Luminosity Distance and Non Perturbative Cosmology

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Importance of an exact non-perturbative approach

- Theoretical motivations:
  Considering all of the effects due to inhomogeneities and anisotropies
  Evaluating the impact of the backreaction
  Non linearity of Einstein equations
- Experimental reasons:
  Comparing the prediction with respect to the next generation measurements of the precision cosmology era
  Re-considering the right averaging procedure for the physical observables

The Geodesic Light-Cone gauge

- New approach to the study of cosmology
- Fully non perturbative
- Gauge fixing of the $g_{\mu\nu}$ on the observer

$$ds^2 = \Upsilon^2 dw^2 - 2\Upsilon dw d\tau + \gamma_{ab}\left(d\tilde{\theta}^a - U^a dw\right)\left(d\tilde{\theta}^b - U^b dw\right)$$

- Light-cone condition: $w =$ constant
- Geodesic flow: $u_\mu = -\partial_\mu \tau$
- Ability to average on the Light-cone (Gasperini, Marozzi, Nugier, Veneziano, JCAP 1107 (2011) 008)

Luminosity distance in this gauge (1)

- Exact expression for some observable quantities as redshift
- Exact non perturbative expression for the Jacobi map (Fanizza, Gasperini, Marozzi, Veneziano, JCAP 1311 (2013) 019)
- This allows us to get an exact expression for the luminosity distance:

$$d_L^2 = \left(\frac{\Upsilon_o}{\Upsilon_s}\right)^4 \frac{4\sqrt{\gamma_s}}{\left[\det(u_\tau^{-1}\partial_\tau\gamma^{ab})\gamma^{3/2t}\right]_o}$$

Luminosity distance in this gauge (2)

- First exact solution of the Jacobi equation
- The expression appears as a simple product of an observer term times a source one
- True only in this gauge
- The result takes care of the right physical phenomena at the observer position, due to his peculiar velocity
- Transformation into the Longitudinal gauge, the Synchronous gauge and among them is fully consistent

Future perspectives

- Solving Einstein equations in this gauge
- Expressing other physical observables with the aim of this gauge (CMB power spectrum, Weak lensing...)
- Averaging over partial region of the sky, in order to compare the local quantities with global ones