

Constraints on Fuzzy Dark Matter Models from Planck 2015 Data

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Fuzzy Dark Matter (FDM)

- **Free scalar field with very small mass** : $\mathcal{L}_\phi = -\frac{1}{2}(\partial\phi)^2 - \frac{1}{2}m^2\phi^2$

motivation : “small scale crisis” etc.

candidate : ultralight axion with negligible self-interaction

- **“Quantum pressure”**

$$\ddot{\delta} + 2H\dot{\delta} - \left(4\pi G\bar{\rho} - \frac{k^2}{a^2}c_s^2\right)\delta = 0 \quad c_s^2 = \left[1 + \left(\frac{2ma}{k}\right)^2\right]^{-1}$$

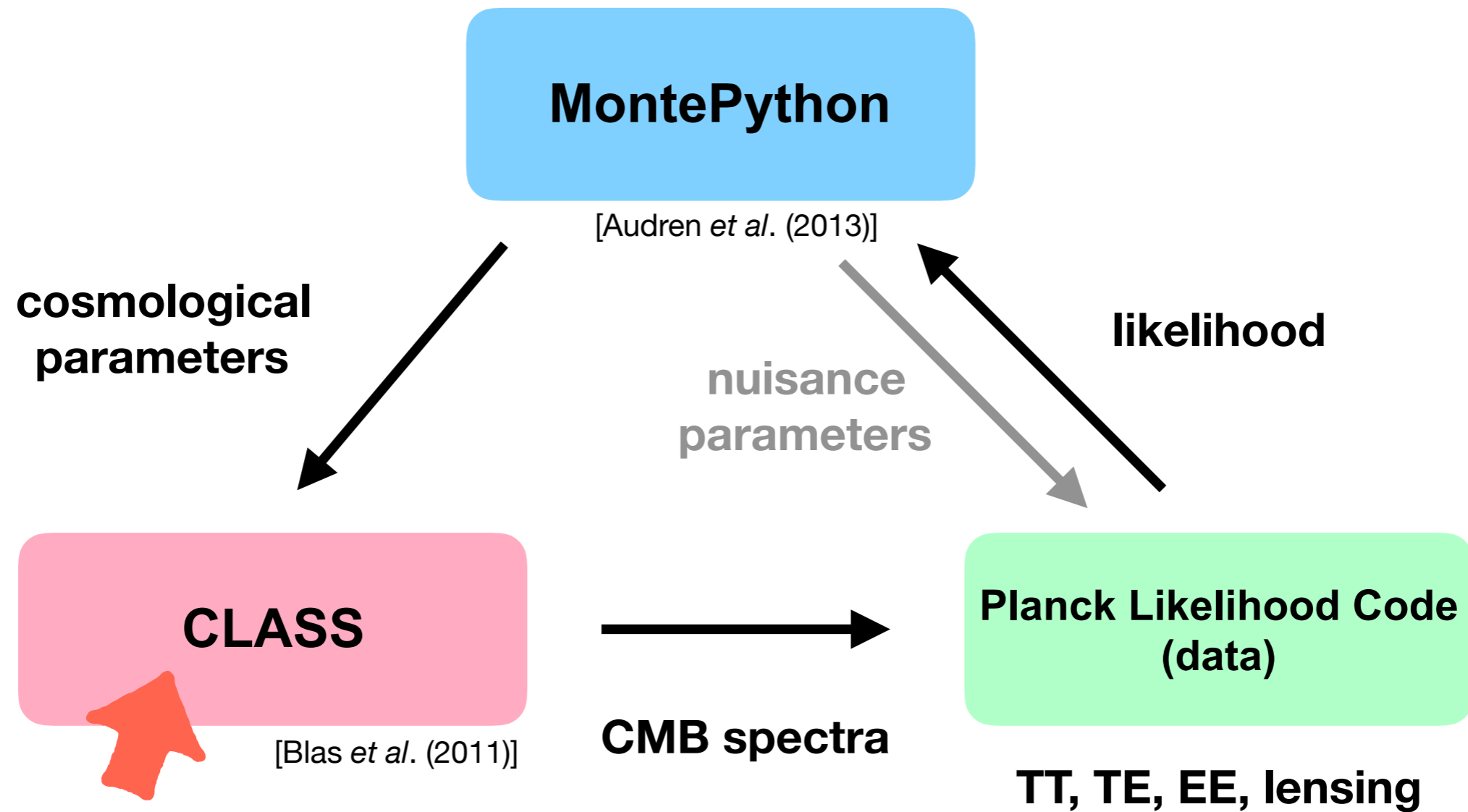
deviation from CDM on small scales (large k)

- **Jeans scale : gravity = pressure**

$$k_J \sim \frac{1}{1 \text{ Mpc}} \left(\frac{m}{10^{-25} \text{ eV}}\right)^{1/2}$$

CMB is sensitive to $m \lesssim 10^{-25} \text{ eV}$

MCMC analysis



Fuzzy DM

w/ “cutoff” approx. [Ureña-López & Gonzalez-Morales JCAP 07 (2016) 048]
(not using fluid approx.)

Some Results

(1) Λ FDM model : DM = FDM

Constraint on mass :

$$\begin{aligned} m &> 10^{-24.1} \text{ eV} \quad (2\sigma) \\ &> 10^{-24.9} \text{ eV} \quad (3\sigma) \end{aligned}$$

(2) Λ (F+C)DM model : DM = FDM + CDM

Constraint on abundance (mass fixed) :

$$\begin{aligned} f = \frac{\Omega_{\text{FDM}}}{\Omega_{\text{DM}}} &< 0.06 \quad (3\sigma) \quad \text{for } m = 10^{-26} \text{ eV} \\ &< 0.19 \quad (3\sigma) \quad \text{for } m = 10^{-25.5} \text{ eV} \\ &< 0.96 \quad (3\sigma) \quad \text{for } m = 10^{-25} \text{ eV} \end{aligned}$$