# Putting Size into Perspective



I have an enormous amount of respect for scientists of all disciplines. The mathematicians, physicists, and engineers who design and build devices that can measure the size of a proton as well as determine distances between distant galaxies equally impress me. Much of my research is based on "common" knowledge that has been published in multiple sources. The purpose of this paper is to provide a relativistic and mildly philosophical interpretation of that knowledge. The intended audience (although written so that my young teens would enjoy it) is anyone who wants to contemplate extremely large and extremely small sizes—relatively speaking, of course. My calculations are included as an appendix to this paper.

~ "Large" Sizes ~

When looking at images of the Earth and the Sun far away (and realizing that the Sun is a medium size-star) it is normal to think about how "empty" space is. Our Sun is one of approximately 70 sextillion stars in the known universe (i.e., 70,000,000,000,000,000,000,000). So when observing the heavens on a clear, autumn night and seeing thousands of tiny dots, one rightly is impressed with the vastness of space. Those dots are probably about the size of our Sun, but are so far away they look like tiny dots—as compared to the relatively large-looking Sun we see on a clear afternoon.

So here we are on Planet Earth. The Earth easily provides a living environment for over 6 billion humans. It's a large place (to use anyway). The sun is massive compared to the Earth; you could fit about 1.3 million Earths inside of the Sun (think of the Sun as a round aquarium and fitting 1.3 million Earth marbles in it—that would be a large aquarium!

The distance between the Earth and the Sun is even more vast. For this discussion let's talk about diameter. Diameter can be thought of as taking a ball (that won't burst) and sticking a long needle right through the middle of it. The amount of the needle inside the ball would represent the ball's diameter. The diameter of the Earth is about 7,928 miles (though the equator). The diameter of the Sun is about 870,000 miles. So, if you were to line up Earths along the diameter of the Sun, you would need about 110 Earths to cover the diameter of the Sun. So, if we were to magically line up Earths between the Earth and the Sun, how many would we need? About 11,730! That's a long way to the Sun—about 93 million miles.

Let's think about these sizes and distances in terms of driving a car 60 m/h without napping or stopping for snacks. If you were to drive this high-tech car through the middle of the Earth (i.e., it's diameter), it would take about six days of non-stop driving to cover the distance of the "Earth Diameter Road." How long would it take to drive through the middle of the Sun? About 604 days, or 1.7 years. The Sun is indeed a large orb as compared to the Earth! Now for the big question, how long would it take to drive at 60 m/h non-stop from the Earth to the Sun? The number is astonishing: 177 years!

It may be difficult to think about driving through the middle of the Earth, so let's think about driving a car around the sea-level surface of the equator of the Earth. At 60 m/h with no stops, it would take about 17 days to make this trip. How about driving one lap around the surface of the Sun? A little over 5 years!

Here's a summary of these ideas:

- If the Earth and Sun were beach balls, the Sun would be able to hold about 1.3 million Earth beach balls.
- The distance from the Earth to the Sun can be thought of as lining 11,730 Earths side-by-side to the Sun.
- A 60 m/h drive without stopping through the middle of the Earth would take about six days; through the middle of the sun, about 1.7 years; from the Earth to the Sun, about 177 years.

## ~ "Small" Sizes ~

Physicists have discovered even smaller building blocks than atoms, but for this exercise in "small" thought, let's stick with the atom. Loosely speaking you can think of an atom like the Earth and Sun. The electron orbits the nucleus similar to how the Earth orbits the Sun.

It is very difficult to comprehend the smallness of an atom. A hydrogen atom is the most basic containing one proton (and makes up the entirety of the nucleus) and one electron. So how small is a hydrogen atom? It is so small, that you could line up, side-by-side (like marbles) 2.5 million hydrogen atoms across the head of a stickpin! Now that is small!

Our bodies are made up of different types of atoms that form to create molecules, cells, muscles, organs, and so on. So how many atoms are in the human body? How about 4 octillion (4,000,000,000,000,000,000,000,000,000)! That's about 57,000 times as many atoms in a human body than there are stars in the entire universe!

Since the size of atoms are so extremely small, it is hard to put the relative sizes of the hydrogen electron and nucleus and the distance between the two in perspective. So let's imagine that we can greatly increase the size of the hydrogen atom such that the electron in the atom is the size of the Earth. How large would the nucleus be, and how many miles would be between them? The answers to these questions are quite astounding.

It the electron was the size of Earth, you would have to increase the size of the Sun by 9-fold and you would have to move the Earth 39.6 billion miles from the Sun (that's

426 times further than the Earth actually is from the Sun)! So taken to scale (i.e., expanding the size of the atom, such that the electron is the size of Earth), the nucleus is much larger than the Sun and the distance between the electron and nucleus is much further than the distance between the Earth and Sun. That's a lot of empty space between the electron and nucleus! Much more space, relatively speaking, than between the Earth and Sun. So why do our bodies look solid; whereas, the space between the Earth and Sun looks empty? It's all about perspective. If you were so small as to be on the surface of the electron, there would be a large expanse of "empty" space! I wonder what other, even small elements exist in all that open space?

Modifying the calculations from the previous section based on increasing the size of a hydrogen atom to the size of Earth, here's what you would have:

- If the electron and nucleus were beach balls, the nucleus would be able to hold about 1 billion electron beach balls (about 756 times as many electrons as the Sun could contain Earths).
- The distance from the electron to the nucleus can be thought of as lining 5,000,000 electrons side-by-side to the nucleus (about 426 times more electrons than number of Earths lined up to reach the Sun).
- A 60 m/h drive without stopping through the middle of the "enlarged" electron would take about six days (same as Earth, of course); through the middle of the nucleus, slightly more than 15 years; from the electron to the nucleus, about 75,400 years!

Summary table (with expanding the Hydrogen electron to the size of Earth)

| Item | Measurement | Difference |
|---|---|---|
| Diameter of Sun | 870,000 miles | |
| Diameter Nucleus (Scaled based on Earth-sized electron) | About 8 million miles | A little over 9 times bigger than the diameter of the Sun |
| | | |
| Distance from Earth to Sun | 93 million miles | |
| Distance to Earth-sized Electron to Scaled Nucleus | 39.6 billion miles | About 426 times further than the Earth to the Sun |
| | | |
| Number of Earths that would fit inside Sun | About 1.3 million | |
| Number of electrons that would fit inside nucleus | About 1 billion | About 769 times more |
| | | |
| Number of Earths lined up to reach the Sun | 11,730 | |
| Number of electrons lined up to reach nucleus | 5 million | |

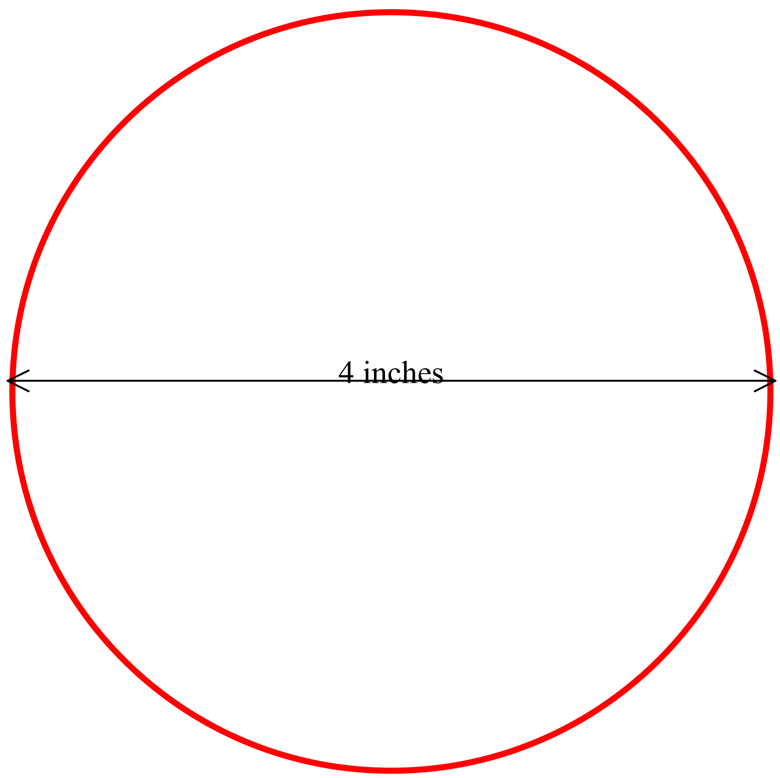
 

~ Scaling the Earth and the Hydrogen Electron to Sizes We Can Comprehend More Easily ~

Even when attempting to simplify those very large and small numbers, it can become difficult to keep relative sizes in perspective.  So here is one more exercise where we reduce Earth and increase the hydrogen electron to both be the size of a cross section of pencil lead.  This results in a much larger hydrogen electron and a much smaller Earth.

With some massive expansion and compression, the Earth and the hydrogen electron are now this size: . ←Here it is, the little dot.

Scaling the Earth down to this size, would result in the sun being this size (about 4 inches in diameter):




The distance you would have to place the two dots apart to represent the relative distance between the Earth and the Sun would be about 12 yards.  If we were able to move far, far away from the Earth and the Sun, that's how it would look—a really small dot (the Earth) about 12 yards away from the larger circle (the Sun).

So how would the electron, nucleus and the distance between the two look if the electron was the size of pencil lead?  The nucleus would be so large it would take several sheets of paper to show: 36 inches in diameter (9 times bigger than the circle representing the Sun)! The circle representing the sun takes about 50% of the width of this page to show, but a circle representing the nucleus would take about 4 ¼ sheets of standard paper placed side by side.

Remember, the Sun circle would have to be about 12 yards away from the Earth dot to accurately represent the scaled down relationship between the Sun and the Earth. So how far away would we have to place the electron dot from the nucleus circle? About 2.8 miles, which is equivalent to 50 football fields lined up lengthwise!

So when scaled to an equal proportion, the nucleus is much larger than the Sun, and the distance between the nucleus and the electron is VASTLY larger than the distance between the Earth and Sun. What's going on in all that space in the 4,000,000,000,000,000,000,000,000,000 atoms in a human body?

~ The End ~

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