Matter density perturbations in interacting quintessence models.

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Abstract

Models with dark energy decaying into dark matter have been proposed to solve the coincidence problem in cosmology. We study the effect of such coupling on the matter power spectrum. The interaction induces a damping of the latter at small scales proportional to the strength of the interaction, c^2, and similar to the effect generated by ultrarelativistic neutrinos. This may serve as a tool to dicriminate between differents interacting models. The interaction also shifts the matter-radiation equality to larger scales. We contrast the matter power spectrum predicted by interacting models with the 2dFGRS data. We obtain an upper bound on the strength of the interaction, namely, $c^2 < 10^{-3}$. We focus on models that during radiation domination show a constant dark matter to dark energy ratio.

The interacting quintessence model

A model with a scaling solution alleviates the coincidence problem [1].

$$\begin{cases} \frac{d\rho_{cdm}}{dt} + 3H\rho_{cdm} = 3Hc^2(\rho_{cdm} + \rho_x) \\ \frac{d\rho_x}{dt} + 3H(1+w_x)\rho_x = -3Hc^2(\rho_{cdm} + \rho_x) \\ \frac{d(\rho_{cdm}/\rho_x)}{dt} = 0 \end{cases}$$

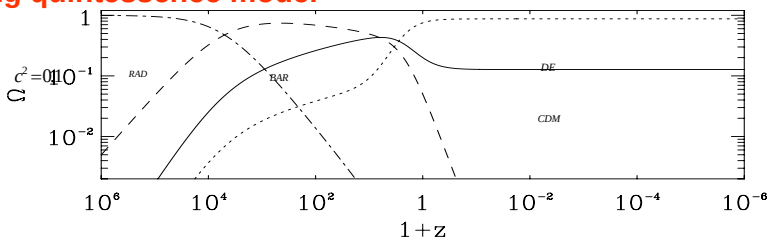
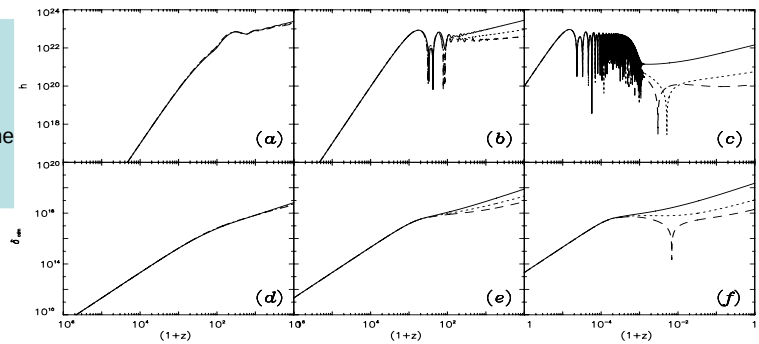


Fig.1 Redshift evolution of different energy densities. The following parameters were assumed $\Omega_{cdm,0}$=0.25, $\Omega_{x,0}$=0.7, $\Omega_{b,0}$=0.05, $\Omega_{rad,}$0=10^{-5} and w_x=-0.9

The matter perturbations evolution

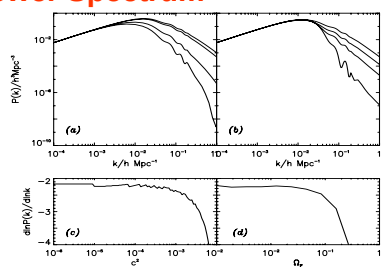
The interacction makes the gravitational potential shallower. Thus, the matter perturbations grow slower inside the horizon [2].

Fig.2 Evolution of the potential h (upper panels) and The CDM density perturbations (lower panels). From Left to right k=10-2,1, 10 h-1Mpc. We study the evolution Of each mode in 3 different cosmological models: the concordance model (c2=0, solid line) and 2 IQM with the same cosmological Parameters,c2=10-3 (dotted line) and 10-2 (dashed line).



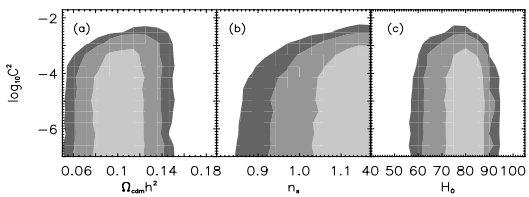
The Power Spectrum

1. The interaction modifies the P(k) slope. The sign of such variation depends on the kind of interaction [3].
2. As c^2 increases k_{eq} decreases. That is a general feature of models featuring de-cdm interaction



Parameter Estimation

Using MCMC we draw the posterior probability of the parameters and estimate them.



1. The combined effect of shifting the scale of matter radiation equality and changing the slope of matter power spectrum at small scales is a distinctive feature of interacting models where dark energy does not cluster at small scales.
2. Our previous results [4] and those presented here indicate the IQM fits the observational data as well as non-interacting models, alleviates the coincidence problem and provides an unified picture of dark matter and dark energy.

[1] W. Zimdahl, D. Pavón and L.P. Chimento, Phys. Lett. B **521**, 133 (2001)

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[3] S. Das, P.S. Corasaniti and J. Khoury, Phys. Rev. D **73**, 083509 (2006)

[4] G. Olivares, F. Atrio-Barandela and D. Pavón, Phys. Rev. D **71**, 063523 (2005)