A brief review of attempts to solve the Hubble tension

What is it all about ?

- Introduction
- Possible solutions:
  - Primordial Gravitational Waves (GWs)
  - Errors on the measurements
  - Coupled Dark Sector
- Conclusion

Introduction

Depending on the method:

$H_0 = 66.93 \pm 0.62\ km.s^{-1}.Mpc^{-1}$ by the Planck data group

$H_0 = 73.24 \pm 1.74\ km.s^{-1}.Mpc^{-1}$ according to Riess et al.

It's a 3.4σ discrepancy, so what's going on ?

Possible solution: Primordial GWs

Modify early universe physics:

Primordial GWs have an impact on the effective number of relativistic degrees of freedom

$$N_{eff} = 3.046 + \left[3.046 + \frac{8}{7}\left(\frac{11}{4}\right)^{\frac{4}{3}}\right]\frac{A_s r}{24 n_t}\left(\frac{k_{UV}}{k_*}\right)^{n_t}$$

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

Get to $H_0 = 68.62^{+0.57}_{-1.20}\ km.s^{-1}.Mpc^{-1}$

Possible solution: Errors on the measurements

Shanks et al. argue that Riess et al. made measurement errors

$$H = \frac{v}{D}$$

Correct errors to increase D and decrease v
Get to $H_0 = 67.6 \pm 1.52\ km.s^{-1}.Mpc^{-1}$

But later Riess et al. explain how this is wrong in a new paper

Possible solution: Coupled Dark Sector

Dark Energy is the leading factor of accelerated expansion:

Parametrize energy flow DM → DE

$$\nabla_\mu T^\mu_{(de)\nu} = \frac{Q^{(de)}_\nu}{a} \text{ and } \nabla_\mu T^\mu_{(dm)\nu} = \frac{Q^{(dm)}_\nu}{a}$$

With

$$Q^\nu_{(dm)} = \xi\, H \rho_{de}\, u^\nu_{(dm)} = -Q^\nu_{(de)}$$

Tension solved with $\xi = -0.26^{+0.16}_{-0.12}$ (at 95% CL) for ΛCDM model

Even better in wCDM model with $w = -1.184 \pm 0.064$ (at 95% CL)

Conclusion

So far, no real solution to the tension ...

But new physics might be the best lead !

What would be your solution ?

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