Astronomy’s Fundamental Flaw

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Astronomy has a fundamental flaw, which originated from the big bang. Since big bang, the universe did not stop expanding in a single day, which was firstly confirmed when Edwin Powell Hubble found the distant galaxies were moving away from us in 1929. However, after almost 100 years, today’s astronomers still cannot determine the exact expansion rate, the Hubble constant H_0 in "Hubble's Law", $v = H_0 d$, where v is the velocity of galaxies running away from us, d is their distance to us. The divergence, formally known as “Hubble Tension”, arises from the different measurement results via two approaches.

One method of H_0 measurement, shown in the right side of the figure, involves the earliest echo of the light in the universe --- the cosmic microwave background (CMB). The CMB originated about 379,000 years after the Big Bang when the universe was no longer too hot that the light could freely travel inside. By characterizing the distribution and amplitude of CMB, astronomers can determine what the universe looks like at the very beginning of the universe, even right after the Big Bang. Then, astronomers can calculate H_0 with the help of theoretical physics from the beginning state of the universe.

Another method is more straightforward: measure the velocity and distance of galaxies, which corresponding to the left part of the figure. While determining the velocity is easy to obtain, the distance is more complicated, and most uncertainties come from it. Astronomers must climb the "distance ladder". The ladder includes a list of ways to determine the distance; unfortunately, these are only valid for certain ranges of distance and a subset of astronomical objects, so astronomers need to combine the methods to reach the galaxies millions of lightyears away.

The H_0 values yielded from the two methods have a gap of about 10%. At face value, It seems not a big problem. However, the issue became more severe when the scientists from both sides tried their best to improve the accuracy and precision of the measurement: the gap between the two measurements still exists, and the astronomers could not regard it as a discrepancy due to random factors. Instead, it is an anomaly that hints at the hidden physics or other factors not included in the current measurement.

At first I was surprised when I learnt about the Hubble's discovery. In his time, the telescope was not so advanced as the present-day ones. As a result, the uncertainty of the measurement was incredible. Furthermore, the follow-up works by other astronomers also suggested that Hubble made some mistakes in his methodology. He got the types of supernovae --- the final step in the Distance Ladder --- wrong. Given all these conditions, seemingly Hubble could not draw the correct conclusion. However, Hubble did notice the expansion trend of the universe, though his "Hubble constant" is about seven times larger than any measurements today. Is his discovery a lucky coincidence? No. The discovery could not have been made without Hubble's intuition and insight into the frontier of physics.

In astronomy, you can find similar examples everywhere. The Hertzsprung–Russell diagram, a plot of stars' colour and their brightness, revealed the evolution traces of stars from the formation to death; the M*-sigma relation, the correlation between the black hole mass and the motion of stars around it, provided some hint on the mystery interaction across the length of four magnitudes. I am really excited about such discoveries fully motivated by the observation, where the simple combination of data brings correlations of distinct objects, revealing the deeply hidden physics behind. The joy of astronomical research just like being a detective: you will collect scattered evidence from every corner of the universe, connect them via various hypothesis with the support of theories, and determine the truth behind the enigma.

It's hard to tell if we can find an answer for the Hubble tension in the following twenty years. Whether the tension is due to some unknown mechanism missing in the CMB observation or some systematics not included in the Distance Ladder, solving the riddle may have little impact on our daily lives. However, the tension does bring a crisis for the astronomers. Countless people are striving for the answer to the tension with more advanced instruments and more convolving theories.

At the same time, astronomy does bring some benefits in other ways. For today's observational astronomy, the technology and financial requirements for supertelescopes are usually impractical in a single country. Therefore, astronomers from worldwide must work together to learn the nature of galaxies millions of lightyears away. One example is the event horizon telescope (EHT): this "telescope" is a group of radio telescopes built in many countries. With the telescope, astronomers took the first photo of the black hole at the centre of the Milky Way. The need for large telescopes makes astronomers one of the most international and globalized communities ever. At present, the astronomy community actually depicts a beautiful paradigm for the future of human beings. There will be no war or dispute anymore, and people can strive to explore the universe, for nothing but to satisfy one's curiosity.

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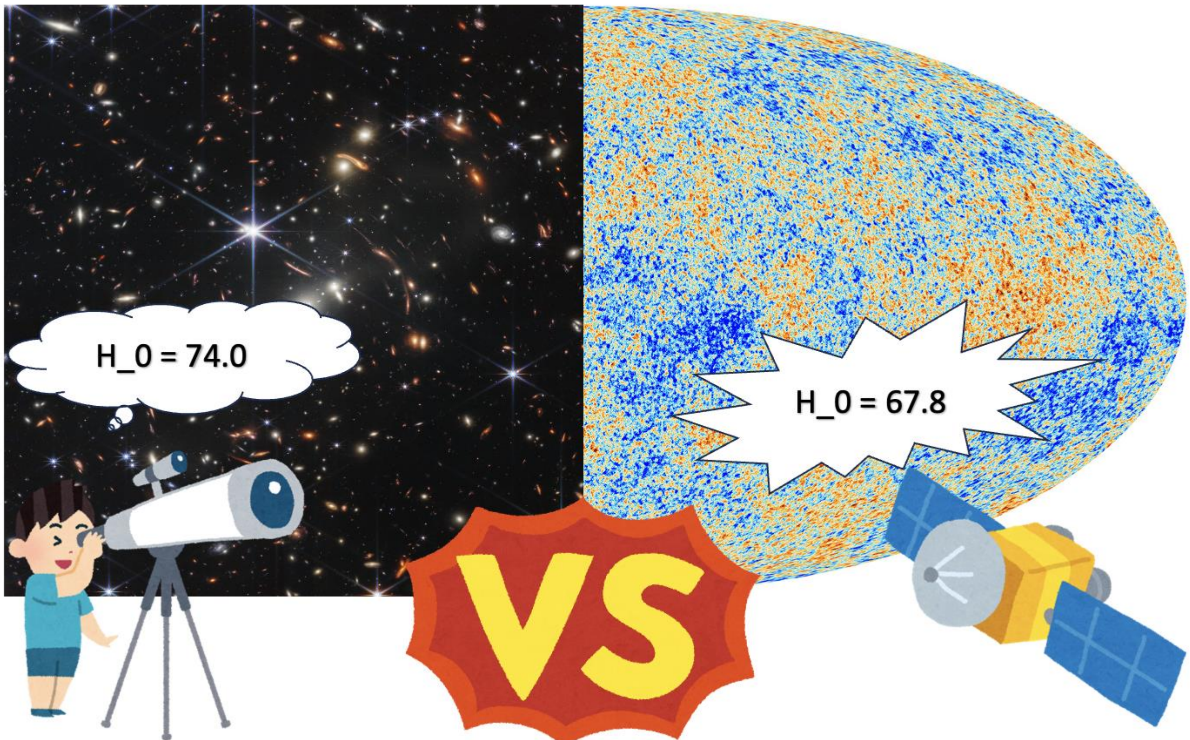
How fast does our universe expand?



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