Dark Energy…

But why is the universe expanding? Why didn't it just remain a tiny singularity forever? Based on Einstein's theory of gravity, we would expect the gravitational forces in the universe to oppose the expansion, causing the universe to slow down in its growth. Knowing this, scientists were baffled when they discovered that the universe's expansion is actually accelerating! There must be some force that overwhelms the gravitational forces, causing the universe to grow at an accelerated rate. Many scientists believe that this force is provided by the mysterious dark energy.

We know very little about dark energy other than it is causing the universe to expand at an accelerating rate and there is a lot of it. Scientists have calculated that about 68% of the universe is dark energy! This is huge compared to the mere 5% that is "normal matter." The matter that makes up humans, our planet, and everything we can observe only accounts for 5% of all that is in the universe!

So where is all this dark energy hiding? Scientists suggest that it is a property of space itself. That is, empty space is not really empty after all! It contains dark energy. As the universe expands, more space is created, resulting in more dark energy, which in turn causes the universe to expand even faster.

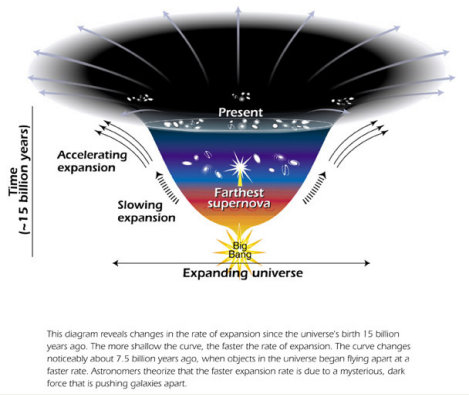

Image credit: Ann Feild (STScI)

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The Big *Bang!*

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HELPING TO FURTHER

PUBLIC UNDERSTANDING

OF PHYSICS CONCEPTS

The Big Bang!

Can you imagine absolutely nothing? Not even empty space—absolutely nothing! This is difficult to picture, because we view reality as something involving space. But what if there was no space?

Many scientists believe that 13.7 billion years ago this strange "absolutely nothing" existed. Then, all of a sudden (and for no known reason), a "singularity" appeared out of this nothingness. A singularity is an infinitely small, infinitely dense point. Basically, matter is squished into a tiny dot until it is infinitely dense. This tiny singularity expanded over time. In fact, it continues to expand today. Of course, the dot has become quite large now. It is our entire universe!

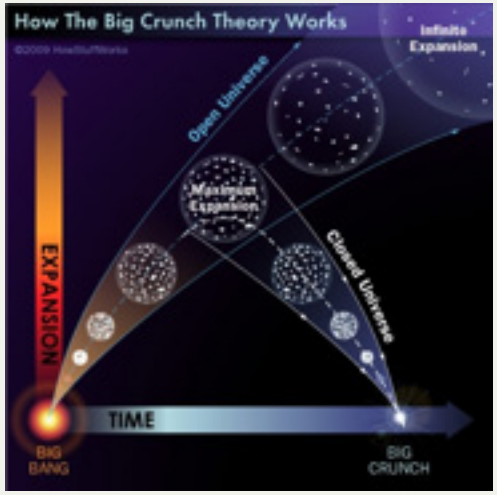


Image Credit: HowStuffWorks

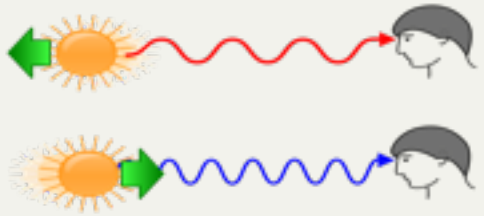
Here is a graphical depiction of this expansion (sometimes called "inflation"). Following the path labeled "open universe," the sphere representing our universe becomes larger and larger over time. You can see in the picture that stars and galaxies are moving farther and farther apart from one another.

Some theorists suspect that this expansion will continue forever—the universe will just keep getting bigger and bigger until every galaxy is infinitely far apart from every other galaxy. Another theory is that the universe will eventually reach a finite maximum size and will then shrink, returning to a singularity. This return to a singularity is referred to as "The Big Crunch." In the image on the previous panel, you can see the "crunch" depicted in the path labeled "closed universe."

Have you ever imagined the Big Bang to be like a gigantic firework explosion? Well, this is not entirely accurate. Although some theorists believe there was a huge, rapid expansion during the first tiny fraction of a second after the universe was born (this is not widely accepted as part of the big bang theory), it is important to remember that the singularity was not exploding into anything. There was absolutely nothing outside the singularity, so, however fast it may have expanded initially, its growth was more like the inflation of a balloon as it grew into a larger and larger universe. We do know, however, that the early universe was extremely hot—so hot that not even protons and neutrons could form! Over time, the universe cooled and a large amount of hydrogen and helium was produced.

You may be wondering how scientists learned so much about the early universe. The Big Bang, of course, is a theory. It has not been proven, because we can't go back in time to watch it happen! Still, scientists have some good reasons to believe the theory is correct.

The most obvious reason is that we know the universe is expanding today. Every second, the universe is bigger than it was the second before! Because of something called the "Doppler shift," light moving away from an observer appears to be shifted towards the red end of the spectrum. Similarly, light that is approaching the observer appears shifted towards the blue end of the spectrum.



Ales Tosovsky, Wikimedia commons

In observing distant stars and galaxies, astronomers have detected a shift towards the red end of the spectrum, indicating that everything is moving away from us. This suggests that the universe is expanding! Scientists have been able to calculate the rate of expansion (and the rate at which this expansion is accelerating), and from this data, they figured out that 13.7 billion years ago, the universe must have been a singularity. This calculation assumes that the expansion did not begin recently, but has been going on continuously since the beginning of time.

Another piece of evidence for the Big Bang is the Cosmic Microwave Background (CMB). The CMB is a form of radiation (a wave) that pervades the universe and is believed to be the remnant of the immense heat initially produced by the Big Bang.

Finally, the large amount of Hydrogen and Helium in our universe supports the theory, since scientists believe the Big Bang produced many atoms of these elements in the early universe.