

**0:01 Is there a border we will never cross?**

0:04 Are there places we will never reach, no matter how hard we try?

0:08 Turns out there are.

0:10 Even with science fiction technology, we are trapped in our pocket of the Universe.

0:16 How can that be? And, how far can we go?

0:29 We live in a quiet arm of the Milky Way; A spiral galaxy of average size,

0:34 – about 100,000 light years across –

0:36 consisting of billions of stars, gas clouds, dark matter, black holes, neutron stars,

0:42 and planets, with a supermassive black hole in the galactic centre.

0:47 >From afar, our galaxy seems dense, but in reality, it consists, mostly, of empty space.

0:55 With our current technology, sending a human to the closest star, would take thousands of years.

1:01 So, our galaxy is pretty big.

1:04 The Milky Way is not alone, though.

1:07 Along with the Andromeda galaxy, and more than fifty dwarf galaxies,

1:11 it's a part of "The Local Group";

1:13 a region of space about ten million light years in diameter.

1:16 It is one of the hundreds of galaxy groups in the "Laniakea Supercluster",

1:21 which, itself is only one of millions of superclusters,

1:25 that make up the observable universe.

1:27 Now, let's assume, for a moment, that we have a glorious future;

1:31 humanity becomes a type three civilisation,

1:34 does not get wiped out by aliens,

1:36 and develops interstellar travel based on our current understanding of physics.

1:42 In this best case scenario, how far could we possibly go?

1:46 Well; the local group.

1:48 It's the biggest structure that humanity will ever be a part of.

1:52 While it's certainly huge, the local group accounts for only 0.00000000001 % of  
2:02 the observable universe.

2:04 Let this number sink in for a moment.

2:07 We are limited to a hundred billionth of a percent of the observable universe.

2:13 The simple fact that there is actually a limit for us, and that there is

2:17 so much universe that we will never be able to touch, is kind of frightening.

2:23 Why can't we go further?

2:25 Well, it all has to do with the nature of nothing.

2:30 Nothing, or empty space, isn't empty but has energy intrinsic to itself;

2:36 so-called "quantum fluctuations".

2:39 On the smaller scale, there is constant action, particles and antiparticles

2:43 appearing and annihilating themselves.

2:46 You can imagine this quantum vacuum as a bubbling part:

2:49 with denser, and less dense regions.

2:52 Now, let's go back 13.8 billion years when the fabric of space

2:57 consisted of nothing at all.

2:59 Right after the big bang, in an event known as cosmic inflation, the observable universe

3:04 expanded from the size of a marble to trillions of kilometres, in fractions of a second.

3:10 This sudden stretching of the universe was so fast and extreme,

3:14 that all those quantum fluctuations were stretched as well,

3:18 and subatomic distances became galactic distances,

3:22 with dense and less dense regions.

3:26 After inflation, gravity began to pull everything back together.

3:31 At the largest scale, the expansion was too quick and powerful

3:34 to overcome but in smaller scales, gravity emerged victorious.

3:39 So, over time, the denser regions, or pockets, of the universe,

3:43 grew into groups of galaxies, like the one we live in today.

3:47 Only stuff inside our pocket – The Local Group – is bound to us gravitationally.  
3:53 But wait, what is the problem then?  
3:56 Why can't we travel from our pocket, to the next one?  
3:59 Here, dark energy makes everything complicated.  
4:03 About six billion years ago, dark energy took over.  
4:07 It's basically an invisible force or effect, that causes,  
4:09 and speeds up the expansion of the universe.  
4:13 We don't know why, or what dark energy is, but we can observe its effect clearly.  
4:18 In the early universe, there were larger, cold spots around the local group,  
4:22 that grew into clusters with thousands of galaxies.  
4:26 We are surrounded by a lot of stuff, but none of those structures and galaxies  
4:31 outside of the local group are gravitationally bound to us.  
4:35 So the more the universe expands, the larger the distance between  
4:39 us and other gravitational pockets becomes.  
4:42 Over time, dark energy will push the rest of the universe away from us,  
4:46 causing all the other clusters, galaxies, and groups to eventually become unreachable.  
4:52 The next galaxy group is already millions of light years away,  
4:55 but all of them are moving away from us, at speeds we can't, ever, hope to match.  
5:00 We could leave the local group, and then fly through intergalactic space,  
5:04 into the darkness, but we would never arrive anywhere.  
5:08 While we will become more and more stranded, the local group will become more tightly  
bound,  
5:13 and merge together to form one giant elliptical galaxy, with the unoriginal name  
"Milkdromeda"  
5:19 in a few billion years.  
5:21 But it becomes even more depressing:  
5:24 at some point, the galaxies outside the local group, will be so far away,  
5:28 that they will be too faint to detect, and the few photons that do make it to us,  
5:33 will be shifted to such long wavelengths, that they will be undetectable.  
5:37 Once this happens, no information outside of the local group will be able to reach us.  
5:42 The universe will recede from view.  
5:45 It will appear to be dark and empty in all directions, forever.  
5:50 A being born in the far future in Milkdromeda,  
5:53 will think there is nothing but its own galaxy in the entire universe.  
5:56 When they look far into empty space, they will only see more emptiness and darkness;  
6:01 they won't be able to see the cosmic background radiation,  
6:05 and they won't be able to learn about the Big Bang.  
6:08 They will have no way of knowing what we know today;  
6:11 the nature of the expanding universe, where it began, and how it will end.  
6:16 They will think the universe is static and eternal.  
6:20 Milkdromeda will be an island in the darkness, slowly getting darker and darker.  
6:26 But still, with its trillions of stars, the local group is certainly  
6:31 large enough for humanity.  
6:33 After all, we still haven't figured out how to leave our solar system,  
6:36 and we have billions of years to explore our galaxy.  
6:40 We have the incredible luck to exist at the perfect moment in time to see,  
6:44 not only our future but also our most distant past.  
6:48 As isolated and remote as the local group is, we can perceive the entire universe,  
6:53 grand and spectacular as it is right now.  
6:59 This video was sponsored by [SquareSpace.com/nutshell](https://www.squarespace.com/nutshell)  
7:03 Do you feel isolated in a humongous universe?  
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7:08 humanoids around you?  
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- 7:35 It really helps.
- 7:36 It is awesome that you watched this far, so we have made a playlist for you about more universe stuff.
- 7:40 Subtitles made by Sebastian Winkelmann
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