PROBING DYNAMICAL DARK ENERGY WITH PRESS-SCHECHTER MASS FUNCTIONS

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This project proposes to discriminate in the wealth of models for dark energy using the formation of non-linear dark matter structures. In particular,it focuses on structures traced by the mass function of dark matter haloes.

Keywords: Semi-analytic modeling, Dark matter, Galaxy clusters, Dark energy theory

1. Introduction

Among the various models proposed for the explanation of the accelerated expansion in terms of dark energy (DE), distinctions can be made between static (cosmological constant) or dynamical (e.g. quintessence), coupled or uncoupled to dark matter (DM), clustering or unclustering or even unified (Chaplygin Gas) DE. This wealth of models calls for discriminating schemes. The goal of this work is to propose a unified analysis extending previous studies (see Le Delliou 2006,[1] Manera & Mota 2006[2] and[3] references therein) of DE impact on dark matter haloes on mass functions, for confrontation with other DE assessments.

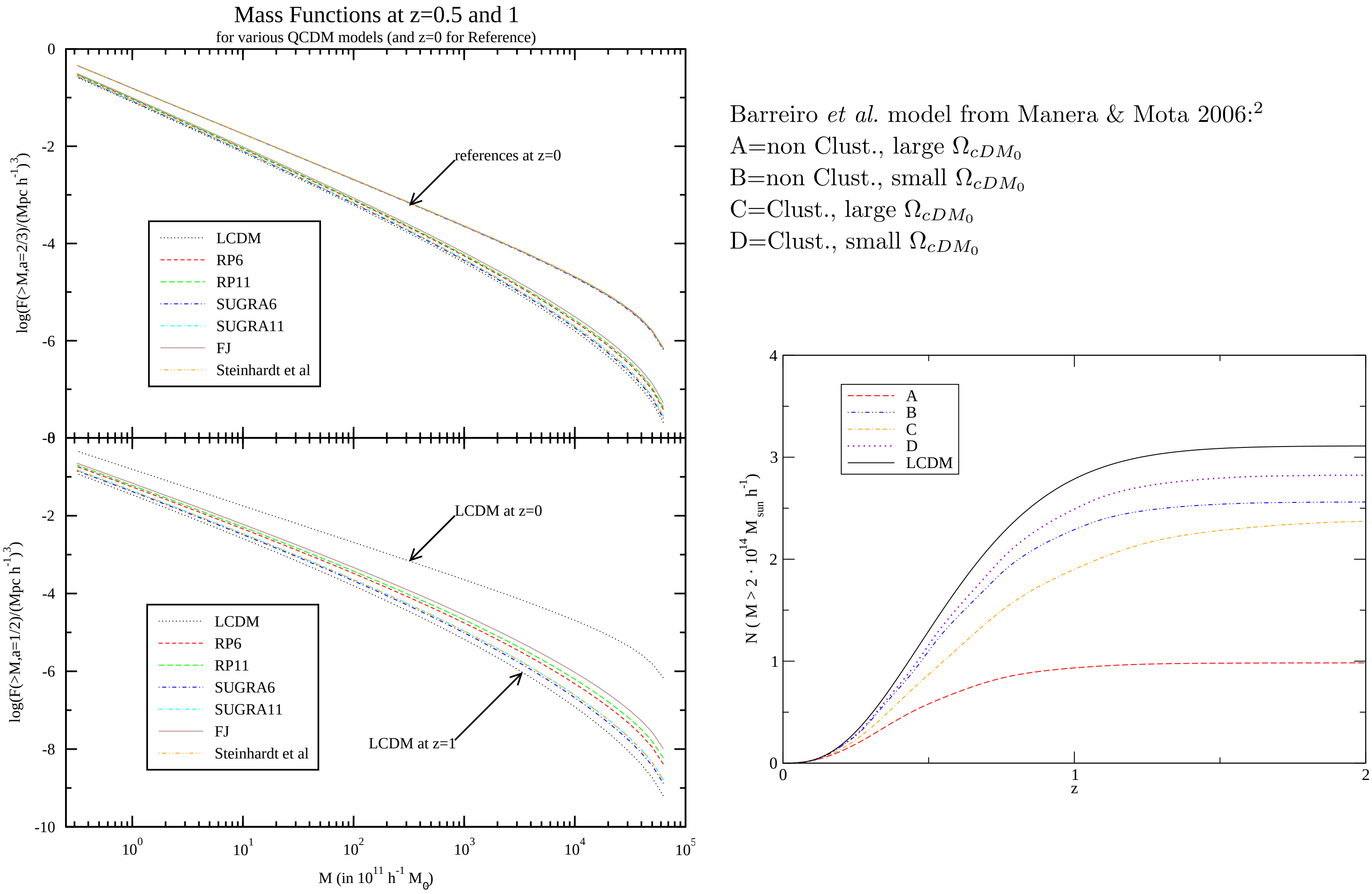
Table 1. Choice of scalar field's potentials

Explored models[1,2]			models under scrutiny	
Model	Potential V	Origin	Model	Potential V
R.P.	$\frac{\Lambda_Q^{4+\alpha}}{Q^\alpha}$	Historical potential; global SUSY	Albrecht & Skordis 2000[4]	$\Lambda_Q^4\left((\kappa Q-M_1)^2+M_2\right)e^{-\lambda\kappa Q}$
SUGRA	$\frac{\Lambda_Q^{4+\alpha}}{Q^\alpha}e^{\kappa^2\frac{Q^2}{2}}$	SUSY+extra dim.=SUGRA superpot.	Sahni & Wang 2000[5]	$\Lambda_Q^4\left(\cosh(\lambda\kappa Q)-1\right)^\alpha$
Ferreira & Joyce 1998	$\Lambda_Q^4 e^{-\lambda\kappa Q}$	extra dim. compactification	Dodelson *et al.* 2000[6]	$\Lambda_Q^4 e^{-\lambda\kappa Q}\left(1+\alpha\sin(\nu\kappa Q)\right)$
Steinhardt *et al.* 1999	$\Lambda_Q^4 e^{\frac{1}{\kappa Q}}$	$=\sum$R.P.	R.P.×F.J.	$\frac{\Lambda_Q^{4+\alpha}}{Q^\alpha}e^{-\lambda\kappa Q}$
Barreiro *et al.* 2000	$\Lambda_Q^4\left(e^{-\alpha\kappa Q}+e^{-\beta\kappa Q}\right)$	double exponential	Bertolami *et al.* 2004[7]	$V_0 e^{3(\alpha-1)\phi}\times\left(\left(\cosh\left(\frac{\kappa\phi}{2/m}\right)\right)^{\frac{2}{\alpha+1}}+\left(\cosh\left(\frac{\kappa\phi}{2/m}\right)\right)^{\frac{-2\alpha}{\alpha+1}}\right)$

2. Models and Mass functions

We model a cosmic fluid with baryons, radiation and, either uncoupled (and coupled) DM with a(n) (un)clustering scalar field DE (quintessence) Q, (non-)minimally coupled to DM, or a Chaplygin Gas (GCG) – DM/DE unified component – defined either from $P \propto -\rho^{-\alpha}$ or from a scalar field mimicking it. We restrict

Fig. 1. Cumulative mass functions for different models



Barreiro *et al.* model from Manera & Mota 2006:[2]
A=non Clust., large Ω_{cDM_0}
B=non Clust., small Ω_{cDM_0}
C=Clust., large Ω_{cDM_0}
D=Clust., small Ω_{cDM_0}

Le Delliou 2006[1]

Manera & Mota 2006[2]

to flat backgrounds, a linear coupling and model clustering through energy conservation. The models are defined by their potential (Table 1). We already studied homogeneous minimal quintessences (left side, upper part[1]) and a coupled, clustering quintessence (left side, lower part[2]). All potentials shown will have clustering and interaction.

We use the top hat spherical collapse to model non-linear structure formation as a Friedmann sphere with higher, varying curvature. We extract the linearly extrapolated overdensity as a function of non-linear collapse scale factor $\delta_{c_0}(a_c)$. This is combined in a Press-Schechter scheme to get the mass function of large scale structures. The results obtained so far are presented in Fig. 1.

3. Conclusions

Extending previous evidence of DE models impact on DM mass functions, our results permit the confrontation of several homogeneous models and the examination of clustering and interacting quintessence. This have shown that more insights can be drawn from confrontation of several homogeneous models[1] and that strong effects on mass function evolution proceed from clustering and interacting quintessence.[2] Indeed, the spread of ∼10% at $10^{14}\,h^{-1}M_{\odot}$ between mass functions and the hierarchy between models on the lower ($z = 1$) panel of the left part of Fig. 1 shows that the method should be most discriminant on clusters scales and that the impact of ω_Q dominates other effects. Moreover, its right part entails that, contrary to homogeneous models, DE clustering increases DM clustering while coupling decreases it. This motivates our extended study of DE models with mass functions. Some pending questions remain: our use of Birkhoff's theorem with spherical symmetry in cosmology may require some mass function corrections; geometric effects are argued to induce a degeneracy in angular mass functions,[8] not taking the bias-geometry dependence[9] into account. We are extending our results to other models (Table 1; Chaplygin gas), including clustering and interacting DE. Further developments are also planned.

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