Viability of a quintessence model with inverse power law potential as a dark energy candidate

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Abstract

We explore the predictions of a cosmological model where the dark energy is described by a scalar field with inverse power law potential obtained from the dynamics of a dark gauge group. The model (φCDM) has two free parameters: the scale factor at which the field condensates (ac) and the density parameter of the field at that moment (Ωφ). Using WMAP9yr data, we found (H0, Ωφ ≃ 0.258 ± 0.114 and Ωχ ≃ 0.258 ± 0.114. We also found Ω ≃ 0.718 ± 0.035, Ωc ≃ 0.702 ± 0.027 and w ≃ -0.941 ± 0.027. As far as the CMB data is concerned, the constraints of this model are in agreement with those of the ΛCDM one. We set the road to extend our analysis to include other types of observations.

The model

1. Starting from the unified scale, the fields of the SM and those of a dark gauge group SU(3) redshift as radiation until a condensation scale Λc is reached. Below that threshold, the fields of the dark group are no longer free and have to be described by means of an effective field φ whose inverse power law potential \( V = \mu X X^{-\alpha} \) can be obtained from the Affleck-Dine-Seiberg superpotential [1].

2. Gauge coupling unification restriction + BBN bounds \( \alpha \equiv 2/3 \) & \( \Lambda_c \sim 50 \text{ eV} \) [2, 3].

3. Free parameters: \( \Omega_c \rightarrow \) density parameter of the dark group at \( a_c \)
\( a_c \rightarrow \) scale factor of the field’s condensation

Background evolution

\[
H^2 = \frac{8\pi G}{3} \rho_{\text{eff}} + \rho_{\text{m}} + \frac{1}{2} \left( \dot{\phi}^2 + V \right)
\]

\( \dot{\phi} + 3H\phi + \dot{V} = 0 \), where \( \dot{V} = \frac{dV}{d\phi} \)

Equation of state

\( \dot{\phi} = H\phi + \frac{1}{2} \dot{\phi}^2 + V \) (synchronous gauge) (3)

Density parameter

Initial conditions

Late-time evolution

Perturbations

Constraint on quintessence parameters from WMAP9yr

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean ± Std</th>
<th>Best Fit</th>
<th>Marginal limits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>68% lower</td>
</tr>
<tr>
<td>( \Omega_X )</td>
<td>0.258 ± 0.146</td>
<td>0.212</td>
<td>0.081</td>
</tr>
<tr>
<td>( \Omega_{\text{ph}} )</td>
<td>2.69 ± 0.52</td>
<td>2.70</td>
<td>2.17</td>
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<tr>
<td>( \sigma )</td>
<td>1.082 ± 0.262</td>
<td>0.926</td>
<td>0.813</td>
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<tr>
<td>( \omega_X )</td>
<td>-0.964 ± 0.027</td>
<td>-0.966</td>
<td>-0.992</td>
</tr>
<tr>
<td>( \Omega_X )</td>
<td>0.762 ± 0.029</td>
<td>0.750</td>
<td>0.734</td>
</tr>
<tr>
<td>( c_s / c_l )</td>
<td>75.18 ± 3.29</td>
<td>75.39</td>
<td>71.55</td>
</tr>
</tbody>
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Comparison with ΛCDM

CMB temperature power spectrum

Forthcoming Research

1. Update to Planck-2013 and Planck-2015
2. Inclusion of BAD and SNeIa measurements

References


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