

## Description of NOVA's *The Fabric of the Cosmos* Universe or Multiverse?

Traditionally, “universe” has meant “all there is.” But in a new picture of the cosmos, nothing is unique. Our universe may be just one of an infinite number. In this view, there are frequent Big Bangs, each creating its own new universe. We may actually live in an expanding “sea” of multiplying universes: a “Multiverse.” In this show, Brian Greene walks viewers through this new theory at the frontier of physics, explaining why this radical new picture of the cosmos is getting serious attention.

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### Main Ideas

- The mathematics of the Big Bang shows that in the very early universe, gravity could act in reverse. This “repulsive gravity” would repel everything around it, causing a huge expansion. This force was so powerful it could take space as tiny as a molecule and blow it up to the size of a galaxy in billionths of a second. And all that energy was instantly transformed into matter. This expansion is called “Inflation,” and it was the “bang” in the Big Bang.
- The mathematics of Inflation suggests that it there’s always some part of space still inflating. In this picture, the Big Bang is not a unique event—multiple bangs happened before ours and countless others will happen in the future. The idea is termed “Eternal Inflation.”
- Eternal Inflation goes on forever, with universes coming into existence at far-flung locations within a grand cosmos. This realm in which new universes form endlessly is called the Multiverse hypothesis. However, since light from any of these other universes could never reach us, the existence of a Multiverse cannot be confirmed. Right now, the Multiverse hypothesis can’t be used to make predictions and it can’t be tested. Critics charge that the Multiverse hypothesis is not really science.
- Astronomers assumed that over time, Inflation would slow down because of the gravitational attraction between galaxies, stars, and planets. But it’s not slowing down. It’s actually accelerating. Some kind of energy in space is counteracting gravity, pushing everything away from everything else, faster and faster. This unidentified energy is termed Dark Energy.
- Unfortunately, the observed value for Dark Energy is many trillions of times weaker than theory suggests. (If Dark Energy were at its predicted strength, matter couldn’t exist. It would push atoms, protons, and quarks apart.) However, the Multiverse hypothesis offers a possible explanation. Given an infinite number of universes, each with a different value of the Dark Energy, one would expect to find one with the value as small as what we’ve measured. So naturally our universe has a value of Dark Energy that is hospitable to life. Without a low value, we wouldn’t be here to talk about it.
- String Theory offers a possible explanation for there being universes with different values for Dark Energy. String Theory requires at least nine (and as many as eleven) dimensions. These multiple dimensions make different laws of physics possible, as many as 10 to the 500, with each one corresponding to a different way of making a three-dimensional world such as ours. And just as DNA can lead to a huge variety of life forms, String Theory can give rise to a huge variety of universes, universes with different properties, such as different values for Dark Energy.
- To accept the Multiverse hypothesis, we’d first need to understand how a universe can begin. And Inflation shows how the Big Bang could create our universe. Next, we’d need to know that our Big Bang wasn’t the only one, and Eternal Inflation indicates that big bangs happen all the time.

Finally, we'd want to understand that there are many different ways a universe can be put together, and String Theory says that there are more than we can even imagine. Taken alone, inflation/eternal inflation, string theory, and dark energy are not proof of a multiverse. Taken together, they suggest the possibility of a multiverse. And yet, the Multiverse hypothesis, with its huge complexity and no predictive power, remains unconfirmed. To date, it is the only hypothesis that explains the number of facts, but it's not so convincing that everybody believes it.