The Size of the Universe

by

Rex Ungericht

All measurements are approximate.

> "Space," ... "is big. Really big. You just won't believe how vastly, hugely, mindbogglingly big it is. I mean, you may think it's a long way down the road to the chemist's, but that's just peanuts to space..."
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> *- Douglas Adams, The Hitchhiker's Guide to the Galaxy*

So, I was sitting around and the thought came to me, "I wonder if I can create a decent description of the size of the universe?" Because I'm the type of person who thinks these things. And because I'm the type of person who thinks these things, I don't get invited to parties much.

But the question is actually more than just about the size of the universe. It's an exploration of the question "How do you make the incomprehensible comprehensible?" I doubt that I'm the one who's going to succeed at this, but I'm going to try.

So I'll start with something that *is* comprehensible. The Earth.

The Earth is much bigger than you or me. But thanks to modern transportation, we can get a handle on its size. For example, if there was a road that ran all the way around the Earth, and you spent 12 hours a day driving 65 miles per hour, you could drive it in about 32 days. If you've ever driven a long distance, you can imagine this. It's big, but it's comprehensible.

It gets a little more difficult once we move away from Earth. The same trip to the moon would take 12 months. That's a long time to be driving 12 hours a day.

But wait. Many of us have flown on airplanes. So let's say we're in a jet that can fly straight to the moon at 500 miles per hour. First we fly from New York to London (7 hours) and then we fly from London to the moon (478 hours, or 20 days). So, flying to the moon is about the same as flying between New York and London 68 times.

But here's where the difficulties begin in trying to describe the size of the universe. Most of us haven't travelled in anything faster than a jet. And once we head out beyond the moon, distances start to get a little crazy. It would take our jet 279,617 hours (11,651 days or 32 years) to get to Mars.

At distances like that, we need something faster. A lot faster.

Humans have managed to build rockets to carry humans into space. The Apollo rockets could travel at 25,000 miles per hour. At that speed, the moon is just 10 hours away. (Of course, the moon missions didn't go there at 25,000 miles an hour; they sped up and slowed down and didn't go in a straight line, and the trip took four days.) But if you could accelerate immediately to that speed and maintain it for the entirety of the trip, Mars is still 5,592 hours, or 233 days away.

If I think about it hard enough, I can just barely comprehend the distance to Mars. But if I want to go further, what do I use as a measuring tool? I find myself reluctantly turning to one of the primary means that astronomers use to measure long distances -- the speed of light.

But is it possible to truly comprehend the speed of light? Let's get back in the car and make the short drive from Minneapolis to St. Paul. Traffic is light, and we make the trip in around 12 ½ minutes. In that same time, a beam of light has left Minneapolis and is now at Mars.

Light is pretty damn fast.

But does it make the distance any more comprehensible? If I tell you that in one hour a beam of light goes 670 million miles, does it make the distance of 670 million miles more comprehensible?

Let's try this. We've got a reasonable handle on how big Earth is. If we could make copies of the Earth and place them next to each other, it would take a string of 30 to reach the moon. It would take a string of 17,639 Earths to reach to Mars. It would take a string of 84,610 Earths to reach a point out between Jupiter and Saturn, which is where light travels in an hour.

One light-hour = the diameter of 84,695 Earths.

Light is really really fast.

In a little over 4 hours, light travels from Earth to Neptune, the outermost planet of the solar system. (Sorry, Pluto.)

To get from Earth to the edge of the solar system, light has to travel about 17 hours. The Voyager 1 spacecraft made the same trip in 36 years. It would take 1,466,061 Earths strung together to get there.

Did I mention that light is incredibly fast?

But wait. There's more than one way to define the size of our solar system. When I said "edge of the solar system" I was referring to the NASA proclamation that Voyager 1 had entered a region beyond the solar wind around 11.6 billion miles out.

But that's the solar wind. What if we use a different measure of what constitutes the solar system?

There is a hypothesized zone of small icy bodies orbiting the sun, way out beyond the end of the solar wind. It is thought that all long-period comets originate from this zone, called the Oort Cloud.

The Oort cloud is (at least partially) caught in our sun's gravity, and therefore can be considered part of the solar system.

And this is where my concept of distance blows a gasket. After a couple of beers, I can almost make myself believe I can comprehend the 17 light-hour distance to the edge of the solar system (as defined by Voyager 1). To get to the Oort cloud, light has to travel for a year. At 670 million miles an hour. And since one year = 8,766 hours, we're talking 5,874,601,670,040 miles. That's almost [Dr. Evil voice ON] six...treeelion...miles! Bwahahahahahaha! [Dr. Evil voice OFF].

How in the world can I comprehend the size of the universe when I can't even comprehend the size of the solar system (including the Oort cloud)? Our solar system is an infinitesimal speck in the universe. And yet the solar system is so huge compared to my typical earthbound measures of distance that my brain can't truly fathom it.

And that's just a single light year. To get to the nearest star outside our solar system (Proxima Centauri), light has to travel for 4.3 years. That's 25,260,787,181,172 miles. Our 25,000 MPH rocket would take 115,663 years to get there.

If we're going to head out beyond the nearest stars, we need something faster than a rocket. We (gasp) even need something faster than light. We need warp drive.

If you've watched the show Star Trek, you know the ships have the ability to move at what seems to be faster-than-light speeds. (This paper is not the place for a discussion of warp drive technology, so we'll just say the ship flies faster than light.)

There have been various definitions given to "warp factors" over the years, so we'll pick this one:

Warp 1 = lightspeed
Warp 2 = 10 times lightspeed
Warp 3 = 39 times lightspeed
Warp 4 = 102 times lightspeed
Warp 5 = 214 times lightspeed
Warp 6 = 392 times lightspeed
Warp 7 = 656 times lightspeed
Warp 8 = 1,024 times lightspeed
Warp 9 = 1,516 times lightspeed
Warp 10 = infinite speed; cannot be attained

So at Warp 2, it takes 22 weeks to get to Proxima Centauri. At warp 9, it takes 24 hours.

But does that help to comprehend the distance? Does 24 hours at 1,516 times the speed of light really mean anything to beings who travel around their planet from 3 MPH (walking) to 500 MPH or so (jet aircraft)? We're talking 25 trillion miles! At 65 or 500 or even 25,000 MPH, you might as well forget it.

And that's just to the closest star.

Even in Star Trek, with ships that on occasion could reach Warp 9.975 (Voyager), the Federation was contained within a single quadrant of the galaxy. When Voyager was thrown from the Alpha Quadrant into the Delta Quadrant, it was going to take them 75 years and a really big odometer to get home at maximum warp.

But speaking of galactic quadrants, let's take a look at our dear Milky Way.

The Milky Way is a flattened galaxy with a bulge in the middle, sort of like a fried egg with the yolk in the middle. The distance from top to bottom is 1,000 light-years, and the distance from side to side is over 100,000 light years.

That's a loooooooooong walk. Even at Warp 9, it's a lifetime.

And if, as Einstein calculated, the ultimate speed limit for anything with mass is the speed of light, then at minimum we humans would need hundreds of thousands of years, and more likely millions of years, just to explore the Milky Way.

At the moment, the speed record for a human created spacecraft is around 100,000 MPH (which was reached by the New Horizons mission to Pluto before the sun's gravity slowed it down).

100,000 MPH. That's 0.00015% the speed of light. That's over 3 years to get to Neptune. 5,800 years to the Oort cloud. 28,380 years to Proxima Centauri.

So, even if we could create manned spaceships that could zip around at 100,000 miles per hour, we're pretty much stuck in our own solar system. Forget nearby stars, and don't even consider exploring the galaxy.

But, I will continue to try and conceptualize the size of the entire universe, of which the Milky Way galaxy is an insignificant speck, not even a gnat on the Empire State building.

But to do it, I have to leave any hope of truly comprehending the size of it all, and just start throwing numbers around and pretend they really mean something to my "a really long trip is from Texas to South Carolina to see my mom" brain.

Since light years and warp drive are too small and slow for intergalactic space, let's use something bigger.

Since our galaxy is around 100,000 light years across, let's say that one Milky Way = 100,000 light years. It would take 25 Milky Ways to reach the Andromeda Galaxy, one of our nearest neighbors.

It would take at least 930,000 Milky Ways to reach across the observed universe -- the part of the universe we've so far managed to get a glimpse of. The true size of the universe may be infinite.

I can intellectually imagine this, but I can't comprehend it. I can barely comprehend the distances from Earth to the outer planets of the solar system, much less a trip of 273,168,977,656,860,000,000,000 miles from Earth to the furthermost observed galaxy. So I leave you with this: a visual representation of the universe.

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Writer, song parodist, happy husband, proud pappa, and mostly nice guy, Rex Ungericht lives in Texas where he's managed to find paid employment for most of his post-college years. You can see some of his feeble efforts at parodyman.com.

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