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https://www.youtube.com/watch?v=l3C_db2RjKo&t=18s

# What does the universe expand into? Do we expand with it?

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My opinions and comments to the text in red

**(01)-** This video was sponsored by the Great Courses Plus. If the universe expands, what does it expand into? That's one of the most frequent questions I get, followed by "Do we expand with the universe?" And "Could it be that the universe doesn't expand but we shrink?" At the end of this video, you'll know the answers. I haven't made a video about this so far, because there are already lots of videos about it. But then I was thinking, if you keep asking, those other videos probably didn't answer the question. And why is that? I am guessing it may be because one can't really understand the answer without knowing at least a little bit about how Einstein's theory of general relativity works. Hi Albert. Today is all about you. So here's that little bit you need to know about General Relativity. First of all, Einstein used from special relativity that time is a dimension, so we really live in a four dimensional space-time with one dimension of time and three dimensions of space. Without general relativity, space-time is flat, like a sheet of paper. With general relativity, it can curve. But what is curvature? That's the key to understanding space-time. To see what it means for space-time to curve, let us start with the simplest example, a two-dimensional sphere, no time, just space. That image of a sphere is familiar to you, but really what you see isn't just the sphere. You see a sphere in a three dimensional space. That three dimensional space is called the "embedding space". The embedding space itself is flat, it doesn't have curvature. If you embed the sphere, you immediately see that it's curved. But that's NOT how it works in general relativity. In general relativity we are asking how we can find out what the curvature of space-time is, while living inside it. There's no outside. There's no embedding space. So, for the sphere that'd mean, we'd have to ask how'd we find out it's curved if we were living on the surface, maybe ants crawling around on it. One way to do it is to remember that in flat space the inner angles of triangles always sum to 180 degrees. In a curved space, that's no longer the case. An extreme example is to take a triangle that has a right angle at one of the poles of the sphere, goes down to the equator, and closes along the equator. This triangle has three right angles. They sum to 270 degrees. That just isn't possible in flat space. So if the ant measures those angles, it can tell it's crawling around on a sphere. There is another way that ant can figure out it's in a curved space. In flat space, the circumference of a circle is related to the radius by 2 Pi R, where R is the radius of the circle. But that relation too doesn't hold in a curved space. If our ant crawls a distance R from the pole of the sphere and you then goes around in a circle, the radius of the circle will be less than 2 Pi R. This means, measuring the circumference is another way to find out the surface is curved without knowing anything about the embedding space. By the way, if you try these two methods for a cylinder instead of a sphere you'll get the same result as in flat space. And that's entirely correct. A cylinder has no intrinsic curvature. It's periodic in one direction, but it's internally flat. General Relativity now uses a higher dimensional generalization of this intrinsic curvature. So, the curvature of space-time
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**(01)-** (01)- This video was sponsored by Great Courses Plus. If the universe is expanding, what is it expanding into? This is one of the most common questions I get, followed by "Are we expanding with the universe?" and "Is it possible that the universe is not expanding, but shrinking?" **I repeat my version in HDV : Before the Big Bang = there is a spacetime 3 +3D which is Euclidean flat, infinite, there is no matter or field in it and time does not run in it and space does not expand. As a result of the rule = principle of alternating symmetries with asymmetries, a "bang" will occur, which is not an explosion but a change from the previous state to the subsequent one. The curvature of the dimensions will change. In the infinite flat state of space-time before the Bang, a final location (our Universe) will "occur" in which there will be the opposite extreme: the curvature of the dimensions will be extremely large. This final location - boiling vacuum, foam of dimensions = plasma begins its genesis of changes of states. The "unpacking" of those curvatures occurs, i.e. the flow-flow of time begins, the "unpacking" of space begins. (it is similar to Guth inflation). However, the curvatures in this foam of dimensions change in such a way that (let's imagine the foam as (!) a homogeneous mixture of black and white balls = mini-locations. "White" locations curve even more, they are packed into packages = balls and... and black locations, on the contrary they will unwrap and this will be our intergalactic 3+3D space-time (with the predominance of gravitational curvature; but also here the three states of unwrapping of dimensions čp will "freeze" into the form of three forces: weak, strong and electromagnetic). So: balls=wave packets (from that foam "poked out" as "clones") will realize elementary particles of matter (quarks, leptons, bosons; each topological shape = a different property;...subsequently in a genetic sequence of changes-transformations of "wrapped dimensions" into atoms, molecules, into compounds, proteins). with the "conglomerates" will present themselves as stars and galaxies. So this is a brief, really brief scenario of the evolution of the "expanding and collapsing" of the curvatures of the 3+3D dimensions of space-time. Large-scale space-time unfolds differently in every "stop-time" since the Bang in the microworld, they "package" and connect packages-balls of space-time dimensions. In the antiworld, the time dimension is packed into a ball in the "opposite" direction than here in our World. Today, even today on the Planck scale it is boiling, the vacuum of dimensions is boiling there, i.e. "boiling" changes in curvature, pairs of virtual particles are born there, etc. (particles have the opposite spin to antiparticles, i.e. the curvature of the time dimension into a ball). Unpacking space-time 3 +3D is not symmetric with respect to the mutual curvatures of the six dimensions...and it also takes place differently in time "stop-states" since the Bang. Time "runs" from the Big Bang = the time dimension is unfolding, and it is better to say that all three time dimensions are unfolding. When anyway? and when not?, that's the question. We know, for example, from STR that time dilates in the direction of the body's movement, but in the other two time dimensions perpendicular to the movement, time no longer dilates. This interpretation is certainly not complete. I will also mention the vision that after the Big Bang, the genesis of the structure of matter, matter structures = sequence of complexity, but also a parallel "sequence of laws and rules" that "take care" of the mutuality of matter "floating in unfolding space-time" arises. With the development of the "variety" of matter structures, the "third sequence of phenomena" also develops, and these are the "properties" of matter (e.g. properties include mass, spin, charge, further e.g. Pauli's principle,...further later chemical properties, etc. etc. Each topological configuration of that "package" as well as conglomerates of packages is a state of "property, e.g. acids as different from bases and from them salts etc. etc. ). All this, that diversity would never have occurred if matter had not been "invented" (by God's providence) from space-time precisely **with the help of the breathtaking "combination" possibilities of 3+3 dimensional curvature and parallel laws, which also arose gradually in accordance with the configurations of the elements of matter....**

Similar to what string theorists sing about in Pale Blue: properties of matter are "produced" by the "strumming-vibration" of strings.
Really, this is not yet a complete explanation, just hints of the variety that can arise only thanks to "expanding and collapsing space-time dimensions". You will find out the answers at the end of this video. It won't be an answer, but it will be an opinion, Ms. Sabina or other physicists. I have to add my opinion. It is central to HDV's vision. http://www.hypothesis-of-universe.com/docs/g/g_033.pdf ; http://www.hypothesis-of-universe.com/docs/aa/aa_147.pdf . I haven't made a video on this yet because there are already tons of videos on it. But then I thought that if you keep asking, the other videos probably didn't answer the question : And why is that? My guess is that it might be because one can't really understand the answer without knowing at least a little bit about how Einstein's theory of general relativity works. Hi Albert. Today is all about you. So here's the little you need to know about general relativity. First, from special relativity, Einstein used that time is a dimension, so we really live in a four-dimensional space-time with one dimension of time and three dimensions of space. I am convinced that there is more than one time dimension as well. No one has ever researched it yet. Unfortunately, it is very depressing that many "things" that are not obvious and observable at first glance have been declared by scientists in equations and only then looked for by observation or nuclear experiments... but this does not apply to time. They never explored it either abstractly before the discovery of reality with multiple dimensions of time, or observationally without theory.
Without general relativity, spacetime is flat, like a sheet of paper. With general relativity, a curve can. But what is curvature? This is the key to understanding spacetime. For me, the key to understanding was the "hot potato principle" http://www.hypothesis-of-universe.com/docs/h/h_082.jpg i.e. how linearity is made from non-linearity, i.e. how the "linear foam becomes nonlinear gravity"... and I understood this from R. Feynman's explanation when he told the students at the blackboard: he took a stick-stick and started waving it, first slowly and then faster and faster and the fastest...; asymmetry turns into symmetry here. Gravity is non-linear and quantum mechanics is linear. We "rape" the parabola by cutting it into non-infinite segments and then reassembling them one after the other and thereby "making" a straight line out of a crooked parabola - that's how Mr. Ullmann did it. http://www.hypothesis-of-universe.com/docs/g/g_039.pdf To see what this means for the curve of space-time, let's start with the simplest example, a two-dimensional sphere, no time, just space. You are familiar with that image of a sphere, but what you see is not just a sphere. You see a sphere in three-dimensional space. That three-dimensional space is called the "embedding space". The insertion area itself is flat, it has no curvature. If you insert the ball, you will immediately see that it is curved. But this is NOT the case in general relativity. In general, we ask relativity how we can find out what the curvature of spacetime is when we live in it. He's not out. There is no space to insert. So for a sphere that would mean, we would have to ask how we would find out it was curved if we lived on the surface, maybe ants were crawling on it. One way to do this is to remember that in flat space the interior angles of triangles are always 180 degrees. This is no longer the case in curved space. An extreme example is to take a triangle that has a right angle at one of the poles of the sphere, goes down to the equator, and closes along the equator. This triangle has three right angles. Their sum is 270 degrees. This is simply not possible in flat space. So if the ant measures these angles, it will find that it is crawling on a sphere. There is another way for an ant to know that it is in a curved space. In flat space, the circumference of a circle is related to a radius of 2 Pi R, where R is the radius of the circle. But even this relation does not hold curved space. If our ant is crawling at a distance R from the pole of the sphere and you are then going around in a circle, the radius of the circle will be less than 2 Pi R. This means that measuring the circumference

is another way of knowing that a surface is curved without knowing anything about space for insertion.
This is food for thought. Whether we have a 3D "net, yarn" space around us without curvature and only insert another 3D space with curved dimensions into it; that is, in the flat 3D space, another 3D non-flat-curved space "swims" to realize, for example, a triangle with 270 degrees of the sum of the angles. By the way, if you try these two methods for a cylinder instead of a sphere, you will get the same result as in a flat space. And that's absolutely right. The cylinder has no internal curvature. It is periodic in one direction, but it is internally flat. General relativity now uses a higher dimensional generalization of this intrinsic curvature

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**(02)-** is defined entirely in terms which are internal to the space-time. You don't need to know anything about the embedding pace. The space-time curvature shows up in Einstein's field equations in these quantities called R. Roughly speaking, to calculate those, you take all the angles of all possible triangles in all orientations at all points. From that you can construct an object called the curvature tensor that tells you exactly how space-time curves where, how strong, and into which direction. The things in Einstein's field equations are sums over that curvature tensor. That's the one important thing you need to know about General Relativity, the curvature of space-time can be defined and measured entirely inside of space-time. The other important thing is the word "relativity" in General Relativity. That means you are free to choose a coordinate system, and the choice of a coordinate system doesn't make any difference for the prediction of measurable quantities. It's one of these things that sounds rather obvious in hindsight. Certainly if you make a prediction for a measurement and that prediction depends on an arbitrary choice you made in the calculation, like choosing a coordinate system, then that's no good. However, it took Albert Einstein to convert that "obvious" insight into a scientific theory, first special relativity and then, general relativity. So with that background knowledge, let us then look at the first question. What does the universe expand into? It doesn't expand into anything, it just expands. The statement that the universe expands is, as any other statement that we make in general relativity, about the internal properties of space-time. It says, loosely speaking, that the space between galaxies stretches. Think back of the sphere and imagine its radius increases. As we discussed, you can figure that out by making measurements on the surface of the sphere. You don't need to say anything about the embedding space surrounding the sphere. Now you may ask, but can we embed our 4 dimensional space-time in a higher dimensional flat space? The answer is yes. You can do that. It takes in general 10 dimensions. But you could indeed say the universe is expanding into that higher dimensional embedding space. However, the embedding space is by construction entirely unobservable, which is why we have no rationale to say it's real. The scientifically sound statement is therefore that the universe doesn't expand into anything. Do we expand with the universe? No, we don't. Indeed, it's not only that we don't expand, but galaxies don't expand either. It's because they are held together by their own gravitational pull. They are "gravitationally bound", as physicists say. The pull that comes from the expansion is just too weak.

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**(02)-** The curvatures of spacetime are defined entirely in terms that are internal to spacetime. You don't need to know anything about the loading rate. The curvature of spacetime appears in Einstein's field equations in these quantities called R. Roughly speaking, to calculate them, we take all the angles of all possible triangles in all orientations at all points. From this you can construct an object called a curvature tensor, which tells you exactly what spacetime curves where, how strong, and in what direction. That is, the tensor "gets out" in that curved

3D space (floating in a flat one), not in that basic flat one in which curvature does not exist. Things in Einstein's field equations are sums over the curvature tensor. In of equations, those things can only be abstract character formations "made" in 3D tensor CURVE space. In reality, there are no tensors…we don't see tensors flying around us.
This is one important thing you need to know about general relativity, the curvature of spacetime can be defined and measured entirely within spacetime. Not like this. Inside the flat 3D (3+3D) space-time, if we define "curvature", we must "add" another 3+3D space-time to it (into it), in which curvatures "may" be realized. These are considerations that need to be discussed in the broad forum of physicists. Another important thing is the word "relativity" in general relativity. This means that you are free to choose the coordinate system ( curved or non-curved ?? ) and the choice of coordinate system does not depend on the prediction of the measurable quantities. ? This calls for a deep explanation. It's one of those things that sounds pretty obvious in hindsight. Certainly, if you make a prediction for a measurement and that prediction depends on any choice you made in the calculation, such as the choice of coordinate system, then that is not good. ? This needs further explanation However, Albert Einstein needed to translate this "obvious" view into a scientific theory, first special relativity and then general relativity. So with that background knowledge, let's look at the first question. My basic understanding of special relativity is that "this mathematics, mathematics constructed in this way" demonstrates the mutual rotation of systems, **a)** the system into which the Observer fits and **b)** the system that is connected to the test object-body where this body moves to the basic Observer. What is the universe expanding into?
And here there are two options - two variants of the view "on the matter" - lying on the table. **A)** the flat infinite 3+3D space-time before the big-bang and "floats" in it **B)** the (finite) location of the 3+3D space-time of curved dimensions, in which the curvature of individual dimensions pulsates from absurd curvature to zero curvature, and...and in in which the curvature of all 6 dimensions can be changed separately, even in combinations. They are therefore two time-spaces that become identical in the "right" extreme position and "separate" in the opposite extreme position. The opposite extreme position is the Big-bang, where *"two time-spaces"* with opposite curvatures live "next to each other". But even that is not entirely true, because after the big-bang both time-spaces "live" "within each other" = the curved spacetime "floats" in the non-curved spacetime. In the genesis of changes, only one space-time changes, the curvatures in it change. In the second, the curvatures do not change. It does not expand into anything, it only expands. More precisely: The Universe (the crooked 3+3D cp) is EXPANDING...and it even expands throughout the universe non-homogenously non-linearly..., it expands all around us (it is evident on Planck scales). The claim that the universe is expanding , is, like any other statement we make in general relativity, about the intrinsic properties of spacetime. It says, loosely speaking, that the space between galaxies is stretching. The "expanding" variant would lead to the solution that "our Universe is expanding "into nothing" and would also lead to "new" points in spacetime "coming into being" and also "out of Nothing". Remember the sphere and imagine its radius increasing. As we discussed, you can figure this out by measuring on the surface of the sphere. You don't need to say anything about the embedding space surrounding the sphere. Now you may ask, but can we put our 4 dimensional spacetime into a higher dimensional flat space? The answer is yes. Here we come to a common unified idea, to a common understanding of "one reality" (to this day there are two realities: **a)** my HDV and **b)** the reality of physicists with their models). For me, in HDV, the higher dimensions are "good for that" in order to use them to realize the artifact → matter.
Sphericalization of the basic dimensions 3+3D leads to the construction of 26 elementary particles of the standard model. http://www.hypothesis-of-universe.com/index.php?nav=ea
And further it is already clear that and how these conglomerate together into more complex

states of matter. ). We don't even need extra dimensions to build all baryonic matter, if it is possible to abstractly justify the "separation" of the space-time grid of 3+3D flat dimensions from the "other" grid of 3+3D dimensions, but all the curved ones, i.e. whether and how the "crooked" grid "**floats**" 3+3D in a grid 3+3D "**uncurved**" and...and how it is realized. You can do it. It generally lasts 10 dimensions. But one could really say that the universe is expanding into this higher dimensional space. Or HDV where the crooked dimensions from the Bang from the boiling vacuum from the foam of space-time u n p a c k . However, the insertion space is completely unobservable by construction, O.K. We humans do not observe around us the basic grid-yarn-net of 3+3 dimensions of a flat space-time in which the space-time of curved dimensions "floats", although we even perceive the curvatures and therefore we have no reason to claim that it is real. So the scientifically supported statement is that the universe is not expanding into nothing. O.K. Crooked dimensions unfold* in the basic flat grid… Are we expanding with the universe? Why do you say that space is expanding with the universe ??, that is flawed logic. The 3+3D base grid does not expand, but in it the "floating" state of globally curved spacetime with curved galaxies expands, unpecked - you say expands. No, we don't. In fact, it's not just that we're not expanding, galaxies aren't expanding either. This is because they are held together by their own gravitational pull. They are "gravitationally bound", as physicists say. The pull that comes from the expansion is too weak.
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**(03)-** The same goes for solar systems and planet. And atoms are held together by much stronger forces, so atoms in intergalactic space also don't expand. It's only the space between them that expands. How do we know that the universe expands and it's not that we shrink? Well, to some extent that's a matter of convention. Remember that Einstein says you are free to choose whatever coordinate system you like. So you can use a coordinate system that has yardsticks which expand at exactly the same rate as the universe. If you use those, you'd conclude the universe doesn't expand in those coordinates. You can indeed do that. However, those coordinates have no good physical interpretation. That's because they will mix space with time. So in those coordinates, you can't stand still. Whenever you move forward in time, you also move sideward in space. That's weird and it's why we don't use those coordinates. The statement that the universe expands is really a statement about certain types of observations, notably the redshift of light from distant galaxies, but also a number of other measurements. And those statements are entirely independent on just what coordinates you chose to describe them. However, explaining them by saying the universe expands in this particular coordinate system is an intuitive interpretation. So, the two most important things you need to know to make sense of General Relativity is first that the curvature of space-time can be defined and measured entirely within space-time. An embedding space is unnecessary. And second, you are free to choose whatever coordinate system you like. It doesn't change the physics. In summary: General Relativity tells us that the universe doesn't expand into anything, we don't expand with it, and while you could say that the universe doesn't expand but we shrink that interpretation doesn't make a lot of physical sense. This video was sponsored by The Great Courses Plus I like to learn new things, and while YouTube is really useful for little nuggets of wisdom, it's not particularly good for structured learning. When it comes to structured learning,

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**(03)-** The same is true for solar systems and planets. And atoms are held together by much stronger forces, (higher dimensional curvatures) so atoms in intergalactic space also do not expand. Only the space between them expands. How do we know that the universe is expanding and not that we are shrinking? To some extent this is a matter of convention. http://www.hypothesis-of-universe.com/docs/c/c_262.jpg Remember Einstein says you can choose any coordinate system you like. So you can use a coordinate system that has scales that expand at exactly the same rate as the universe. So if I equate the Observer with a photon, with a system associated with a photon. If you use them, you would conclude that the universe is not expanding in these coordinates. O.K. You really can do that. However, these coordinates do not have a good physical interpretation. This is because they will mix space with time. So you can't stand still on these coordinates. Whenever you move forward in time, you will also move sideways in space. That's weird and that's why we don't use those coordinates. The claim that the universe is expanding is actually a statement about certain types of observations, notably the redshift of light from distant galaxies, but also a number of other measurements. And these statements are completely independent of what coordinates you choose to describe them. However, to explain them as the universe expanding in this particular coordinate system is an intuitive interpretation. So the two most important things you need to know to understand general relativity is first that the curvature of spacetime can be defined and measured entirely in spacetime. Loading space is unnecessary. And secondly, you can choose any coordinate system you like. It doesn't change the physics. In summary: General relativity tells us that the universe is not expanding into nothing, we are not expanding with it, and even if you could say that the universe is not expanding, but we are shrinking, that interpretation does not make much physical sense. ← I will skip/postpone the comment on this whole passage that was said for the time being.

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