

DJORGovski: And so we'll end with so-called Cosmic Concordance.

These two ladies are called Urania and Calliope. You guys know who they were? Urania was the muse of astronomy, which was regarded as an art in the action world. And Calliope was the muse of music. And they have some teaching assistants there with reads and whatnot.

So this is what we mean by Cosmic Concordance. That all kinds of different cosmological measurements, from different physics, different tools, different techniques, different directives are all converging to the same spot in the parameter space of energy density of matter and energy density of dark energy. But in this case cosmological called constant.

So each of them has some uncertainty ellipse. You can trade off errors of one quantity versus the other. But somehow you put them all together and they always intersect very precisely at this one spot. And so, this is why it's called Cosmic Concordance.

So any one of these measurements by itself doesn't tell you a lot. For example, microwave background tells you you are this close to fly. And supernova tells you there has got to be some dark energy. But only in their combinations do you get those precision results.

So the fact, if we get same results from all manner of completely different measurements-- supernovae, clusters of galaxies, microwave background, globular clusters, et cetera, et cetera-- is very reassuring and makes us think that, indeed, we know what cosmological parameters are. We may not know the nature of dark energy. We're not sure about nature of dark matter either. But in terms of global descriptors, seems like we nailed it.

And so this is today's best estimate universe, largely from Planck satellite. Those are currently the best measurements we have. And a handy way to remember this

is universe is 13.8 billion years old. Hubble constants about 70.

Visible stuff amounts to maybe 4 and 1/2% of everything. I'm sorry. Various amount of 4 and 1/2% of everything. About 30% of universe is matter of including dark matter. And 70% is this mysterious new thing. I'm not even going to call it substance because it's probably not substance. It's just cosmological constant.

So this is actually pretty remarkable that we can figure all this out just sitting here on planet Earth and deducing things, observing distance universe just on past light count.

This pie chart is a little older. Percents have changed since then. But pretty much still what's going on.

And so that completes our cosmic journey. I'll just leave you with this picture that just came out from the Hubble Space Telescope Propaganda Factory. This was one of their deep fields with some of their images that were obtained. And they are in a slightly bigger picture than this with 10,000 faint galaxies. And you can see some closer ones. We can recognize the spirals or ellipticals. But every little dot in this picture, except for two stars that have the diffraction spikes, every little dot is a galaxy.