which we call here the graviton, is not contained in Einstein's equations. We introduce this energy into Einstein's equations by the analogy between the electromagnetic field A_m and the Proca field as

Massless field to Proca field

$$\Box A_m = 0 \quad \longrightarrow \quad \Box A_m + \frac{m_g^2 c^2}{\hbar^2} A_m = 0$$

$$\Box g_{mn} = 0 \quad \longrightarrow \quad \Box g_{mn} + \frac{m_g^2 c^2}{\hbar^2} g_{mn} = 0$$

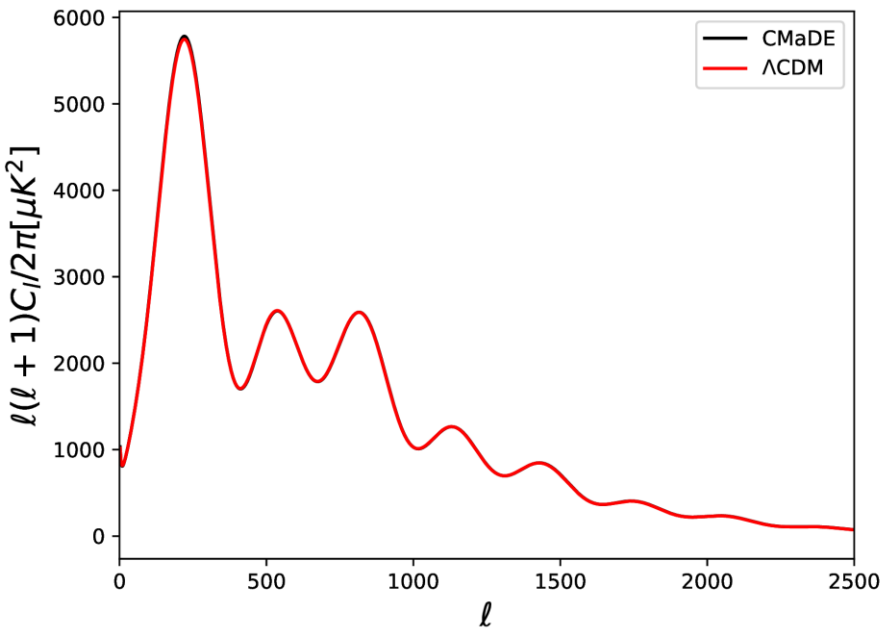
where m_g is the virtual mass associated with the quantum energy E of the graviton. We note that the mass of the graviton is zero, E is a consequence of the quantum vibration of the graviton. With this energy, Einstein's equations then become

Einstein's equations taking into account the quantum vibrations of the graviton

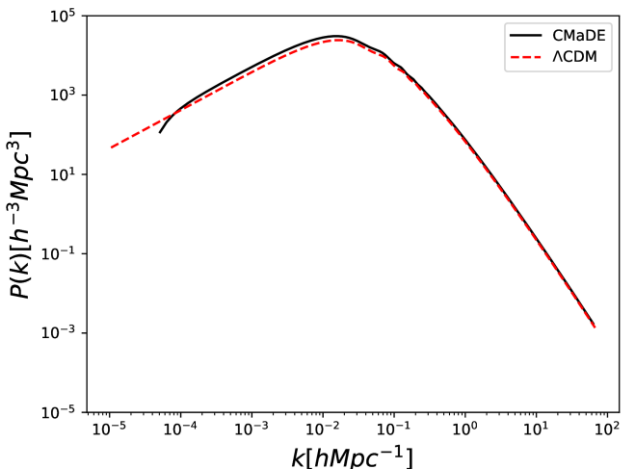
$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R + \frac{2\pi^2}{\lambda^2} g_{\mu\nu} = \kappa T_{\mu\nu} \qquad \lambda = c \int_1^0 \frac{dt}{a}$$

Thus, these new equations (RevMexFis 67(2021)040703 arXiv:2108.05206 and RevMexFis 68(2022)020705 arXiv:2203.07876) do not have dark energy, the

extra term appears because we introduce in Einstein's equations the quantum character of the graviton. Note that there are no free constants. These new equations predict that the Universe is expanding with acceleration and that the profile of the Cosmic Microwave Background and the Mass-Energy Spectrum of the universe are



Profiles of the CMB for $\Omega_{0k} = -0.003$ (upper panel) and MPS (lower panel) observations using an amended version of CLASS code. We compare them with the best fit of the ΛCDM model, using data from the Planck satellite. Note that the CMB temperature fluctuations are the same as the ΛCDM, the only difference is in the first maximum. For the MPS there are very small discrepancies for the small structure.



The CMaDE model settings are $\Omega_{0r} = 5.67 \times 10^{-5}$, $H_0 = 72.6$ km/s/Mpc, $\Omega_{0b} = 0.044$, $\Omega_{0k} = -0.003$, for the closed universe. Observe that the value of H_0 is very close to the observed one from the local distance ladder

In conclusion, considering the gravitational field quantum nature we find that if we take into account the quantum energy of the graviton we could see it as a variable “cosmological constant”.With this result, we could explain the real value of the dark energy density parameter and the coincidence problem, without postulating any exotic matter or modifying Einstein's equations. Nevertheless, we think that this hypothesis opens a new window of research and must be further studied.