Disformal Dark Energy

and Disformal Quintessence

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Outline

1. Disformal Dark Energy
   - Disformal Transformations
   - Field Theories from Disformal Relation
2. Disformal Quintessence
   - Linear Perturbations
   - Parameter Constraints
3. Conclusions

Introduction

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- Need slow down mechanism!

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$\Rightarrow$ Can slow down the time flow

Field Theories from the Disformal Relation I

Disformal Prescription

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$$\sqrt{-\bar{g}}\ \Lambda = \sqrt{-g}\ [1 + B(\partial\phi)^2]^{1/2}\ \Lambda$$

is a Chaplygin gas.

Field Theories from the Disformal Relation II

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- Tracking solutions

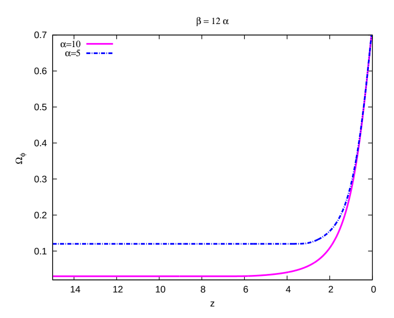
$B(\phi) = \exp[\beta(\phi + \phi_x)/M_p]$

- Transition if $\beta > \alpha$
- $\phi_x \rightarrow$ transition time $\rightarrow \Omega_\phi$

Background Dynamics

- Early dark energy:

$$\Omega_\phi \propto \alpha^{-2}$$



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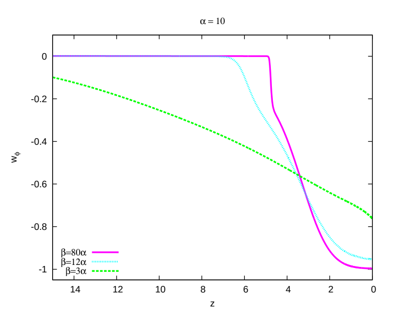
$$w_0 + 1 \sim \alpha/\beta$$



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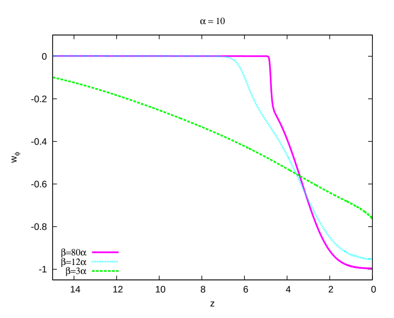

Λ-limit

- high α: Negligible amount of early DE
- high β/α: Fast transition to $w_\phi \approx -1$

Linear Perturbations

Equations involved, different from Λ in

Expansion Effects

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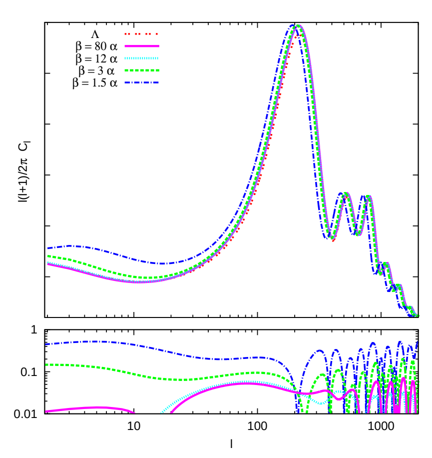
DE perturbations $\longrightarrow$ speed of sound $\quad c_s^2 \approx 1 - \delta g_{00}$

- Before transition: $c_s^2 \approx 1$
- Transition: $0 < c_s^2 < 1$, but DE perturbations well supressed

Effects on the CMB

$\alpha = 10$



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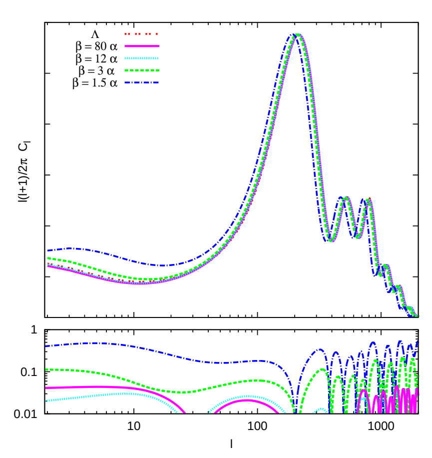

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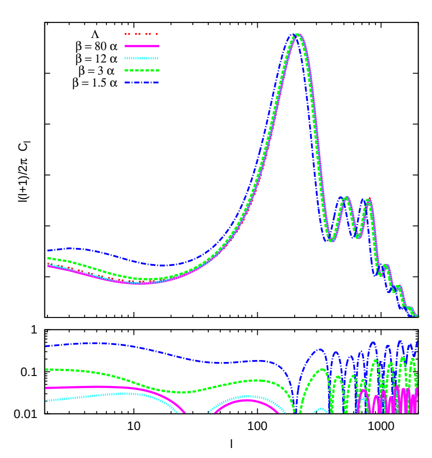

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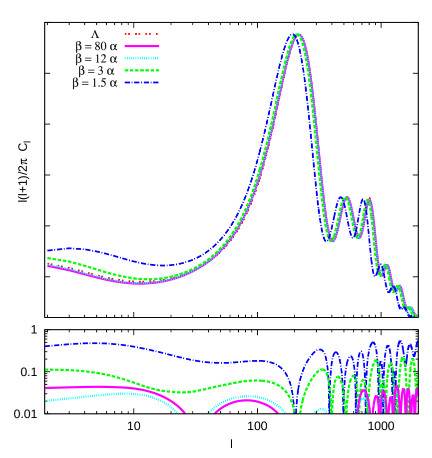
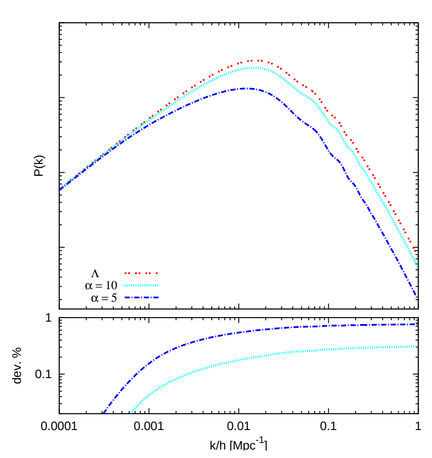


- $\neq$ normalisation
- Angular shift
- ISW effect (small)

Effects on the Matter Power

$\beta = 12\alpha$



- Early DE (α):

  Higher $H(z)$ reduces growth

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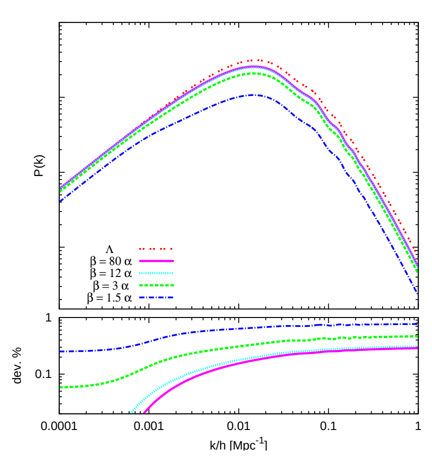

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- Acceleration (β/α):

  Longer structure wash out

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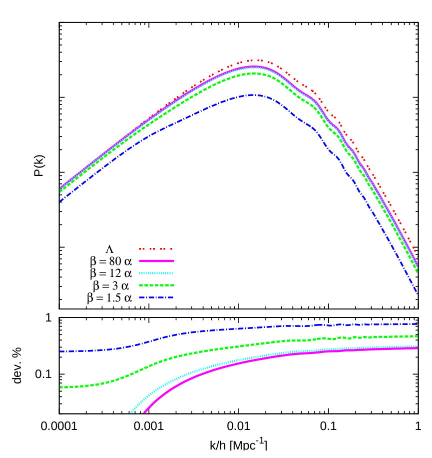

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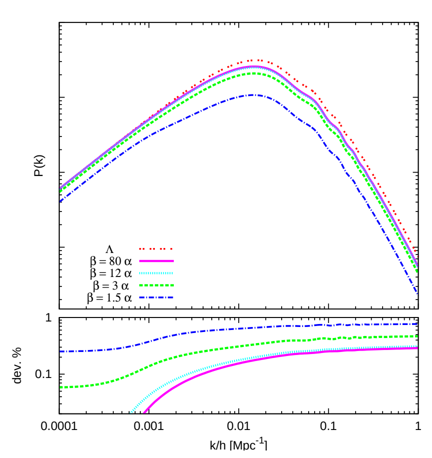

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- Unknown galaxy bias factor can compensate

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- Data from:

  - WMAP7
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- Luminous red galaxies: Best galaxy bias in range $[1, 3]$

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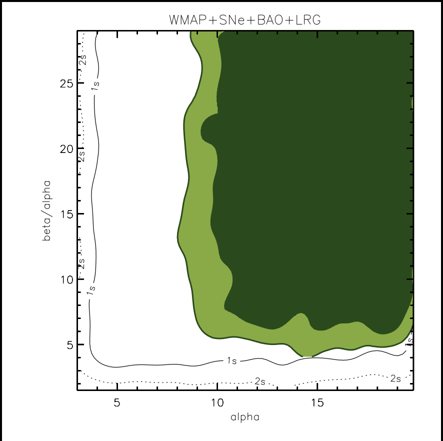

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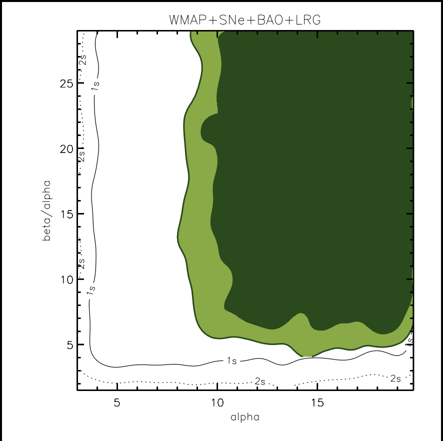

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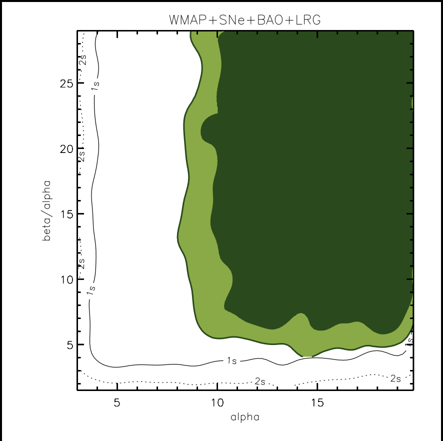

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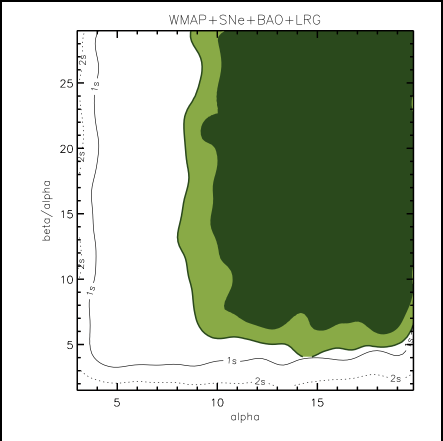

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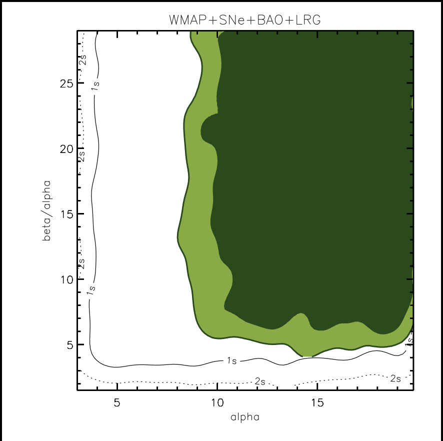

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Allowed Region

- Compatible with Λ limit

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To Do:

- Disformal couplings for matter/radiation/gravity