The Scaling Cubic Galileon: Phenomenology and Cosmological Constraints

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based on

I. S. Albuquerque, N. Frusciante, N. J. Nunes, S. Tsujikawa, Phys. Rev. D98, 064038 (2018)

I. S. Albuquerque, N. Frusciante, M. Martinelli, *In preparation*

Modified gravity (MG) models have been widely explored as alternatives to the ΛCDM model. We present the Scaling Cubic Galileon (SCG), a MG model capable of reproducing a late-time acceleration period and of alleviating the Coincidence Problem of ΛCDM thanks to an early-time scaling behavior. We explore the modifications introduced by this model in the expansion history and provide theoretical predictions for different large-scale structure observables using the Einstein-Boltzmann code EFTCAMB. We find distinguishable characteristics with respect to the ΛCDM model which can be tested with present and future observational surveys. We provide preliminary observational bounds on the cosmological and model parameters.

GOING BEYOND ΛCDM: WHY?

Several unanswered questions:

- What is the nature of Λ?
- The Λ Problem: $\Lambda_{theo} \neq \Lambda_{obs}$, mismatch of $\sim$60 orders of magnitude!
- The Coincidence Problem: why are the energy densities for matter and Λ, Ω_m and Ω_Λ, of comparable magnitude today?

Some observational inconsistencies:

- H_0 tension of about 4.4σ;
- σ_8 tension of about 3σ.

THE SCALING CUBIC GALILEON MODEL

$$S = \int d^4x\sqrt{-g}\left[\frac{m_0^2}{2}R + X - V_1 e^{-\beta_1\phi} - V_2 e^{-\beta_2\phi} - A\ln\left(Xe^{\lambda\phi}\right)\right]$$

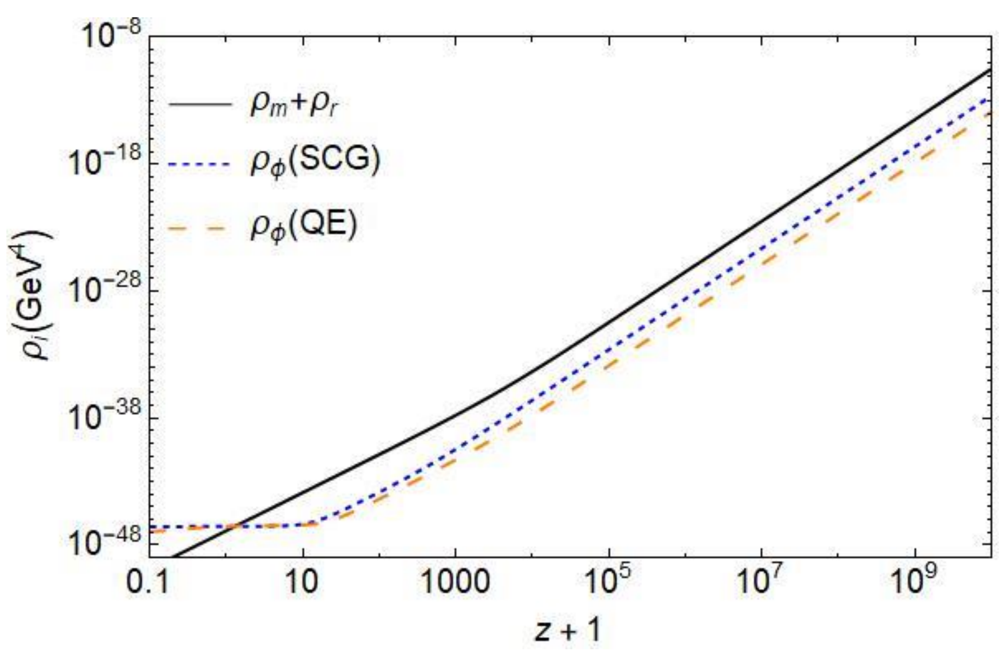
- The gravitational interaction is modified on large scales through the introduction of the Galileon scalar field ϕ;
- Compatible with Gravitational Wave constraints: $c_T^2 = 1$.

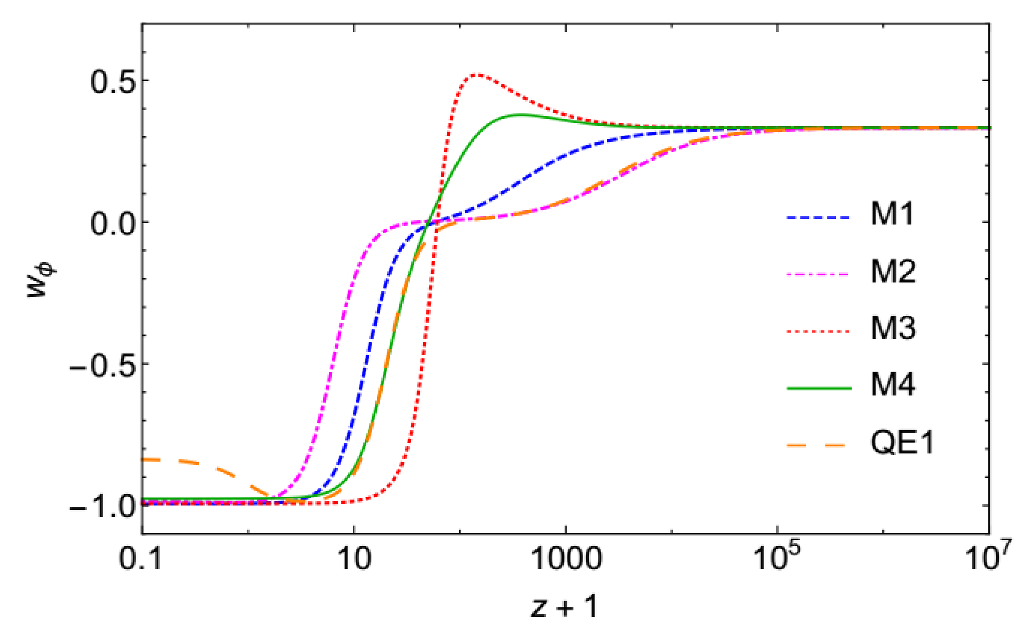
Model	β_1	β_2	A	λ	$w_\phi^{(0)}$
M1	100	0.7	-0.3	154	-0.993
M2		0.7	0.09	8	-0.988
M3		0.7	-0.28	148.3	-0.993
M4		2.5	-1	150	-0.975
QE1		0.7	0	0	-0.927

Table 1: Model parameters for 4 SCG test models together with a Quintessence (QE) model. Also shown, today's equation of state parameter for ϕ - $w_\phi^{(0)}$.

THE BACKGROUND DYNAMICS OF THE SCG

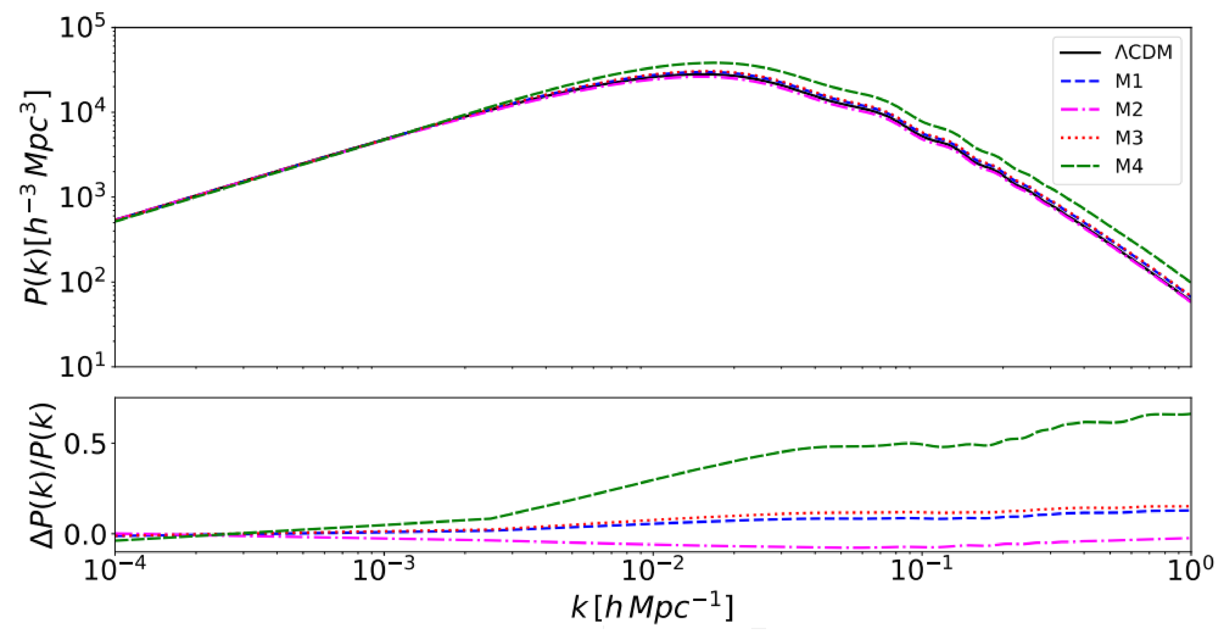
- It has scaling solutions: the energy densities of the scalar field ϕ and the matter components $(m + r)$ scale together at early-time. This might alleviate the Coincidence Problem;
- The SCG can give origin to a $w_\phi^{(0)}$ closer to -1 than QE.



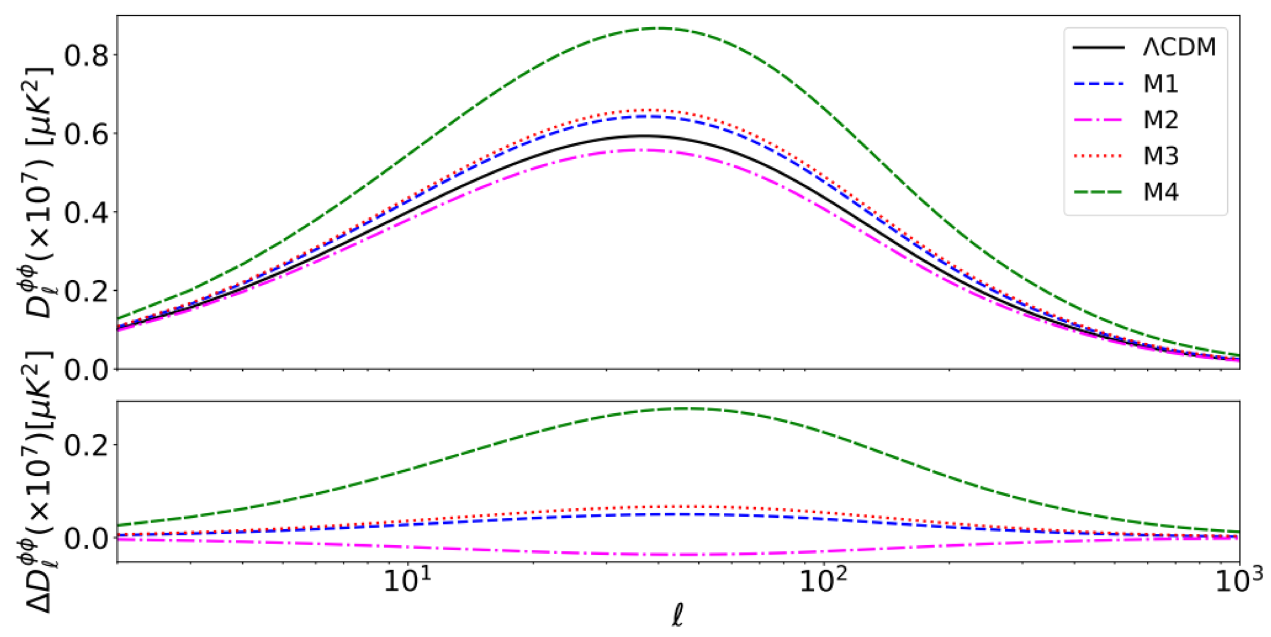


COSMOLOGICAL OBSERVABLES AND CONSTRAINTS

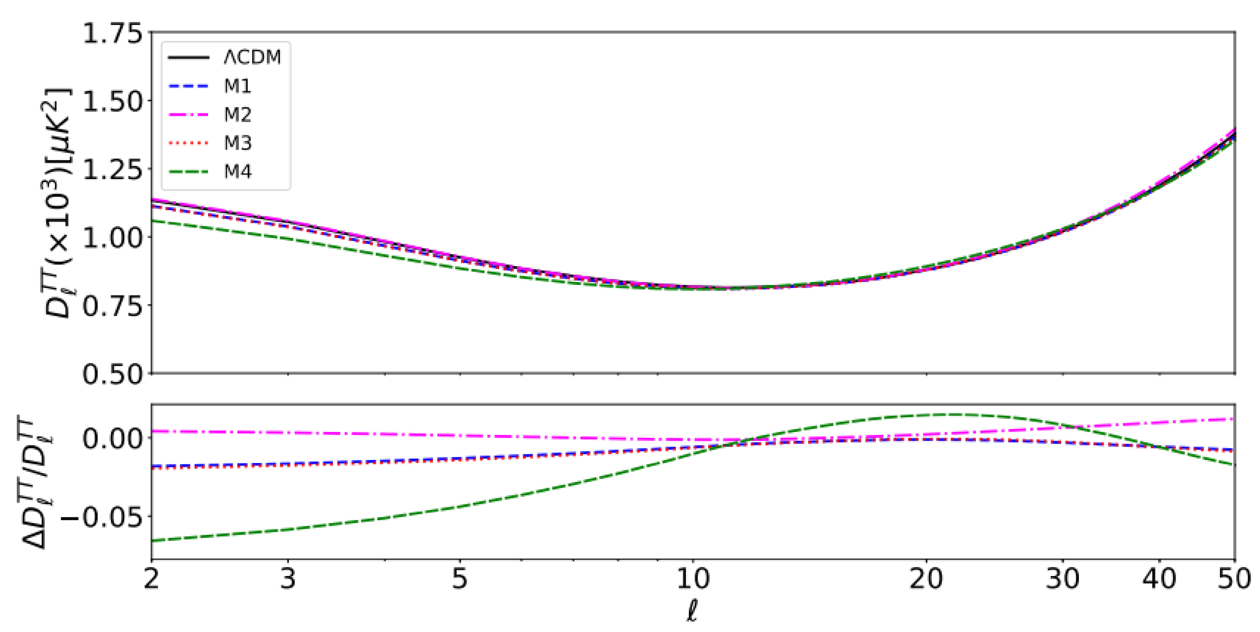
- The matter power spectrum $P(k)$ can be either enhanced or suppressed with respect to ΛCDM. The latter might alleviate the σ_8 tension;



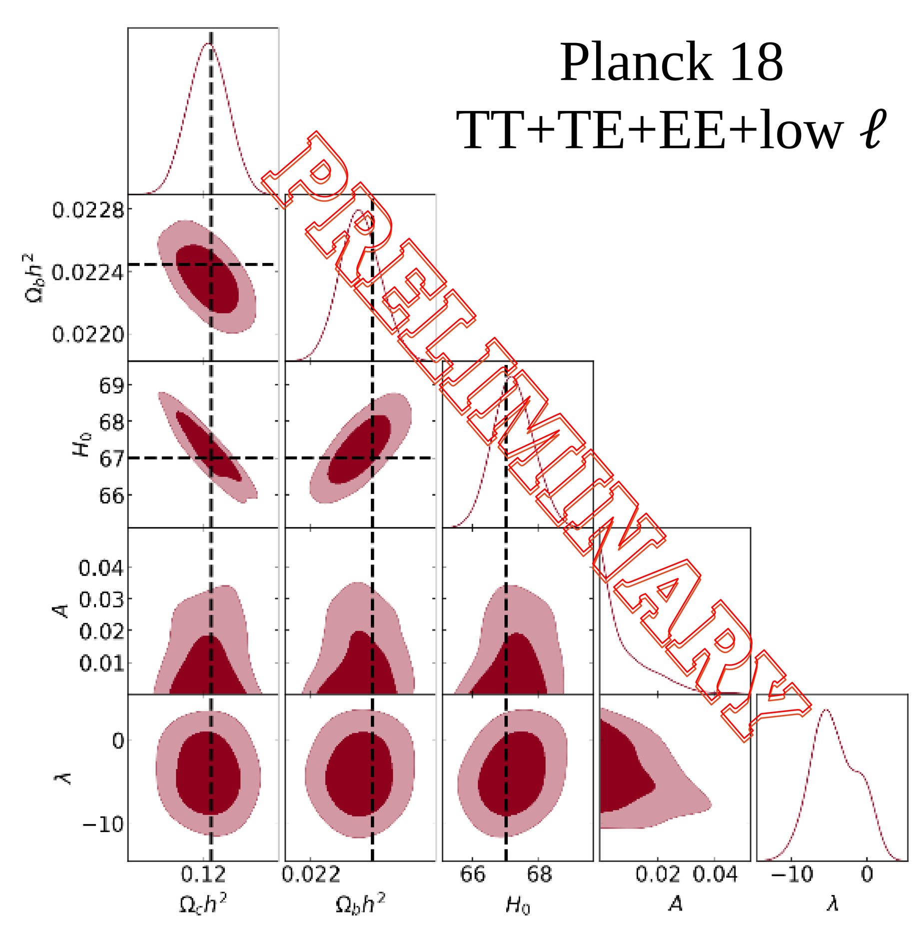
- Models with enhanced $P(k)$ show an enhanced lensing power spectrum $D_\ell^{\phi\phi}$, the opposite holds for suppressed $P(k)$;



- Important feature: a suppressed ISW (or low-ℓ) tail, which might provide a better fit to the CMB data.



- Parameters β_1 and β_2 are not sampled because their effect is limited to the stability of the model.



CONCLUSION

The SCG model shows interesting features that might have the potential to challenge ΛCDM, thus it deserves further study.

This work is supported by Fundação para a Ciência e a Tecnologia through the PhD grant 2020.07237.BD and the research grants UIBD/04434/2020, UIDP/04434/2020 and PTDC/FIS-OUT/29048/201.