How Big is the Universe (and Other Related Questions)?

But First a Primer…

If you were to count to 1 billion, it would take would take about 30 years.

A trillion is 1,000 billions.

A light year (often used in discussing the universe) is equal to six (6) trillion miles or the distance light can travel in one year.

How Big is the Universe in Light Years?

One common answer you might find says scientists estimate (with the knowledge they currently possess) that the universe is around 14 billion light years, but…

How large is the observable universe?

By Paul Halpern on October 10, 2012

If you were born on an isolated desert island in the middle of the ocean and had no communication with the outside world, your knowledge of geography would be limited. Peering through binoculars, gazing out in any direction, your view would be bounded by the sea's horizon. Although you might speculate about what lies beyond the edge, you'd lack tangible evidence to support your hypothesis.

Confined to our planet and its environs, we face the same situation: We can see a portion of the universe, but we can only speculate about its full extent. We might surmise through its flat geometry that it continues indefinitely in all directions, like a prairie stretching out as far as the eye can see. (Flat in this context refers to a straight three-dimensional space, like an endless box.) However, our understanding of the *actual* universe is bounded by the edge of the *observable* universe. We cannot know for sure what lies beyond the enclave our instruments can detect.

Accordingly, we might wonder: How large is the part of the universe we're potentially able to observe directly? At first glance, the answer might seem like a simple calculation. The speed of light is approximately 186,282 miles per second, or about 5.9 trillion miles per year. The time that has elapsed since the Big Bang is 13.75 billion years. Multiple the two figures and—voilà—we find that over the entire history of the universe, light could have travelled 13.75 billion light-years, or 81 billion trillion miles. But, in fact, that answer would be wrong.

Let's think about when the light was produced. From the time of the Big Bang to the era of recombination (when neutral hydrogen atoms formed) some 380,000 years later, the universe was opaque to light. Photons bounced between charged particles and didn't travel very far. The reason is that charged particles interact with photons—either absorbing or emitting them. Only after the era of recombination could light journey through space. That is because photons can pass through neutral hydrogen gas without being diverted. Therefore, any estimate of the size of the observable universe must assume that the farthest light we see was released after that pivotal era when space became transparent. (We may someday be able to detect neutrinos and other particles from before that era, pushing the timeline earlier and enlarging the realm of what is observable, but for now we are still limited.) The difference between the two times doesn't change the calculation much, but is important to note.

Another adjustment is far more important. Since the primordial burst of creation, space has been stretching as the universe expands. A galaxy's distance from us today is far greater than it was when it released the light. We can think, by analogy, of a relay race in which a girl tosses a ball to her teammate and then runs away from him. If the coach later asks the teammate what is the farthest throw he has caught he would give a very different answer than if he is asked where is the farthest player he has caught a ball from. Similarly, the distances traveled by the photons hurled by light sources do not reflect the much greater extent of the sources' current positions. Thus, we could potentially observe light sources that are much farther out than 13.75 billion light-years, if their light was released when they were close enough to Earth.

Yet another factor that expands the limit of the observable universe is its acceleration. Not only is the universe expanding; its growth has been speeding up. Data from the Hubble Space Telescope, the WMAP (Wilkinson Microwave Anisotropy Probe) satellite and other instruments have been used to pin down the rate of acceleration, along with the current expansion rate, the age of the universe, and other important cosmological parameters.

Taking advantage of this wealth of information, in 2005 a team of astrophysicists led by J. Richard Gott of Princeton performed a detailed calculation of the radius of the observable universe. Their answer was 45.7 billion light-years—more than three times bigger than our first, naïve estimate! Within this sphere lie hundreds of billions of galaxies, each with hundreds of billions of stars.[1]

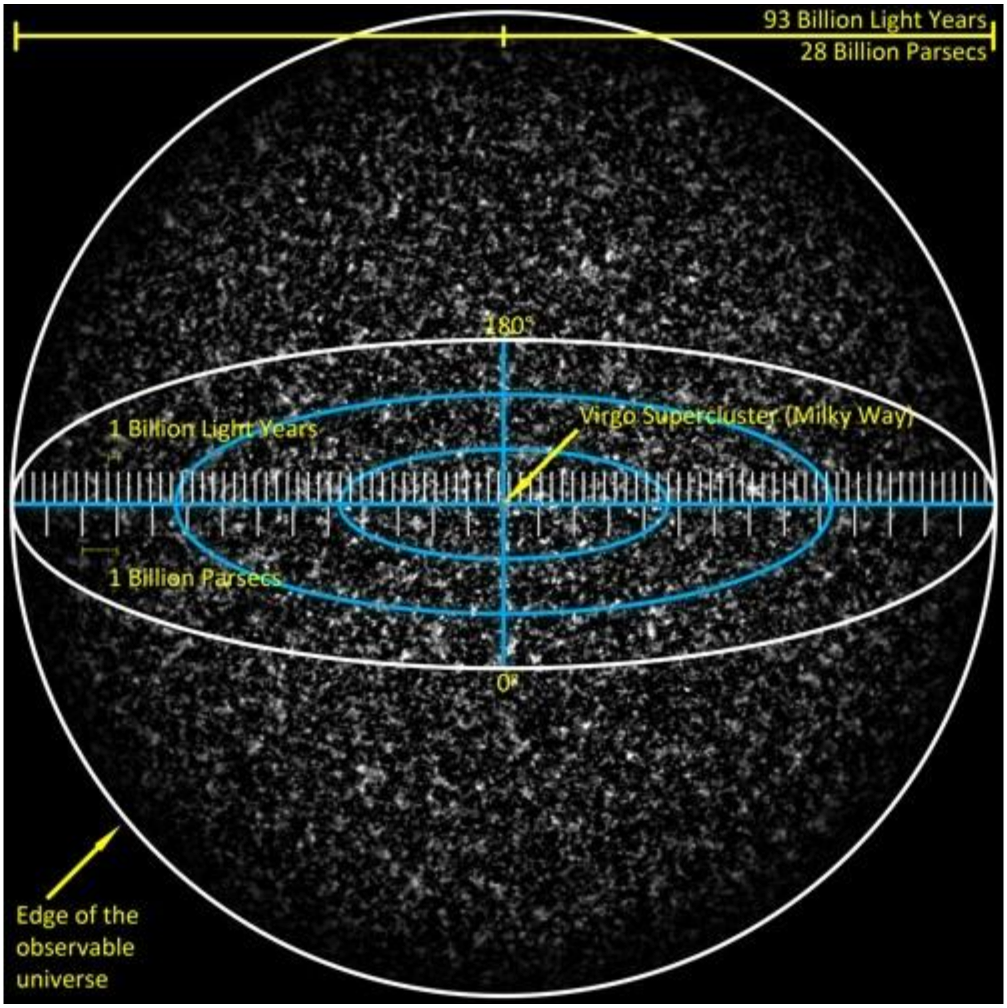


Image credit: Andrew Colvin

Gott's team calculated this radius by figuring out how far away from us a source would be today if the light we now observe from it was emitted during the recombination era. In our relay race analogy, that's determining where someone must have stood if she threw a ball and we caught it, and then using her running speed to figure out where she must be right now.

Interestingly, as the universe expands, the size of the observable portion will grow—but only up to a point. Gott and his colleagues showed that eventually there will be a limit to the observable universe's radius: 62 billion light-years. Because of the accelerating expansion of the universe, galaxies are fleeing from us (and each other) at an ever-hastening pace. Consequently, over time, more and more galaxies will move beyond the observable horizon. Turning once again to our relay race analogy, we imagine that if the players get faster and faster as the race goes on, there will be more and more who were so far away when they first threw the ball that the light would never have had time to reach us.

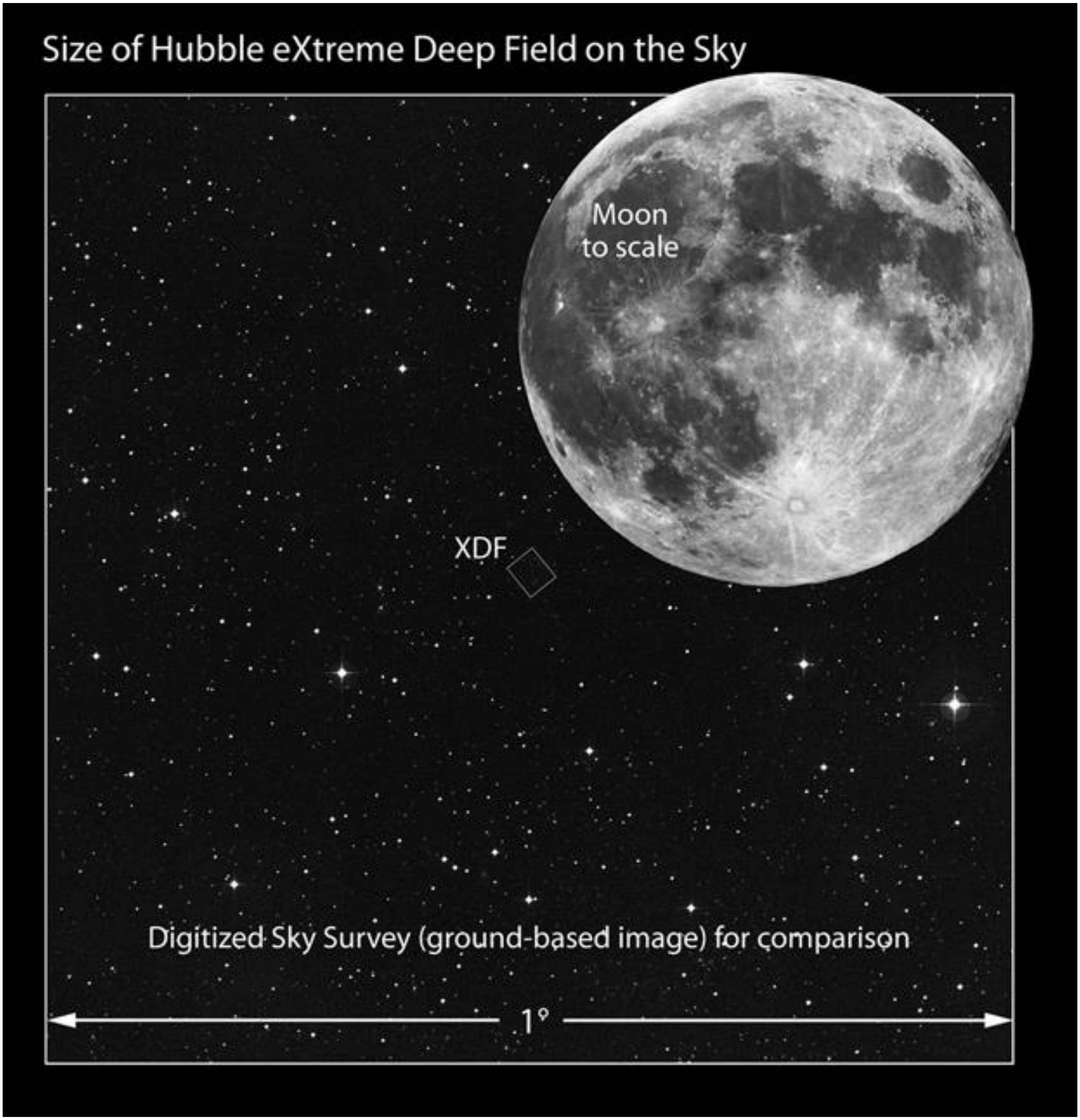
Naturally not everything within the observable universe has been identified. It represents the spherical realm that contains all things that could potentially be known through their light signals. Or to draw from a famous comment by former Secretary of Defense Donald Rumsfeld, the observable universe contains "known unknowns," such as dark matter, that could eventually be analyzed. Beyond the observable universe lie "unknown unknowns": the subject of speculation rather than direct observation.

[1] The 45.7 billion light-year radius includes only light sources. If neutrinos and other particles that could penetrate the opaque conditions of the early universe are included the value becomes 46.6 billion light-years.

How Many Galaxies are there in the Universe?

Our Earth feels like all there is, but we know that it’s just a tiny planet in a vast Solar System. And our Solar System is just one member of a vast Milky Way galaxy with 200 to 400 billion stars. But how many galaxies are there in the entire Universe?

This is a difficult number to know for certain, since we can only see a fraction of the Universe, even with our most powerful instruments. The most current estimates guess that there are 100 to 200 billion galaxies in the Universe, each of which has hundreds of billions of stars. A recent German supercomputer simulation put that number even higher: 500 billion. In other words, there could be a galaxy out there for every star in the Milky Way.



Hubble: Our Best View of the Universe thus Far

http://hubblesite.org/gallery/album/galaxy/

Which Is Greater, The Number Of Sand Grains On Earth Or Stars In The Sky?

by **Robert Krulwich**
September 17, 201210:19 AM

Here's an old, old, question, but this time with a surprise twist. The question is — and I bet you asked it when you were 8 years old and sitting on a beach: Which are there more of — grains of sand on the Earth or stars in the sky?

Obviously, grains and stars can't be counted, not literally. But you can guestimate.

Science writer David Blatner, in his new book *Spectrums*, says a group of researchers at the University of Hawaii, being well-versed in all things beachy, tried to calculate the number of grains of sand.


Emilian Robert Vicol via Flickr

They said, if you assume a grain of sand has an average size and you calculate how many grains are in a teaspoon and then multiply by all the beaches and deserts in the world, the Earth has roughly (and we're speaking *very* roughly here) 7.5×10^{18} grains of sand, or seven quintillion, five hundred quadrillion grains.

That's a lot of grains.

Gilles Chapdelaine/NASA & ESA

OK, so how about stars? Well, to my amazement, it turns out that when you look up, even on a clear and starry night, you won't see very many stars. Blatner says the number is a low, low "several thousand," which gives the sand grain folks a landslide victory. But we're not limiting ourselves to what an ordinary stargazer can see.

Our stargazer gets a Hubble telescope and a calculator, so now we can count distant galaxies, faint stars, red dwarfs, everything we've ever recorded in the sky, and boom! Now the population of stars jumps enormously, to 70 thousand million, million, million stars in the observable universe (a 2003 estimate), so that we've got multiple stars for every grain of sand — which means, sorry, grains, you are nowhere near as numerous as the stars.

So that makes stars *the champions o*f numerosity, no?

Ummm, no. This is when Blatner hits us with his sucker punch. Yes, he says, the number of stars in the heavens is "an unbelievably large number," but then, very matter-of-factly, he adds that you will find the same number of molecules "in just ten drops of water."

Plinkk via Flickr

Say what?

Let me repeat: If you took 10 drops of water (not extra-big drops, just regular drops, I'm presuming) and counted the number of H_2O molecules in those drops, you'd get a number equal to all the stars in the universe.

This is amazing to me. For some reason, when someone says million, billion or trillion, I see an enormous pile of something, a grand scene, great sweeps of desert sand, twirling masses of stars. Big things come from lots of stuff; little things from less stuff. That seems intuitive.

But that's wrong. Little things, if they're really little, can pile up just like big things, and yes, says Blatner, water molecules "really are that small."

So next time I look up at the sky at all those stars, I will be impressed, of course, by the great numbers that are out there. But I will remind myself that at the other end of the scale, in the nooks and crannies of the physical world, in the teeniest of places, there are equally vast numbers of teenier things.

We are surrounded by vastness, high and low, and either way, as Blatner's book says, we "can't handle the biggitude."