Phantom dynamical dark energy for the late phase acceleration of the universe

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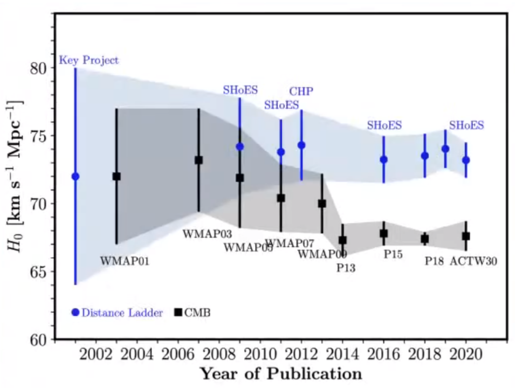
Standard ΛCDM?

Hubble Tension



CMBR Measurement Planck2018

$67.4 \pm 0.5 \text{ kms}^{-1}\text{Mpc}^{-1}$

Aghanim, et al., Astron. Astrophys. 641 (2020) A6

Local Measurement SHoES2022

$73.04 \pm 1.04 \text{ kms}^{-1}\text{Mpc}^{-1}$

Riess et al., Astrophys. J. Lett., 934.1 (2022) L7

$$T(H_0) \approx 5\sigma$$

Phantom Dynamical Dark Energy (PDDE)

Assumption: equation of state of dark energy density slightly deviates from the cosmological constant

$$\rho_D + p_D = -\tfrac{\alpha}{3} \qquad \rho_D(z) = \rho_{D_0} - \alpha \ln(1+z)$$

$$\omega_D = -\left(1 + \frac{\alpha}{3(\rho_{D_0} - \alpha \ln(1+z))}\right)$$

$$\alpha \begin{cases} < 0, & \text{Quintessence} \\ = 0, & \Lambda\text{CDM} \\ > 0, & \text{Phantom} \end{cases}$$

$$H^2(z) = H_0^2(\Omega_{m_0}(1+z)^3 + \Omega_{D_0} - \Omega_{pdde} \ln(1+z))$$

Bayesian analysis strategy

Parameter Inference

Bayes Theorem

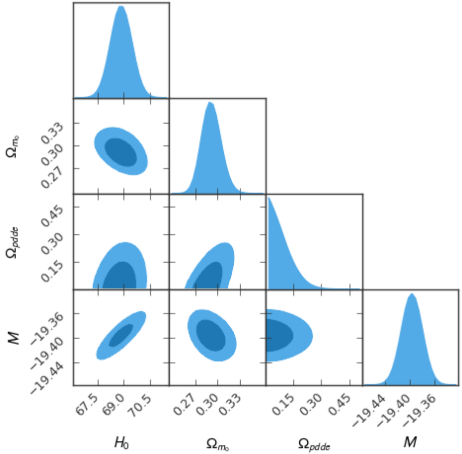
$$P(\theta|D, M) = \frac{P(D|\theta,M)P(\theta|M)}{P(D|M)}$$

$$P(D|\theta, M) \equiv \exp(-\chi^2(\theta)/2)$$

$$\chi^2(\theta) = \sum_k \left[\frac{A_k - A_k(\theta)}{\sigma_k}\right]^2$$

Marginal PDF

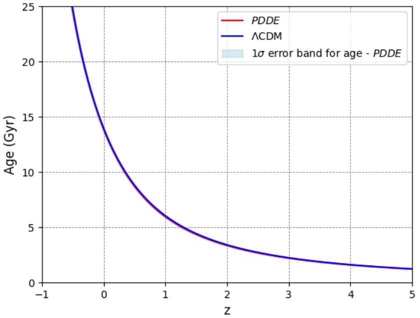
$$p(\theta_1|D, M) \equiv \int p(\theta|D, M) d\theta_2 ... d\theta_n$$



Data	SNIa+BAO+OHD
H_0	68.86 ± 0.5746
Ω_{m_0}	0.291 ± 0.011
Ω_{pdde}	0.063 ± 0.059
M	-19.39 ± 0.0157

Age of the universe

$$t_a - t_B = \int_0^a \frac{1}{aH(a)} da$$



PDDE Model

13.86 ± 0.27 Gyr

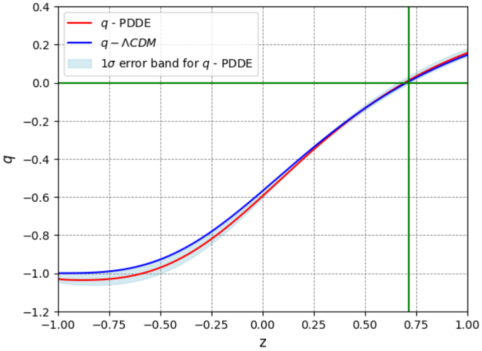
Standard Model

13.78 Gyr

Deceleration parameter

$$q = -1 - \frac{1}{2h^2}\frac{dh^2}{dx}$$

$$q = \frac{\Omega_{m_0} a^{-3} - 2\Omega_{D_0} - \Omega_{pdde}(2\ln a + 1)}{2\Omega_{m_0} a^{-3} + 2\Omega_{D_0} + 2\Omega_{pdde}\ln a}$$



Present Value

$$q_0 = -0.59 \pm 0.01$$

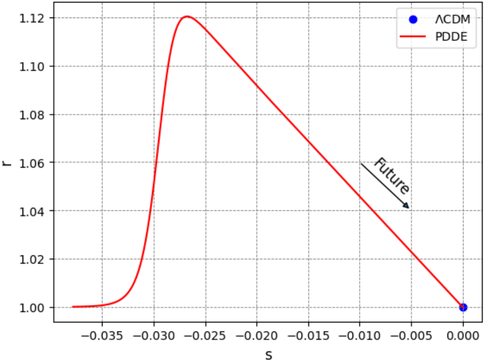
Transition redshift

$$z_T = 0.69 \pm 0.03 \text{ (PDDE)}$$
$$z_T = 0.70 \text{ (}\Lambda\text{CDM)}$$

r and s parameters

$$r = \frac{1}{2h^2}\frac{d^2h^2}{dx^2} + \frac{3}{2h^2}\frac{dh^2}{dx} + 1 = \frac{3\Omega_{pdde}}{2\Omega_{m_0}a^{-3} + 2\Omega_{D_0} + 2\Omega_{pdde}\ln a} + 1$$

$$s = -\frac{\frac{1}{2h^2}\frac{d^2h^2}{dx^2} + \frac{3}{2h^2}\frac{dh^2}{dx}}{\frac{3}{2h^2}\frac{dh^2}{dx} + \frac{9}{2}} = -\frac{\Omega_{pdde}}{\Omega_{pdde} + 3\Omega_{D_0} + 3\Omega_{pdde}\ln a}$$



Model selection

$$AIC \equiv -2 \ln \mathcal{L}_{max} + 2k$$

$$BIC \equiv -2 \ln \mathcal{L}_{max} + k \ln N$$

$$\Delta AIC = -2.80$$

$$\Delta BIC = -7.80$$

Evidence based on BIC

$\lvert\Delta \mathrm{BIC}\rvert$	Strength of evidence
< 2	Weak Evidence
$2 - 6$	Positive evidence
$6 - 10$	Moderate evidence
> 10	Strong evidence

- **Evidence of PDDE model against the ΛCDM model is weak**

Conclusions

- PDDE model is introduced as an alternate to concordance ΛCDM model.
- Estimated the model parameters for SNe Ia+BAO+OHD dataset using the Bayesian inference procedure
- Computed values of the cosmographic parameters within the PDDE model is close to the ΛCDM model.
- Model selection showed that the evidence of PDDE model against the ΛCDM is weak
- PDDE model can not be considered as a potential alternate to the ΛCDM model

Thank You For Your Attention!!