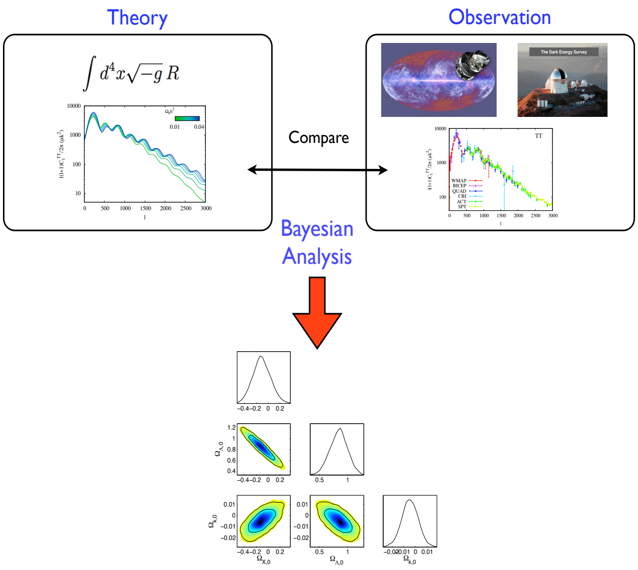
Updated Cosmology

with Python



José-Alberto Vázquez

ICF-UNAM / Kavli-Cambridge

In progress

August 12, 2017

Project 1

In previous lectures, given the FRW metric, and by using Gravipy, we obtained the Einstein tensor

$$
\begin{aligned}
G^0_0 &= -3\left[\left(\frac{\dot{R}}{R}\right)^2 + \frac{c^2 k}{R^2}\right], \qquad (1)\\
G^i_j &= -\left[2\frac{\ddot{R}}{R} + \left(\frac{\dot{R}}{R}\right)^2 + \frac{c^2 k}{R^2}\right]\delta^i_j. \qquad (2)
\end{aligned}
$$

and hence, the Friedmann equations.

Project: follow a similar route, but now with the perturbed metric (in conformal Newtonian Gauge)

$$ds^2 = a^2[(1+2\psi)d\tau^2 - (1-2\phi)\delta_{ij}dx^i dx^j], \qquad (3)$$

to get the perturbed Einstein equations.

Project 2

Given an action, get the E-L equations, i.e. the Einstein-Hilbert action, given by

$$S_{EH} = \int d^n x \sqrt{-g} R = \int d^n x \sqrt{-g} R_{\mu\nu} g^{\mu\nu},$$

leads to the definition of the Einstein tensor:

$$G_{\mu\nu} = R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R.$$

The action for an scalar field

$$S = \int d^4 x \sqrt{-g} \left[\frac{1}{2} \partial_\mu \phi \partial^\mu \phi - V(\phi) \right], \tag{4}$$

leads to the *Klein-Gordon* equation:

$$\Box^2 \phi + \frac{dV}{d\phi} = 0. \tag{5}$$

Project: given an action, get the dynamics.