Weekly Report

Summary

- **Period:** Jan 12 to Jan 18, 2021
- **Task Finished:** Fit LCDM+Curvature, modify and run LCDM+$N_{\rm eff}$, CDM+CLP dark energy, LCDM+massive neutrino models.
- **Questions Meet:**
  - How to modify the CLASS code and fit the LCDM+Neff model?
  - What the best fitting parameters mean for the Hubble tension problem?
- **Plans for next 7 days**:
  - Debug and finish the Kev's table
  - Summarize current results (theory, coding and other) to a short note as a very initial draft for the paper in the future.

Progress in Details

In this part, I will write a bit more about the progress for the past days. This week I ran the *Cobaya* code for LCDM+Curvature, LCDM+$N_{\rm eff}$, CDM+CLP dark energy and LCDM+massive neutrino model.

Curvature

For the LCDM+curvature model, we only add one parameter Ω_K which denotes the energy density from curvature. Note that in this case, we have the **budget equation** as

$$\sum_X \Omega_X = 1 + \Omega_K$$

Then I fit all LCDM model and Ω_K with *Cobaya* with the setting for Ω_K distribution as **uniform** distribution. Finally, we obtain $\Omega_K = -0.055$ and $H_0 = 52.91$.

$N_{\rm eff}$

Assume that we have standard model neutrino and other equivalent neutrino, the total radiation density $\rho_{\rm R}$ consists of three parts: (1) photon, (2) SM neutrino and (3) other neutrino. The $N_{\rm eff}$ is defined as the equivalent number of neutrino species,

$$\left(\frac{\rho_{\rm R}}{\rho_\gamma}\right) = 1 + \frac{7}{8}\left(\frac{4}{11}\right)^{4/3} N_{\rm eff}$$

Note that in *CLASS*, I am not sure whether we have proper provided parameters as $N_{\rm eff}$. I need to go into the code and define $N_{\rm eff}$ for the fitting if necessary.

CLP Dark Energy

We define w as the ratio of energy density and pressure of a certain species, $w = \rho/\mathcal{P}$. In LCDM model, we have $w = -1$ for dark energy. We also have extend parameterization of dark energy, or Chevalier-Linder-Polarski dark energy as

$$w(a) = w_0 + w_a(1-a)$$

where w_0 and w_a are constant. In the *Cobaya* fitting, I set Omega_Lambda=0 and add w0_fld as a free parameter for fitting. The fitting is still running.

Massive Neutrino

In the Planck fitting of LCDM, they consider a model with one massive neutrino and two massless neutrino. In this case, I consider the LCDM+$\sum m_\nu$ model where the sum denotes the total mass of three species. In the *Cobaya* fitting, I set N_ncdm=1, deg_ncdm=3, N_ur=0 and let m_ncdm as a free parameter for fitting. The fitting is still running.