Herds and Shepherds in Cosmology

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Abstract

In the last five years, no problem in cosmology has received as much attention as what is called ``Hubble tension." Hundreds or perhaps even thousands of papers have investigated the observations that originate the tension within the standard cosmological model or proposed alternative scenarios. Historically, in the last five decades, we should not be surprised to find tensions of 4-6$\sigma $ because they are much more frequent than indicated by the Gaussian statistics, and they stem from underestimation of errors, not from real tensions in the background physics or cosmology. Moreover, there are tens of tensions and problems in the standard model that are more challenging than this. Why, then, is there so much noise and commotion surrounding Hubble tension in the last five years? The answer to this question has to do with the fact that this tension has been promoted by the dominant groups that control cosmology, the same teams who promoted the idea of concordance cosmology and dark energy based on Supernovae Ia and Cosmic Microwave Background Radiation analyses.

The Universe is very large, and we are very small compared to it, not only in size. Creating a cosmology that attempts to explain the whole existing Universe is an obsession shared by all cultures. We think we now have the true cosmological model, like many civilizations that have come before us. There are, however, reasonable grounds for thinking that the total truth about the origin and evolution of the Universe is beyond our reach. Nonetheless, there is widespread propaganda claiming that absolute truth about the Universe has already been obtained, and, like in any religion or ideology that constitutes the essence of our society, there are shepherds or priests controlling the flow of ideas and guiding the herds so they do not deviate from what they consider this absolute truth.

Only the standard model, usually known as the "Big Bang" is considered by most professional cosmologists, while the challenges of the most fundamental ideas of modern cosmology are usually neglected, owing mainly to sociological factors. Funding, research positions, prestige, telescope time, publication in top journals, citations, conferences, and other resources are dedicated almost exclusively to standard cosmology. Moreover, religious, philosophical, economic, and political ideologies in a world dominated by anglophone culture influence the contents of cosmological ideas.

The standard cosmological model is a long list of speculative ideas to which many ad hoc elements [e.g., charge conjugation parity symmetry violation (CP violation), non-baryonic dark matter, and inflation] were added when the theory did not reproduce observations. At the end of the 1990s, another patch was applied to the theory in an effort to solve new inconsistencies with the data: "dark energy," which supposedly produced acceleration in the cosmic expansion. The problems to be solved were basically the new Hubble-Lemaître diagrams with type Ia supernovae (SNIa) as putative standard candles, the numbers obtained from cosmic microwave background radiation (CMBR) anisotropies, and especially estimates of the age of the Universe, which were inconsistent with the calculated ages of the oldest stars. The renovated standard model including these new elements added ad hoc would come to be called the ΛCDM cosmological model,

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where Λ stands for dark energy and CDM stands for cold dark matter. Such models became the favored subgroup of models of non-baryonic dark matter.

Some cosmologists have referred to ΛCDM as "concordance cosmology" to emphasize that this model agrees with all the known observations. Other authors were critical of the standard model and preferred instead to call it "consensus cosmology." This term emphasizes that this new cosmology is, above all, a sociological question of agreement among powerful scientific teams in order to establish the orthodoxy of a fundamental dogma. This agreement was mainly between two powerful cosmological groups, the teams dedicated to the analyses of SNIa (Riess et al. 1998) and CMBR (Dodelson & Knox 2000), who found a rough coincidence in the necessary amount of dark energy, albeit with large error bars. This coincidence reinforced these groups' belief that they had discovered an absolute truth, thus compelling the rest of the community to accept this truth as a solid standard. Meanwhile, they discarded the results of other less powerful cosmological groups that presented different values of the parameters or that could interpret the results of SNIa or CMBR without needing to introduce an exotic element like dark energy. Talking about consensus cosmology, Rudolph 'Rudy' Schild (b. 1940) once queried, "Which consensus? Do you know who consented? A bunch of guys at Princeton who drink too much tea together."

The last 25 years in the development of cosmology have been characterized by a lack of discussion on its fundamental ideas. The belief that all the major problems have been solved became a tenet. Minor subtleties (byzantine arguments) about, for example, the equation of the state of dark energy and the types of inflation or the coldness or hotness of dark matter, continued to be debated, but the fundamental ideas did not. This is the epoch of the highest social recognition of cosmology: Not only do schools, museums, and popular science journals have described the Big Bang as well-established and as something to be compared to Darwin's evolution and natural selection theory, but cosmology have occupied a privileged ranking among the most prestigious natural sciences. For instance, researchers of cosmology and its dark were awarded Nobel Prizes in Physics in 2011 and 2019, respectively, for the putative discovery of the dark energy that produces the acceleration of the expansion and for the inclusion of the dark components in our understanding of the Universe.

One may wonder whether unconfirmed quasi-metaphysical speculations should form part of the body of recognized knowledge of physics, leaving behind the conservative tradition of Nobel committees not awarding prizes for speculative proposals. Einstein did not receive either of his Nobel Prize for his discovery of special and general relativity. Moreover, Curtis did not receive a Nobel Prize for his definitive recognition of the true nature of galaxies in the Great Debate of 1920. Neither Lemaître nor Hubble received the Nobel Prize for their discoveries about the expansion of the Universe, but we now have committees that give maximum awards for the highly speculative proposal of the acceleration of the expansion, whose reality has yet to be confirmed. We certainly live in a very special time for cosmology.

This is also the epoch in which the main enterprise of cosmology consists of spending big money on megaprojects that achieve accurate measurements of the values of the cosmological parameters and solve any small problems that remain to be explained. However, this brand of epistemological optimism has declined over time, and the expression "crisis in cosmology" is stubbornly reverberating in the media. The initial expectation of the removal of the pending minor problems arising from increased accuracy of measurements has backfired: the higher the precision with which the standard cosmological model tries to fit the data, the greater the number of tensions that arise. That is, the problems are proliferating rather than diminishing.

The top shepherds of the business of cosmology also pretend to be leaders of the crisis and tell the herds which problems are relevant and require further attention. In the last five years, no problem in cosmology has received as much attention as what is called "Hubble tension." Hundreds or perhaps even thousands of papers have investigated the observations that originate the tension within the standard cosmological model or proposed alternative scenarios. The tension was mainly triggered by the claim made in 2019 of a Hubble-Lemaître constant, H_0, estimated from the local SNIa distance ladder, which is at odds with the value extrapolated from CMBR data, per the standard ΛCDM cosmological model, which gave an incompatibility at the 4.4σ level (Riess et al. 2019). This tension was later increased up to 6σ depending on the datasets considered.

This Hubble tension is unsurprising, given the number of systematic errors that may arise in the measurements. As a matter of fact, there have always been tensions between different measurements of the values of H_0, which have not received much attention. Before the 1970s, due to different corrections of errors in the calibration of standard candles, the value of the parameter continuously decreased, leading to incompatible measurements of different epochs. Even after the 1970s, some tension has always been present. Statistical analyses of the measurements of H_0 after the 1970s have also shown that the dispersion of its value is much larger than would be expected in a Gaussian distribution (Chen et al. 2003), given the published error bars. The only solutions to understand this dispersion of values are to assume that most of the statistical error bars associated with the observed parameter measurements have been underestimated or to assume that the systematic errors were not properly taken into account.

The fact that the error bars for H_0 are so commonly underestimated might explain the apparent discrepancy of values. Indeed, a recalibration of the probabilities with this sample of measurements to make it compatible with a Gaussian distribution of deviations indicates that a tension of 4.4σ would be a tension of 2.1σ in equivalent terms of a Gaussian distribution of frequencies (López-Corredoira 2022b). Meanwhile, a tension of 6.0σ would be a tension of 2.5σ in equivalent terms of a Gaussian distribution of frequencies. That is, we should not be surprised to find tensions of 4-6σ because they are much more frequent than indicated by the Gaussian statistics, and they stem from underestimation of errors, not from real tensions in the background physics or cosmology.

Values of H_0 derived from CMBR are subject to errors in the cosmological interpretation of CMBR with ΛCDM, and they are subject to the many anomalies remaining to be solved in CMBR anisotropies. Moreover, Galactic foregrounds in CMBR are not perfectly removed and are an important source of uncertainties. Values of H_0 derived from SNIa are affected (and not properly corrected) by dust extinction in SNIa depending on the type of host galaxies, variations of the intrinsic luminosity of SNIa with the age of the host galaxies, etc. Ignoring all these latent variables can only lead to underestimated errors and possible biases. We must also bear in mind that the value of H_0 is determined without knowing which scales of the radial motion of galaxies and clusters of galaxies relative to us are completely dominated by the Hubble-Lemaître flow. The homogeneity scale may be much larger than expected, thus giving important net velocity flows on large scales that are incorrectly attributed to cosmological redshifts.

Why, then, is there so much noise and commotion surrounding Hubble tension? There are tens of tensions and problems in the standard model that are more challenging than this (López-Corredoira 2022a), but the cosmological herds are currently obsessed with solving the Hubble tension as the key problem in cosmology. The answer to this problem has to do with the fact that this tension has been promoted by the dominant groups that control cosmology. These, again, are the SNIa and CMBR teams who promoted the idea of concordance cosmology and dark energy. In the late 1990s, they told herds something like, "Now we have a consensus. Everybody should go in this direction," and we saw thousands of cosmologists, almost the whole community, moving in this direction like guided sheep. Now, one of the supreme leaders, Adam Riess (who won a Nobel Prize in 2011), has said that there is an important problem in cosmology. It is the problem derived from the analysis performed by his own team on SNIa data in comparison with CMBR data, expressing something like, 'There is a tension in cosmology, and everybody should go in this direction." Again, we see the sheep-cosmologists struggling to understand this tension and reinvent cosmology by adding new patches.

This is called "groupthink," a sociological phenomenon studied in depth, for instance, by psychologist Irving Lester Janis (1918–1990). Orthodox cosmology has an important element of groupthink, of following a leader's opinion. Any opinion, however outrageous, can be accepted if it is supported by the leading cosmologist. In this way, the Big Bang theory, even if it is a very speculative set of hypotheses, still finds a place in the psychology of the wider community of scientists.

The analysis by Cass R. Sunstein (b. 1954) in his book *Conformity* (Sunstein 2019) applies to social dynamics in the sciences. Conformity dynamics are particularly pronounced when dealing with very difficult problems. Social experiments in a multitude of contexts clearly show that when a problem is hard to solve, as in cosmology, people tend to follow the crowd, tending to defer to those who are perceived as authorities on the matter. A key mechanism in this collective effect is so-called informational cascades, by which people primarily rely on the signals conveyed by others rather than on independent information. Once this happens, the subsequent statements or actions of few or many others add no new information. They are just following their predecessors. This cascade is very hard to stop, as shown by social networks on the Internet. A reputational cascade develops along with and reinforces an informational one. At this stage, it simply becomes too risky to go against the core consensus.

As said in *Novum Organum* by English philosopher Francis Bacon (1561–1626):

> The human understanding when it has once adopted an opinion (either as being the received opinion or as being agreeable to itself) draws all things else to support and agree with it. And though there be a greater number and weight of instances to be found on the other side, yet these it either neglects and despises, or else by some distinction sets aside and rejects; in order that by this great and pernicious predetermination the authority of its former conclusions may remain inviolate. (Chapter XLVI)

Note: some parts of this article were taken from the book Fundamental Ideas in Cosmology (López-Corredoira 2022).

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