Investigating the Hubble Constant Tension - Two Numbers in the Standard Cosmological Model

Weikang Lin
In collaboration with Katie Mack and Liqiang Hou
North Carolina State University
Comparing to other results is important and pressing

Usual presentation of the constraints:

Disadvantages:

1. Many constraints are not strong

2. Combining probes may make results on H0 to be correlated

3. Model dependence gets more complicated

Figure from Verde, Treu and Riess 2019, *Tensions between the Early and the Late Universe*, summary of KITP conference
Solution: plot individually in $H_0-\Omega_m$ plane

Advantages:

1. Constraints are presented as independently as possible

2. Constraints not need to be strong on $H_0$ (e.g., single-sided constraints)

3. Compatibility can be viewed in a more robust way

4. Effectively see whether a nonstandard model can reconcile all
Good to find a numerical way to compare:

Multi-dataset Index of Inconsistency: (Lin & Ishak 2017)

$$\text{IOI}(N_d) = \frac{1}{N_d} \left( \sum_{i=1}^{N_d} \mu_i^T C_i^{-1} \mu_i - \mu^T C^{-1} \mu \right),$$

& the associated Outlier Index: (Lin & Ishak 2019)

$$\mathcal{O}_j \equiv \frac{1}{2} \left[ N_d \text{IOI} - (N_d - 1) \text{IOI}^{(j)} \right]$$

<table>
<thead>
<tr>
<th>(IOI) &amp; $\mathcal{O}_j$</th>
<th>CV SN</th>
<th>Planck</th>
<th>BAO (L)</th>
<th>BAO (H)</th>
<th>others</th>
</tr>
</thead>
<tbody>
<tr>
<td>All (3.21)</td>
<td>7.63</td>
<td>3.91</td>
<td>2.16</td>
<td>1.41</td>
<td>&lt;1.1</td>
</tr>
<tr>
<td>CV SN (1.87)</td>
<td>N/A</td>
<td>1.97</td>
<td>1.46</td>
<td>1.63</td>
<td>&lt;1.5</td>
</tr>
<tr>
<td>WMAP (3.54)</td>
<td>7.80</td>
<td>3.80</td>
<td>2.09</td>
<td>1.43</td>
<td>&lt;1.1</td>
</tr>
<tr>
<td>TRGB CV SN (1.75)</td>
<td>N/A</td>
<td>2.17</td>
<td>1.54</td>
<td>1.59</td>
<td>&lt;1.4</td>
</tr>
</tbody>
</table>
Conclusions:

• Very beneficial to compare constraints individually in $H_0$-$\Omega_m$ plane;

• Most constraints consistently overlap in some common region along different degeneracy directions;

• The local measurement(s) is the main driver of the tension;

• Hard for high-, mid- or low-z models to reconcile all constraints as they stand;

• Proposals that shift the local measurement(s) are more likely than a problem with LCDM at large scales.

This work is based on Lin, Mack & Hou (2019): arXiv tomorrow morning.

For more on IOI: