THE THEORETICAL-PRIOR FOR THE BRANS-DICKE CLASS AT COSMOLOGICAL SCALES

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- to assume dark energy and dark matter as building blocks of the energy matter content of the universe (ΛCDM), within the theory of General Relativity.
- However, dark energy remains undetected and not theoretically understood ...
- Thus, it is reasonable to explore other modifications to General Relativity (GR) at cosmological scales.

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Y-S Song et al. arXiv:1001.0969

$\Delta \rightarrow$ comoving matter-overdensity

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\begin{aligned}
\mu &= \frac{Q}{\eta} && \rightarrow \text{ peculiar velocities and the growth of matter} \\
\Sigma &= \frac{Q}{2}\left(1+\frac{1}{\eta}\right) && \rightarrow \text{ ISW and lensing potential.}
\end{aligned}
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- The simplest set of scalar-tensor theories of gravity is the generalized Brans-Dicke class (usually called scalar-tensor theories).

$$S = \int d^4x \frac{\sqrt{-g}}{16\pi G} \left(f(\phi)R + \frac{\omega(\phi)}{\phi} g_{\mu\nu} \nabla^\mu \phi \nabla^\nu \phi - V(\phi) \right) + S_m$$

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 1. Studying a particular theory defined by $\omega(\phi)$ and $V(\phi)$.

 2. Use a phenomenological approach: to construct the corresponding theoretical prior from an ansatz of the growth behavior.

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\Phi - \Psi &= \phi \\
k^2\Phi &= 4\pi G a^2 \Delta + \frac{1}{2}k^2\phi \\
k^2\phi &= \frac{1}{(3+2\omega(\phi))}\left(8\pi G a^2\delta + M^2\phi + ...\right) \\
&\downarrow \\
\mu &= \frac{4+2\omega+M^2a^2/k^2}{3+2\omega+M^2a^2/k^2} \\
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- μ measures the strength of the Newton coupling. If $M = 0$, it is scale-independent which is appropiate at cosmological scales.

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- We solved the equations for the background and linear perturbations numerically beyond the quasiestatic limit considering standard energy-matter content of the universe with help of CAMB.
- The space of parameters was sampled using the Monte-Carlo method numerically implemented in a modified version of COSMOMC.

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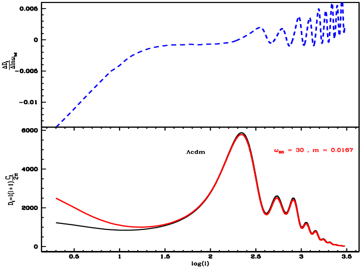

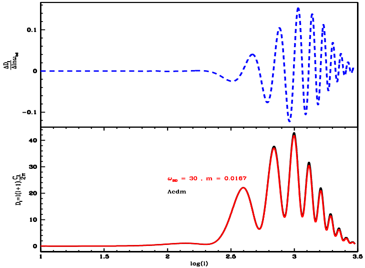

ω_{BD} affects the temperature perturbations on large scales due to the Integrated Sachs-Wolfe effect and ee-polarization modes at small scales.

We used two types of models

- *Restricted*: The Newton's coupling at solar system and cosmological scales are equal: $G_c = G_{ss} = \mu$. *Unrestricted*: $G_c = \xi G$. $\xi \rightarrow$ free parameter

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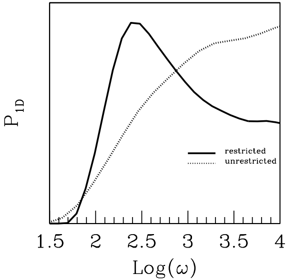

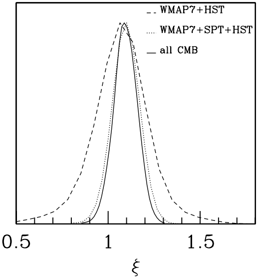

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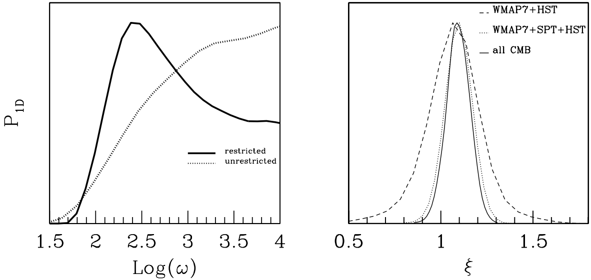

- Our best constraints from WMAP7 yrs, South Pole Telescope (SPT), high-l : $\omega_{BD} > 288$ and $0.97 < \xi < 1.22$ at 95% of confidence level. A.Avilez and C. Skordis, arXiv:1303.4330

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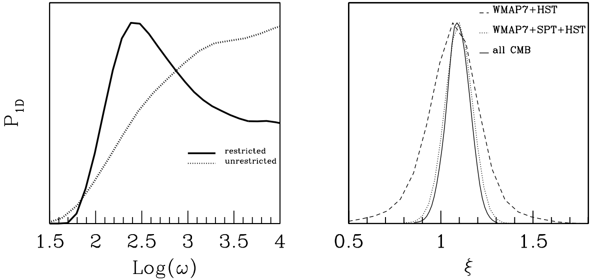

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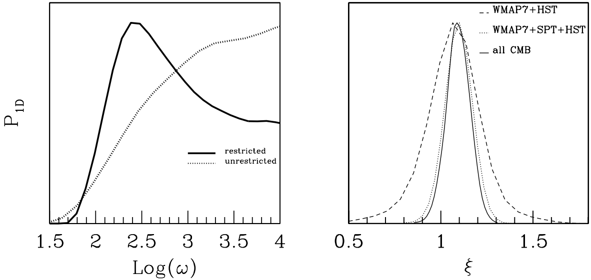

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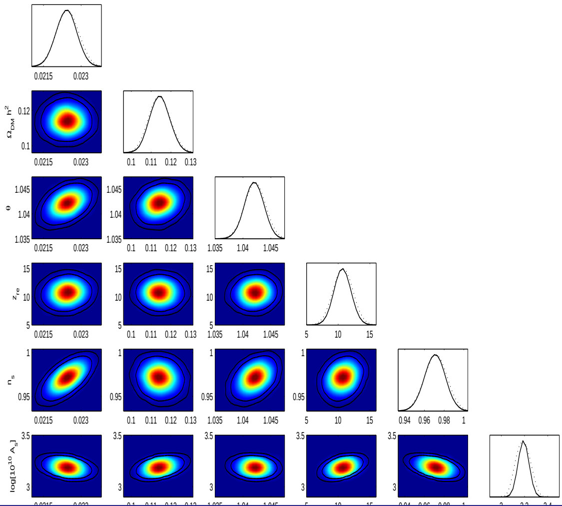
- Forecasted to be $\omega_{BD} > 1000$ from Planck. X. Chen and M. Kamionkowski, arXiv: 9905368

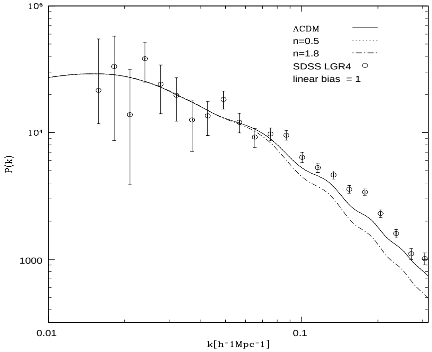
Time-Independent Case: Cosmological Parameters



Time-dependent case

The most natural way to determine the exponent *n* is to use the Large Scale Structure observations

- Direct measurements power spectrum of galaxies,



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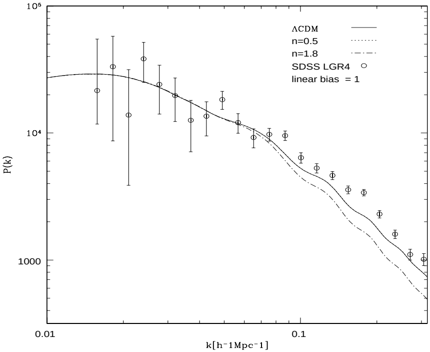

n is sensitive to mpk measurements at small scales yet in the linear regime. Mayor effects expected if interactions and non-linearities were considered

- The expansion history may constrain n by using the Alcock-Paczynski test(APT)

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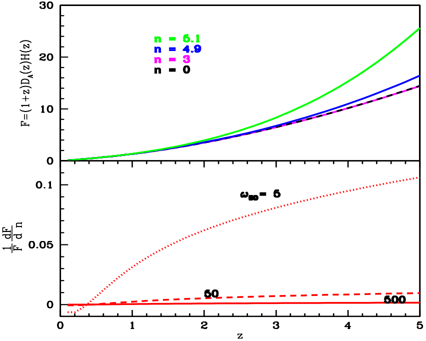

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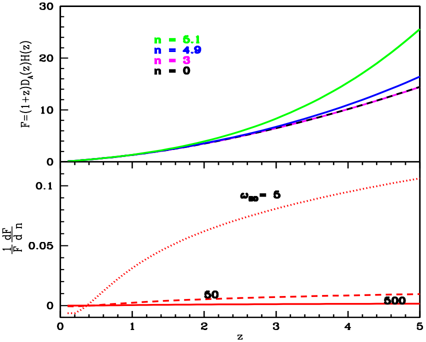

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- The AP distortion only becomes significant if $\|\omega_{BD}\| \approx O(1) \rightarrow$ self-accelerating theories.

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- Observing the AP effect at high redshift would allow us to thightly constrain the growth exponent within the Brans-Dicke class context. AP effect at low redshift brings interesting phenomenology of self-accelerating theories.