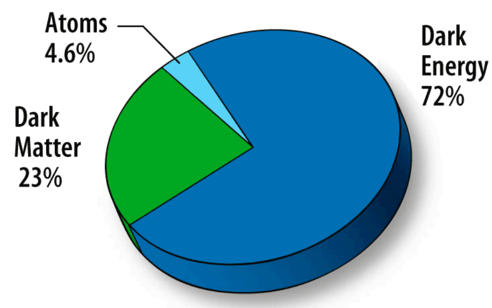
Dark Energy – Much Ado About Nothing



If you are reading this, then very possibly you have heard that Dark Energy makes up roughly three-fourths of the Universe, and you are curious about that. You may have seen the Official NASA Pie Chart that shows what the Universe is made of (at right). You may have heard Tyson deGrasse expounding about it on PBS. And there is no question that the term "Dark Energy" does refer to something. However, from the layman's point of view, there are two small problems with understanding Dark Energy when you call it Dark Energy: (1) It's not dark. (2) It's not energy.

Dark Energy is the winner of my personal award for the most misleading physics jargon of the 21st Century. This monument to misdirection was generated because it sounded cool, not because it is even close to being accurate. The jargon term Dark Matter already existed – and does, by the way, refer to something real – and rather than giving a descriptive name to their theoretical musings, the theoreticians decided, why not use a cute parallel name to Dark Matter? Why not create the buzz term *Dark Energy*?

To which I say, like wow, man. That name is so – hip.

Unfortunately, it is also nearly meaningless. Thus, the first thing we must do is get it straight: Dark Energy does not exist. Calling it an energy implies that the Dark Energy is, well, an energy – and it isn't. It cannot be turned into heat, or electricity, or anything else that you and I would normally identify as energy. There is no need for anyone to ponder how to solve the global warming problem by extracting our nation's energy out of the Dark Energy, because there isn't anything to extract. (I hate to rain on the theoretical parade, but since Dark Energy has neither energy nor mass, I can guarantee you that it is going to be pretty hard to utilize.) Calling it "dark" energy doesn't make it energy.

Now, it is true that astronomers have a dust-covered tradition of using the word "dark" to describe anything their telescopes cannot see. Therefore "dark" becomes the same thing as "invisible" or "undetectable" inside the halls of astronomy. However, dust-covered tradition is no excuse for creating scientific terminology so monumentally misleading, if confusion were cement then "Dark Energy" would be a super-highway system. (Besides, how seriously can you take people who use the term "dwarf star" to describe stellar behemoths that are 100,000 times brighter than the Sun? One must never trust astronomers to put clarity ahead of cuteness.)

And finally, who says that ordinary energy can't be dark also? The bottle of Cola Cola on my desk contains 1,004,640 joules of chemical energy, but I only know that because the label says so. Take the label off, put the bottle on the Moon, and ask an astronomer to determine its energy content just by staring at it with a telescope, and I will show you dark energy. That 72% of dark blue in the NASA pie chart above does represent something, but whatever it is, it isn't energy, dark or otherwise.

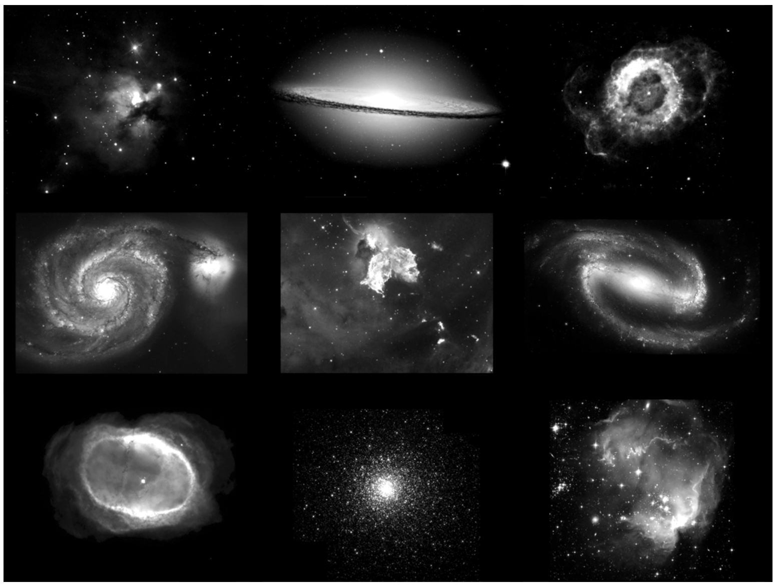
So here is the real question: What are the theory boys *trying* to refer to, when they say Dark Energy, and whatever it is, what gives them the right to claim that it "makes up" 72% of the Universe?

Aha. Well, that is a fairly long story, but it has some good physics in it and it is actually a quite fascinating question. To answer it, let us go back to the beginning.

Observational Evidence For The Expanding Universe

The Big Bang Theory of Cosmology holds that the entire Universe was once packed into a speck that was 10^{-28} times the radius of a proton. (Or 0.0000000000000000000000000000000000000001 meter, if you prefer.) That's pretty small, and the Universe did not stay that small for long. The Universe exploded outwards, with its outer boundary moving essentially at the speed of light compared to points not near the boundary. And the Universe is still expanding to this very day.

Edwin Hubble, for whom the famous Hubble Space Telescope is named, receives the lion's share of the credit for proving that our Universe is expanding. At the turn of the last century, astronomers generally felt that everything visible in the sky was contained inside the Milky Way galaxy. The Milky Way in turn was thought to be a static collection of gas and stars, setting in an infinite, dark, three-dimensional space. This is sometimes called the Island Universe Hypothesis. There were a few naysayers, who felt that at least some of the faint nebula (which the new science of photographic astronomy was finding in droves) had to be outside the Milky Way – but the majority view was that spiral nebula were just new stars being born. It was thought that the flat disks surrounding them would eventually give rise to new planets, just as had once happened for the Sun.



This picture of a static "Island Universe", and the notion that spiral nebulae were only young stars, began to crumble in 1923. That was when Edwin Hubble (1889 – 1953) proved that even the largest, and therefore presumedly the closest of the spiral nebula, the famous Andromeda Nebula, lay far beyond the edge of the Milky Way galaxy. The technical details of how he did this are a bit messy – but in short, he showed that a particular type of star, a so-called Cepheid variable, existed both in the Andromeda Nebula and in the stream of stars that we call the Milky Way. Then, by comparing the relative brightnesses of the two groups of stars, he was able to prove that the ones in the Andromeda Nebula were about 20 times farther away than the ones in the Milky Way, i.e., he showed that the Andromeda Nebula was of vast size and lay far outside the Milky Way.

This was a very important discovery. In astronomy, one cannot underestimate the difficulty and the importance of determining how far away some foggy blur of white light is. At top left is a collection of nine photographs of several nebulas as seen from Earth. Three of these lie far outside the Milky Way, at distances of millions of light-years. The others are much closer, within 20,000 light-years. Can you tell which is which, just by looking? (The answer is at the bottom of the page.) Determining distances in astronomy is a critical problem, and one of the hardest. The use of "candles", which is astronomer slang for stars of a known type and therefore known brightness, is a time-tested way of measuring distances in deep space. Hubble pioneered this method.

Hubble's next step after developing the use of Cepheid variables as a powerful "candle" was to correlate the distances of many galaxies with their *red-shifts*. Red-shifted light is light whose color has been tinted in a very particular way: it has been moved uniformly towards the red end of the rainbow *after* it was emitted. That is, the light has been reddened by its transit through space, and not by anything to do with the galaxy that emitted it. All waves, including light, can be characterized by their wavelength – the distance between successive crests in the wave – so therefore shifting the color of the light also means that you have changed the wavelength of the light. Longer wavelengths of light correspond to the red end of the spectrum, thus, to say that light has been red-shifted is the same as saying that its wavelength has become longer, or been stretched, while it was moving from one place to another.

Answer: Starting at top left, Item 1 in Row 1, Item 2 in Row 2, and Item 3 in Row 3, are photographs of a huge gas cloud in the Milky Way. In fact, they are all photographs of the same cloud, just taken at different magnifications. Item 2 in Row 1, and Items 1 and 3 in Row 2, are spiral galaxies. They are many million of light-years away. Item 3 in Row 1 and Item 1 in Row 3 are so-called planetary nebula, which are rather small clouds of gas given off by dying stars. Item 2 in Row 3 is a globular cluster, a tight collection of about 100,000 stars that orbits the center of the Milky Way.

A similar (but not identical) type of shift occurs with sound, when the source of the sound is moving. If the sound source is moving towards you then the sound waves become compressed as they enter the air and decrease in wavelength, whereas if the source is moving away from you then the waves becomes stretched and increase in wavelength. This is known as the Doppler Effect, and it is responsible for the famous "eeeee-wooo" sound of a train whistle (high pitch to low pitch change) as a train passes you.

Very interesting, you may well say (talking about "eeeee-wooo" train whistles and galactic red shifts), but why did Hubble set about trying to graph red shifts versus distance, once he had learned to how measure galactic distances using Cepheid variables? Was this a random choice? Did he just wake up one morning and decide that this would be fun?

No, of course not. The red shift data would indicate how *fast* the galaxies were moving, whereas the Cepheid data would indicate *where* the galaxies were. If the galaxies and their speeds were random, something like people walking this way and that in a big crowd, then there would be no correlation. That within itself would have been interesting, because it would have indicated that the galaxies had no particular direction in which they wanted to move.

If, one the other hand, there *were* a correlation, then that would be *really* exciting, because it would indicate that the galaxies *did* have a preferred direction, which opens up all kinds of other questions. What direction did they prefer? Why did they have it? Was the Earth also participating in the general stampede or not?

Wow. Those are good questions. (And dare I say, if you aren't thrilled by the very anticipation of what Hubble discovered next, then it is time for you to put this essay down and reach for the sports page.)

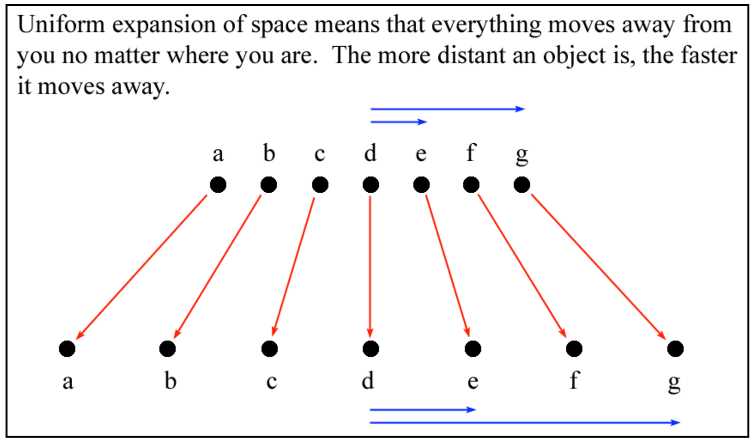
Hubble, I should point out, did not take the red-shift measurements himself. One often reads that, but it isn't so. He took his own Cepheid data, but he used the red-shift data of others. Astronomers already had a lot of red-shift data from photographic surveys, and there wasn't much reason for Hubble to re-invent the wheel. Translating the red-shift data into speeds wasn't hard, because astronomers knew which colors that the incandescent strontium, barium, sodium (and so on for all the other elements) had to give off in stars. Each element gives off a particular spectrum that is as unique as a fingerprint, and it never changes, whether observed on Earth or in a distant star. Earth-based astronomers, of course, only had spectral patterns obtained *after* the light had travelled through space, that is, after they had been red-shifted, but that was OK. Figuring out what the spectral patterns looked like *before* they were red-shifted was roughly the equivalent of a musician identifying a symphony after the conductor has changed the key and the tempo. It isn't too hard, for the experts.

So, without further ado, what did Hubble find? He found that the degree of the red shift for any given galaxy correllated very well with how far away the galaxy was: the greater the distance, the greater the red shift. It did not matter where the galaxy was in the sky; all that mattered was how far the light had come. In other words, *all* the galaxies very near the Earth were *slowly* moving away from the Earth (except for the Andromeda Nebula, which is a very special case). And *all* the galaxies far from the Earth were *swiftly* moving away from the Earth (no exceptions). And all the galaxies in between were moving away from the Earth at speeds that corresponded to exactly how far away they were.

If the Universe was a crowd, then the Earth was apparently the equivalent of a ticking time bomb, because every galaxy out there was rushing away from us, and the farther away they were, the faster they were rushing.

This discovery was amazing even at first glance, because if nothing else it implied that if one turned around the expansion then all the galaxies would have been together at one point at some time in the past. That is, it implied the existence of what we today call the Big Bang. But far more amazing was the fact that the Earth appeared to be at the center of the expansion – and I say "appeared" very deliberately, because I doubt that it crossed Hubble's mind for a microsecond that the Earth really was the absolute center of the Universe. Instead, he immediately realized that the Earth was participating in a *uniform expansion*, and now let us turn our attention to discovering exactly what that is.

Uniform Expansion



Let us talk about geometry for a while. Suppose you take an infinitely-long rubber band and put seven dots on it labeled **"a"** to **"g"**, as shown at right. If you expand the rubber band uniformly (stretch all of it by the same amount) then the dots will move apart as shown by the red arrows. The dots are equally spaced before the expansion, and they still are afterwards. If you focus your attention on any one dot, let's say dot **"d"**, then you can see that dot **"e"** has moved a certain distance from dot **"d"**. But dot **"f"** has moved that exact same distance from dot **"e"**, so therefore dot **"f"** has moved *twice* that distance from dot **"d"**. And so it goes. Dot **"g"** is three dots over from dot **"d"**, so it has moved three times as far (relative to **"d"**) as dot **"e"** has. If I stretch the rubber band continuously, then the more distant dots must always move farther than the closer ones, which means that the farther away a dot is from dot **"d"**, the faster it must be moving.

Here is the good part. If you are on dot **"d"**, then the dots on *both* sides of you appear to be moving away, which means you are at the center of the Universe (so to speak), and standing still. Now notice that anybody standing on any of the other dots will see exactly the same thing! Every dot appears to be in the middle of the rubber band, from the viewpoint of that dot. The fast-moving dots are always *someone else*, not you, and they are always far away.

What Hubble saw was that every galaxy in the visible Universe (except Andromeda) was racing away from the Earth, no matter where the galaxy was in the sky. Good Heavens! Did this mean that the ancient astronomers were right after all, and that the Earth really was the center of the Universe!?

Well, no, because Hubble also saw that the speed with which a galaxy was moving *only* depended on how far away it was: double the distance to the galaxy, double its speed. In other words, this is exactly the signature of uniform expansion. What Hubble had discovered, in essence, is that Earth is dot **"d"**, and the galaxies are dots **"a"** through **"g"**. This meant that the ancient astronomers were right, sort of, in the sense that the Earth indeed sets at the center of the Universe. However, this title is not as impressive as you might think, because in a Universe undergoing uniform expansion, *everywhere* is the center of the Universe!

One can visualize the way that uniform expansion always places you in the center by imagining that you are on a ship in the middle of the ocean. If you look over the railing, what do you see? You see the ocean, stretching away in all directions and forming a perfect circle around you. Then, as you sail towards the distant horizon, what happens? Do you approach the horizon? (Do you fall off the edge of the Earth?) No. The horizon stays exactly where it is. No matter which direction you sail, no matter how fast you sail, you are always surrounded by the same boring circle of ocean, and you are always in the center of the circle.

In a similar way, from planet Earth, we see a spherical Universe which looks the same in every direction and has an "edge" at 13.7 billion light-years. The edge represents the most distant things we can see with our telescopes. (A light-year equals the distance that light can travel in one year, or 5,878,451,895,552 miles.) If we could instantly quantum-jump five billion light-years in any direction we wished, we would see – ?

The same thing. No matter where you are, the Universe is always spherical with an edge 13.7 billion light-years away. There is no use trying to reach the edge. You can't even make it come closer, let alone reach it. The uniform expansion of the Universe, as first documented by Hubble, means that all the galaxies close to us are being pulled away at modest speeds, whereas all those far away are streaking outwards at speeds exceeding 90% that of light. This is true everywhere, for all the rest of the planets in the Universe as well as for ourselves. Like ships in the ocean, always surrounded by unchanging circles of water, every point in the Universe is surrounded by the same spherical ocean of stars, expanding uniformly away from that point.

If this were a live lecture, it is a sure bet that right about now someone would raise their hand and ask rather anxiously if this means we all being pulled apart, bit by bit. The fortunate answer is no, because the material forces which hold us together are far stronger than the ultra-microscopic strain that results from the expansion of space. Imagine gluing some buttons to a rubber balloon. Then, as you inflate and stretch the rubber, the buttons will uniformly move apart. However, the buttons themselves are too hard to give way to the slight strain being placed on them by the rubber sheet, and they do not expand. In our Universe, the buttons are the galaxies. The gravitational forces within galaxies are more than enough to hold them together, so they do not expand. The Milky Way has the same diameter that it had 11 billion years ago.

Indeed, most galaxies are organized into loose clusters, and even those clusters usually have enough mutual gravitation to resist expansion. The Milky Way is in a small cluster called the Local Cluster. ("Small" is an exceptionally accurate word in this case, since The Local Cluster only has two major members: the Milky Way and the Andromeda Nebula.) The Andromeda galaxy is the only galaxy that is not receding from us because it and the Milky Way are close enough together to form a cluster, and their gravity is pulling the two towards their doom. The Andromeda Nebula is scheduled to collide with the Milky Way in about three billion years.

Which brings us to a very subtle point regarding the light that distant galaxies emit. Why is it "red shifted"? It is partly due to the Doppler effect, but mostly it is because light *cannot* hold itself together as the Universe expands. Returning to my rubber sheet analogy, imagine a pattern shaped like a dime, but made out of powdered sugar sprinkled on the sheet. The pattern possesses no cohesiveness at all, and as the sheet is stretched it will simply expand. Light moving through the Universe is exactly like this. It has no ability to resist the stretching of space. As the space holding the light expands, the light is stretched and that shifts it towards the red end of the rainbow. (Red light has a longer wavelength than blue light.) The more time that the light spends travelling through space, the more stretched it becomes, and that is why the light from far-away sources is redder than the light from nearer sources.

A very common misconception about the expansion of the Universe is that it's an explosion, with sparks of fire spectacularly blowing away in every direction just like a pyrotechnic kaboom in a Hollywood movie. It is very easy to see how such a misconception could arise, because when an astronomer says "explosion" or "expansion" of the Universe, what else is a layman supposed to think of? Exactly how complicated is a "KABOOM!" supposed to be?

Well, alas, it is pretty complicated, because Mother Nature feels no need to do anything just because it makes sense to people. The problem with visualizing the Big Bang as a Hollywood kaboom is that the kaboom is merely expanding into space which is *already there* – whereas the Universe IS space, and it is expanding unto itself. Not the same thing.

Here is a better analogy. Suppose we go back to our rubber balloon. You will be a two-dimensional germ on the surface of a balloon which is the size of the Earth. Two dimensions is all that you can comprehend, and all that you can perceive or travel in. The surface of the Earth then represents your Universe. It seems two-dimensional to you, because you are so small that movement in any direction seems to be occurring in a flat plane. However – regardless of how flat the Earth may appear to be, in fact it is curved – in the *third* dimension. Thus, if you take off in one direction and keep moving forever, it seems on the one hard that you are moving in a straight line, yet on the other hand if you keep going long enough and far enough, then you will circle the Earth and end up back where you started!! It seems impossible!! Yet, all it means is that the Earth is curved in a dimension that you cannot perceive.

And, if someone were to suddenly begin inflating the Earth with a giant air pump, what then would our hypothetical germ see? It would seem that somehow, someway, more space was "appearing". The surface of the Earth is still round, and finite, but it is expanding *outwards*, and the germ cannot perceive that. All it knows is that it can still circumnavigate the Earth, space is still finite, yet the distance it has to travel to circle the Earth has somehow gotten larger!

We are in the same boat, except that our Universe exists in three dimensions rather than two. If you could set out in any direction in some kind of super-light-speed cruiser, and move in a "straight" line, then you would see the galaxies rushing past you. And rushing past, and rushing past. No matter how far you went, the galaxies would keep coming. And then, one day, viola! You would see the Earth in FRONT of you, and you would be back where you started!! You would have circled the 3D universe, just like the germ circling the Earth. Our Universe is curved in four dimensions. That's the only difference.

To put it more succinctly, as our Universe expands, the galaxies are pulled apart. But the spreading is like paint spots on a balloon that is being inflated. The paint spots get farther apart, but there still isn't any "edge" to the balloon, or any place where the spots "end". They just keep inflating in a spherical shape. In exactly the same way, our Universe has no edge, and no center, but it is still uniformly expanding.

Cool, huh? Now you know why Hubble's discovery was so exciting.

The Speed Of The Expansion

Since Hubble's day, astronomers have devoted a considerable amount of time to refining their knowledge of the Universe's expansion. One topic that always gets a lot of attention is whether or not the expansion will stop someday, or even turn around into a collapse. The simplest way to imagine the Big Bang is to assume that everything started out with a uniform velocity, but is slowing down under the influence of gravity. (In my balloon analogy, this would be like using magnetic buttons instead of ordinary buttons. The attractive magnetic forces acting between the buttons would tend to counter the expansion from air pressure.)

It is easy to calculate how much mass the Universe *would need* for gravity to eventually bring its expansion to a halt, similar to the way Earth's gravity can bring back anything tossed into the air. It is not nearly so easy to measure how much mass the Universe *actually has*, never mind compare it to how much it would need, because so much of the Universe's mass is buried out of sight in the form of cold, invisible gas. Nonetheless, after decades of research, astronomers finally concluded that the answer was NO. There isn't anywhere near enough matter in the Universe to stop its expansion. Our picture of the Universe for many years afterwards was that of an expanding space whose expansion speed was thought to be slowing down, somewhat, due to the attraction gravity, but that was all. The picture was fairly simple.

Then, starting around 1998 and continuing until the present, astronomers began making new measurements of the Universe's expansion with unprecedented accuracy. The new method involves searching for the stellar time bombs known as Type Ia supernovae, and using the light from those to determine the exact distance to a galaxy. (The details of this method truly are far outside the scope of this essay, and I'm not going to say anything more about them. In this essay, that is. You can read my essay on Type Ia supernovae for more information.)

With the new data, astronomers were able to determine not only the current expansion rate of the Universe, but also the rate at times in the past. To everyone's considerable surprize, the data indicated that the expansion rate of the Universe was NOT slowing down! True, up until about nine billion years ago, the expansion rate *had* been dropping slowly – not startling, since one figures gravity will have that effect – but after that point, and continuing until the present, the evidence indicated that the Universe's expansion rate has actually been *accelerating*! Instead of slowing down, the galaxies are now flying away from each other at an *increasing* rate, or to put it another way, with each passing day they behave more like rockets taking off into the stratosphere than they do like rocks slowing down as they rise against gravity.

If we were ants living on a two-dimensional balloon, the only possible explanation for such a thing would be that something, somehow, was increasing the air pressure that is inflating our balloon. The ants would no doubt call it the Dark Air-Pump Problem. Since we live in a three-dimensional Universe, the only possible explanation is that something, somehow, is increasing – well, it is increasing whatever unknown thing that is already increasing the size of our Universe. Wow. Talk about an unbounded problem. We don't even know what is increasing the size of the Universe, let alone why the unknown thing is accelerating. This is precisely the type of utterly unbounded problem that theoreticians love to work on, because it allows them to calculate almost anything without fear of being contradicted by unnecessary details such as facts. Maybe it isn't so hard to understand why they decided to call this unknown thing "Dark Energy", even though it clearly has nothing to do with energy as we normally think of energy.

Fortunately, my only purpose here is to explain what the so-called Dark Energy is, not to review the blizzard of theories about it, so to that end, let's look at what most physicists believe is the simplest explanation.

The Cosmological Constant

When Albert Einstein was working on his General Theory of Relativity, which he completed in 1916, he discovered that when he applied its formidable mathematics to the known Universe, the mathematics had one small problem. It predicted that the Universe had to be a closed and curved four dimensional object – exactly as we have discussed above – but the theory also predicted that if you put any matter or energy into your Universe, then its gravity would cause the Universe to collapse. That did not seem reasonable to Einstein, particularly since at that time, in 1916, all the learned astronomers around him were certain that we lived in a static Universe, neither expanding nor contracting.

Einstein saw that his equations could be modified, without any change to the essential physics, by adding an apparently unnecessary constant. Since the constant had no particular value, Einstein realized that he could adjust it such that the Universe would *not* collapse if it also had mass and energy. So, he added it. He called it the Cosmological Constant. And he *assumed* that it had a value which would exactly balance the gravity of the Universe, and thus make his theory agree with reality. (This meant that the Cosmological Constant was acting to *push* the galaxies apart, unlike gravity, and therefore it was acting exactly like some kind of mysterious "pressure", causing all of space to to expand . . .)

If you are shocked that the famous Einstein should "fiddle" with his equations to make them match reality, you shouldn't be. As I have already noted, Mother Nature is under no obligation to do anything just because it makes sense to humans. One can either understand that or one can be wrong. By all accounts, Einstein was not especially happy with the idea that he could only make his theory work by giving this unknown constant a value that just "happened" to be what he needed to perfectly balance gravity. Theoretical physicists never like miraculous coincidences, even if they seem to be inevitable. But, he went ahead and published it, and the Cosmological Constant thus entered physics history.

The meaning of the Cosmological Constant is difficult to explain, because it has to do with the tendency of space to affect space. (In cosmology, space is not just an empty place. It acquires an identity of its own and can be bent, created, reduced, and made to jump through all kinds of other hoops.) The Cosmological Constant tells you how much and what kind of pressure or tension that space can exert upon itself to cause itself to expand. About the best analogy I can think of is that of a hoop of wire or metal tape wound into a tight coil. If you let go of the coil, then it will immediately relax and loosen into a coil with a larger radius. The spring tension causing the "expansion" of the coil comes from the coil itself, and that is something like Einstein's constant.

The miraculous coincidence that Einstein had invoked for the Cosmological Constant came completely undone when Hubble published his data on the expansion of the galaxies, in 1929. The Universe was NOT static! It was expanding, and since no one had any solid data on either the size of the Universe or how long the expansion had been going on, that meant you were back at the beginning with respect to the Cosmological Constant. Once again, it could be anything. Einstein retracted his value for the Constant, and in his later years declared that it was the "worst mistake of my life". If he had never used it, then he might well have predicted that the Universe was either expanding or contracting some 13 years before Hubble's work.

In the following decades, as more data was gathered about the size of the Universe and the amount of mass in it, it became clear that everything we saw could be explained very well by just a simple model where ordinary matter is "rising" against gravity. Any space "pressure" acting to change the velocities of the galaxies had to be very, very small. In principle the Cosmological Constant could be anything, but as more data came in the feeling steadily took hold that the Constant was not merely very small, but probably exactly zero. This just seemed right, for one thing. And, by the 1980's, there were several theories in elementary particle physics which required the Constant to be exactly zero if the theories were to work.

This was the state of affairs when, in 1998, evidence began to mount that the Universe *was* accelerating, after all! Theories to explain this flew like snowflakes in a blizzard, but the simplest one is simply that Einstein's Cosmological Constant isn't exactly zero. It is very small, but not zero. Because the Constant represents a sort-of "vacuum pressure" that space exerts on itself, the more space you have, the more pressure it can create. Thus, we can explain the new data by saying that in the first nine billion years after the Big Bang, the Universe was so small that the pressure of the space was smaller than the attraction of gravity, so the expansion of the Universe was slowed by gravity. After nine billion years, the Universe became large enough that the pressure of the (ever increasing) space exceeded gravity, and thus the expansion of the Universe began to accelerate.

Dark Energy, Finally

This subtle pressure on space created by space itself is exactly the thing that astronomers are talking about when they say "Dark Energy". As we have seen, Dark Energy is not dark, but rather undetectable (or invisible), and it is not an energy at all, but rather a tendency for space to expand as a result of a sort-of "pressure" on itself. So, "Undetectable Vacuum Self-Pressure" would be a fine name for it, or at least an accurate one. However, that didn't sound as cool to the theoreticians as "Dark Energy", so "Dark Energy" it became.

And now you know where the name came from. The next issue is that remarkably exact-sounding figure of 72% which theoreticians claim to be the part of the Universe that Dark Energy constitutes. Out of what hat did they pull that number?

Well, at this point in time, 13.7 billion years after the Big Bang, if you compare the force of gravity which is tending to pull the Universe back together to the force of the vacuum self-pressure which is tending to make the Universe expand, then you get a ratio of about 7 to 18, or 28% to 72%. Hence, if you quite arbitrarily decide that the vacuum self-pressure should be put on the same playing field with the real matter and energy that is causing gravity, then TA-DA! You can say that the Universe is "made up of" 28% gravity and 72% vacuum pressure, or 72% Dark Energy.

This bit of bizarre jargon-juggling is exactly equivalent to inflating a balloon with air pressure, and then claiming that the balloon is *not* made of 100% rubber, but in fact is constituted of 28% real rubber and 72% ***Dark Rubber***, because the air pressure acting on the the balloon has a ratio of 18 to 7 when compared to the elastic force of the rubber that is trying to make the balloon collapse.

There, doesn't that make perfect sense?

In fact, the Universe we can see is made up entirely of ordinary matter and energy. The vacuum self-pressure that is tending to make the Universe expand is quite real, yes, but it is also quite different from mass and energy, and placing all of them on the same playing field is comparing apples to oranges on a truly cosmic scale. They can be compared only to the extent of what effect they have on the expansion of the Universe, and this is both a very narrow comparison and a very misleading one.

However, at this juncture in the history of physics, it is clear that we are stuck with "Dark Energy". It is way cooler (not mention more conducive to getting grant funding) to claim that the Universe is 72% composed of some mysterious "Dark Energy" than to use descriptive language, and that is that. Perhaps on some level I should feel happy about this state of affairs, because otherwise how could I have so much fun composing an entire essay for laymen whose main point is to shoot down just two words of jargon? We all need something complain about, and I suppose that Dark Energy is mine.