Analysis of Hubble Tension

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Abstract

The results of measurements of Hubble constant H_0, which characterizes the expansion rate of the universe, shows that the values of H_0 vary significantly depending on Methodology. The disagreement in the values of H_0 obtained by various teams far exceeds standard uncertainties provided with the values. This discrepancy is called Hubble Tension. In this paper, we discuss Macrostructures of the World and provide an explanation of Hubble Tension in frames of the developed Hypersphere World-Universe Model (WUM).

1. Introduction

W. L. Freedman in the paper "New analysis by UChicago astronomer finds agreement with standard model in ongoing Hubble tension" outlined the following situation with the measurements of an expansion rate of the universe [1]: *Our universe is expanding, but our two main ways to measure how fast this expansion is happening have resulted in different answers. For the past decade, astrophysicists have been gradually dividing into* ***two camps: one that believes that the difference is significant, and another that thinks it could be due to errors in measurement.*** In the article "Measurements of the Hubble Constant: Tensions in Perspective," she provides an excellent review of the Hubble Constant measurements [2]:

- As apparent fissures in the standard model have been emerging, there are also indications that there may be cracks that need attention in the local distance scale as well. For example, the Tip of the Red Giant Branch (TRGB) method and the Cepheid distance scale result in differing values of $H_0 = 69.6 \pm 1.9\ km/sec\ /Mpc$ for the TRGB and 73.2 ± 1.3 for the Cepheids;
- In contrast, (early-time) estimates of H_0 based on measurements of fluctuations in the temperature and polarization of the cosmic microwave background (CMB) consistently yield lower values of $H_0 = 67.4 \pm 0.5$ and $67.6 \pm 1.1\ km\ s^{-1} Mpc^{-1}$, respectively, both adopting the current standard ΛCDM model;
- High values of H_0 were initially obtained from time-delay measurements of strong gravitational lensing with $H_0 = 73^{+1.7}_{-1.8}\ km\ s^{-1} Mpc^{-1}$, apparently consistent with the Cepheid measurements. However, recent detailed consideration of the assumptions in the modeling of the lens mass distribution leads to a much lower value of the Hubble constant, as well as a significantly larger value of the uncertainty $H_0 = 67.4^{+4.1}_{-3.2}\ km\ s^{-1} Mpc^{-1}$, currently consistent with the CMB and TRGB measurements;
- This TRGB calibration was updated and yield value of $H_0 = 69.6 \pm 0.8\ (stat) \pm 1.7\ (sys)\ km\ s^{-1} Mpc^{-1}$. To date, the TRGB is the only method with comparable numbers of galaxies in its calibration relative to Cepheids;
- The updated TRGB calibration applied to a distant sample of Type Ia supernovae from the Carnegie Supernova Project results in the value of Hubble constant of $H_0 = 69.8 \pm 0.6\ (stat) \pm 1.6\ (sys)\ km\ s^{-1} Mpc^{-1}$. No statistically significant difference is found between the value of H_0 based on TRGB and that determined from measurements of the cosmic microwave background.

2. Macrostructures of the World

Laniakea Supercluster (LSC) is a galaxy supercluster that is home to Milky Way (MW) and approximately 100,000 other nearby galaxies (see **Figure 1**). It is known as one of the largest superclusters with estimated binding mass $10^{17}\ M_{\odot}$. The neighboring superclusters to LSC are Shapley Supercluster, Hercules Supercluster, Coma Supercluster, and Perseus-Pisces Supercluster. Distance from the Earth to the Centre of LSC is $250\ Mly$.

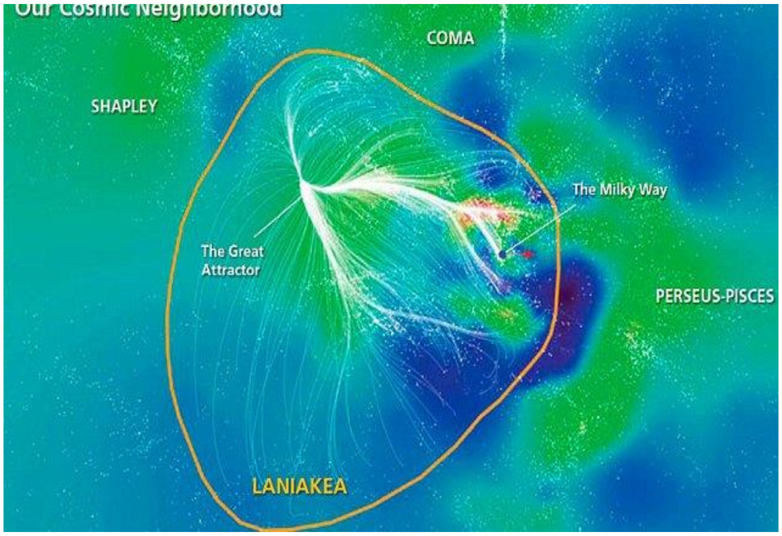


Figure 1. Laniakea Supercluster. Adapted from [3].

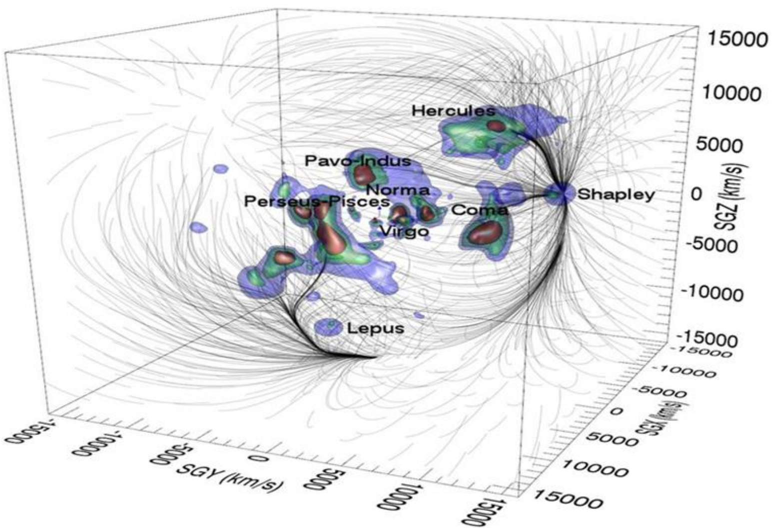


Fig. 2. Structure within a cube extending 16,000 km s−1 (~200 Mpc). Adapted from [3].

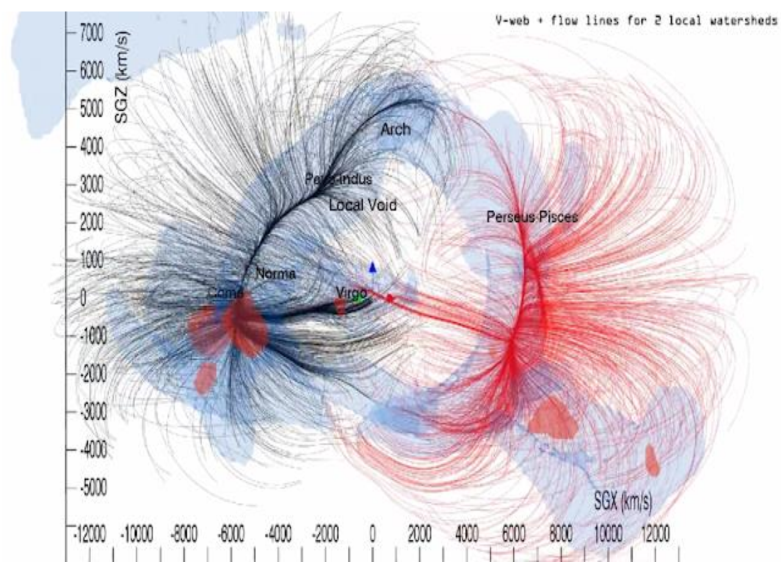


Fig. 3. A representation of structure and flows due to mass within 6,000 km s-1 (80 Mpc). Adapted from [3].

We emphasize that about 100,000 nearby galaxies are moving around Centre of Laniakea Supercluster. They belong to LSC. All these galaxies did not start their movement from the "Initial Singularity". The neighboring superclusters have the same structure (see **Figure 2** and **Figure 3**). It means that the World is, in fact, a Patchwork Quilt of different Luminous Superclusters ($\gtrsim 10^3$) [4].

According to R. B. Tully, *et al.*, "*Galaxies congregate in clusters and along filaments, and are missing from large regions referred to as voids. These structures are seen in maps derived from spectroscopic surveys that reveal networks of structure that are interconnected with no clear boundaries"* [3].

P. Wang, *et al.* made a great discovery: "*Most cosmological structures in the universe spin. Although structures in the universe form on a wide variety of scales from small dwarf galaxies to large super clusters, the **generation of angular momentum across these scales is poorly understood**. We have investigated the possibility that filaments of galaxies - cylindrical tendrils of matter hundreds of millions of light-years across, are themselves spinning. We have found that these objects too display motion consistent with rotation making them the largest objects known to have angular momentum. **These results signify that angular momentum can be generated on unprecedented scales***" [5].

A. Lopez reported about the discovery of "*a giant, almost symmetrical arc of galaxies – the Giant Arc – spanning 3.3 billion light years at a distance of more than 9.2 billion light years away that is **difficult to explain in current models of the Universe**. This new discovery of the Giant Arc adds to an **accumulating set of (cautious) challenges to the Cosmological Principle**. The growing number of large-scale structures over the size limit of what is considered theoretically viable is becoming harder to ignore. **Can the standard model of cosmology account for these huge structures in the Universe as just rare flukes or is there more to it than that?"*** [6].

WUM. These latest observations of the World can be explained in frames of the developed WUM only [7];

- "*Galaxies **do not** congregate in clusters and along filaments."* On the contrary, Cosmic Web that is "*networks of structure that are interconnected with no clear boundaries"* is the result of the Explosive Volcanic Rotational Fission of Dark Matter (DM) Cores of neighboring Superclusters;
- *"Generation of angular momentum across these scales"* provide DM Cores of Superclusters through the Explosive Volcanic Rotational Fission;
- *"Spinning cylindrical tendrils of matter hundreds of millions of light-years across"* are the result of spiral jets of galaxies generated by DM Cores of Superclusters with internal rotation;
- The Giant Arc is the result of the intersection of the Galaxies' jets generated by the neighboring DM Cores of Superclusters;
- 13.77 Gyr ago, when the Laniakea Supercluster emerged, the estimated number of DM Supercluster Cores in the World was around $\sim 10^3$ [4]. It is unlikely that all of them gave birth to Luminous Superclusters at the same cosmological time being far away from each other. The 3D Finite Boundless World presents a Patchwork Quilt of different Luminous Superclusters, which emerged at different Cosmological times;
- The main conjecture of BBM: "*Projecting galaxy trajectories backwards in time means that they converge to the Initial Singularity at $t=0$ that is an infinite energy density state*" is wrong because all Galaxies are gravitationally bound with their Superclusters (**Figure 1**, **Figure 2**, **Figure 3**).

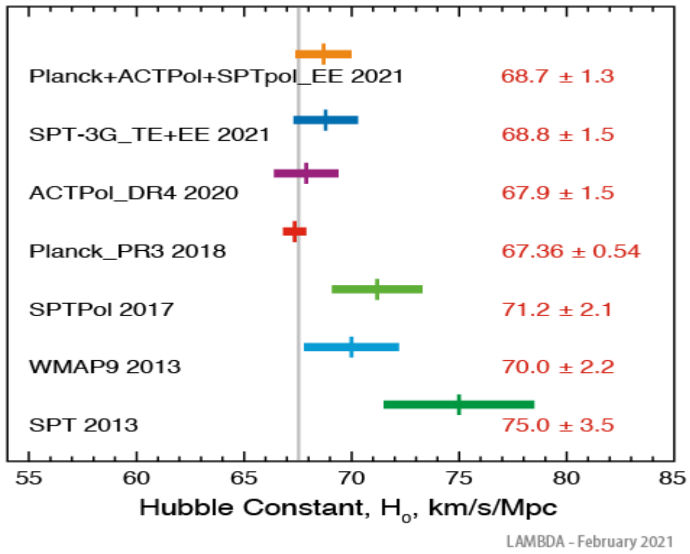
3. Hubble Tension Explanation

The experimental observations of galaxies in the universe show that most of them are disk galaxies [8]. It is well-known that when observing spiral galaxies, the side spinning toward us have a slight blueshift relative to the side spinning away from us. Therefore, there is a meaning of a redshift of a Center of galaxy only. The redshift of the Centre of LSC is 0.0708. But it does not mean that LSC is moving away from MW. On the contrary, MW is moving away from the Centre of LSC. In LSC, some galaxies are moving toward MW, and the other are moving away (see

Figure 1). Then redshift depends on the position and movement of a particular galaxy in LSC against MW. More complicated situation with redshift is when galaxies belong to neighboring superclusters, which emerged at different cosmological times.

According to WUM, the value of the Hubble parameter H depends on the cosmological time: $H = \tau^{-1}$. It means that a value of H should be measured based on Cosmic Microwave Background (CMB) radiation only.

Figure 4 illustrates recent H_0 determinations using only CMB data. Adapted from [9].



The calculated value of Hubble constant in 2013 [10]: $H_0 = 68.733\, km/s\ Mpc$ is in excellent agreement with the most recent measured value in 2021: $H_0 = 68.7 \pm 1.3\ \ km/s\ Mpc$ using only CMB data [9].

In frames of WUM, Hubble Tension can be explained the following way:

- All measurements of Hubble constant are model-dependent;
- Statistics of these measurements is not sufficient to yield reliable conclusions;
- Hubble's law in Standard Cosmology is valid for the Big Bang Model (BBM) only when all galaxies start their movement from a single point named "Initial Singularity" that is not the case in WUM;
- There are observations of Galaxies, which belong to different Superclusters;
- The value of H depends on the cosmological time $H = \tau^{-1}$ and is higher for the earlier Epoch of the World. It means that the value of H should be measured for each Galaxy separately depending on a distance to it and corresponding cosmological time. We must not calculate average values of H depending on Methodology;
- The value of H should be measured based on Cosmic Microwave Background Radiation only.

This explanation is in good agreement with the experimental results provided by W. L. Freedman who belongs to the camp that believes that the difference could be due to errors in measurement. I belong to the camp that believes that the difference is significant!

The main differences between BBM and WUM are:

- Mainstream scientists, following BBM, measure the values of the Hubble constant based on various characteristics of Macroobjects, the distribution of which in the World is spatially Inhomogeneous and Anisotropic and temporally Non-simultaneous;
- WUM suggests that the value of the Hubble constant should be measured based on Cosmic Microwave Background Radiation only, which depends on the characteristics of the Medium of the World. The Medium is Homogeneous and Isotropic. Its parameters do not practically depend on Macroobjects, which can create some fluctuations in the Medium.

References

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